COLORADO
Department of Transportation

Survey Manual

Chapter 2

General Procedures

Colorado Department of Transportation

2021

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2.1.0 – Acronyms Common to the Right of Way (ROW) Manual and CDOT

BLM	Bureau of Land Management (Department of Interior)
BPR	Bureau of Public Roads (Predecessor to Federal Highway Administration)
BuRec	United States Bureau of Reclamation (Department of Interior)
CAD	Computer Aided Drafting
CATX	Categorical Exclusion
CBLINES	Calibrated Base Lines (aka CBL)
CDPHE	Colorado Department of Public Health and Environment
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
HARN	High Accuracy Reference Network
CPA	Certified Public Accountant
CPW	Colorado Division of Parks and Wildlife (Colorado Department of Natural Resources)
CRS	Colorado Revised Statutes
DORA	Colorado Department of Regulatory Agencies
EDMI	Electronic Distances Measuring Instruments
FEMA	Federal Emergency Management Agency (U.S. Department of Homeland Security)
FHWA	Federal Highway Administration
FIR	Field Inspection Review
FLTC	Federal Land Transfer Coordinator
FONSI	Finding Of No Significant Impact
FOR	Final Office Review
GLO	General Land Office (US Dept. of Interior, Bureau of Land Mgmt.)
GPS	Global Positioning System
HED	Highway Easement Deed
HUD	United States Office of Housing and Urban Development
IGA	Intergovernmental Agreement
LPA	Local Public Agency
LSCD	Land Survey Control Diagram
LiDAR	Light Detection and Ranging

MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MUTCD	Manual on Uniform Traffic Control Devises
NEPA	National Environmental Policy Act
NGS	National Geodetic Survey
NHS	National Highway System
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NSRS	National Spatial Reference System
NPS	National Parks Service, US Dept. of the Interior
PCD	Project Control Diagram
PL	Public Law
PLS	Professional Land Surveyor (Licensed in the State of Colorado by DORA)
PLSCD	Preliminary Land Survey Control Diagram
PS&E	Project Specifications and Estimates
PSI	Preliminary Site Investigation
QA	Quality Assurance
QC	Quality Control
RFP	Request for Proposal
ROD	Record of Decision (US Environmental Protection Agency)
ROW	Right Of Way
ROWPR	Right Of Way Plan Review
RS	Revised Statute (Federal - first official codification of the Acts of Congress)
State Land Board	State Board of Land Commissioners (Department of Natural Resources)
STIP	Statewide Transportation Improvement Program (4-year transportation planning document required by FHWA)
SUE	Subsurface Utility Engineering
SUP	Special Use Permit
TMOSS	Terrain Modeling Survey System
UAS/UAV	Unoccupied Aerial System/Unoccupied Aerial Vehicle

USC	United States Code
USDOT	United States Department of Transportation
USFS	United States Forest Service
USGS	United States Geological Survey

The CDOT Survey Manual is intended to be used as a guide for Surveyors working on all projects administered by CDOT, to ensure minimum accuracies and data quality standards are met. It is not the intent of this Manual to supersede the use of Professional judgement or conduct. If the Professional Land Surveyor in responsible charge of work performed for a CDOT project would like to propose methods which deviate from procedures as outlined in this manual without sacrificing accuracy or quality, those deviations will only be accepted with prior documented approval from the CDOT Regional Professional Land Survey Coordinator who has direct oversight responsibility for the project.

2.1 Equipment Checking and Calibration

2.1.1 General

Equipment must be properly maintained, regularly checked, and calibrated for accuracy at the beginning of any survey project to ensure that the equipment is operating properly. Errors due to poorly maintained or malfunctioning equipment will not be accepted. If any equipment errors are found to exist they must be reported to the Region Survey Coordinator prior to the start of the survey. These errors will need to be verified and eliminated prior to performing any survey. For surveys lasting longer than six months, the checking, and calibration of equipment shall be repeated once every six months to show that the equipment is staying within acceptable tolerances.

Any variation from the specifications shall have the prior approval of the Region Survey Coordinator.

2.1.2 Equipment

Equipment is defined as any and all types of survey and or office survey equipment used to perform the functions of land surveying. The specifications and procedures as stated in this chapter shall apply to any and all makes and models of equipment. The specific maintenance, adjustment, care, use and, repair information is contained in the owners/operating manual for your instrument. If a particular brand or model of equipment is not specifically addressed within this chapter, the manufacturers' owners/operating manual shall be consulted for instructions on the care for the equipment.

For GPS equipment see Chapter 3 – GPS Surveys, for additional information.

2.1.3 Equipment Abuse

Any CDOT employee who misuses or abuses any surveying equipment is subject to adverse action in accordance with the policies and procedures of CDOT. Misuse or abuse includes taking CDOT surveying equipment without prior authorization of the Region Survey Coordinator, damaging or losing equipment due to lack of care, or using equipment for personal business.

2.1.4 Electronic Survey Instruments Adjustments, Calibration or Repairs

All electronic survey instruments shall be repaired, adjusted, or calibrated only by an authorized equipment vendor or manufacturers service department.

2.1.5 Equipment Types

There are many types of equipment used to perform the functions of land surveying for CDOT. The types of equipment currently used at CDOT include but are not limited to the following:

1. Global Positioning System receivers, antennas, cables, poles, height rods, etc.
2. Electronic and Robotic total stations, Terrestrial Lidar Scanners with on-board data collectors
3. Hand-held data collectors
4. Electronic digital bar-code levels (First and Second Order)
5. Automatic first order and second order digital levels
6. **E**lectronic **D**istances **M**easuring **I**nstruments (EDMI)
7. Barcode level and automatic level rods
8. Hand-held calculators
9. Lap-top computers
10. Cellular telephones
11. Battery chargers
12. Cables / accessories
13. Tribrachs
14. Prisms
15. Steel and fiberglass tapes
16. Adjustable and 2 meter fixed, height tripods
17. poles, plumb-bobs, right angle prisms
18. Prism poles
19. Magnetic locators
20. Power tools such as saws, grinders, jackhammers, etc.
21. Hand tools such as sledgehammers, shovels, drivers etc.
22. Hand-held two way radios
23. Cameras
24. Barometers / thermometers
25. Traffic control devices
26. First aid kits
27. Vehicles

2.1.6 Survey Crew Responsibilities

The survey crew chief is responsible for the crew's equipment and shall assure that all members are trained to properly care for the equipment and shall delegate the responsibilities accordingly. The crew chief shall also see that the equipment is used for its intended purpose. Members of a crew must understand the absolute necessity of using the proper equipment, in the proper condition, for the given tasks. Proper care and respect for all equipment is required of every survey crewmember.

2.1.7 Equipment Care and Protection

For the care and protection of equipment, the following rules shall be observed:

1. Care shall be taken when moving survey instruments. Manufacturer's recommendations shall be followed.

2. Instruments such as total stations and terrestrial scanners should never be lifted by the standard or horizontal axis, rather by their base and handle.

3. When equipment is being moved to or from its case or tripod, it should be lifted by the base or handle.

4. Never point an instrument's telescope directly at the sun as the sun’s rays will damage the diodes in the EDMI, and may also result in permanent eye damage to the user.

5. Never carry an instrument on its tripod or over your shoulder except as indicated by the instrument's owners/operating manual.

6. When equipment is being set up, the leveling screws should never be tightened any more than necessary to eliminate looseness. Over tightening damages the fine threads of the leveling screws, and sets up stresses that make observations erratic and often will deform vital parts of the instrument.

7. Instruments shall be protected from rapid change in temperature. Instruments shall be allowed to acclimatize to current conditions prior to use in accordance with the manufacturers requirements.

8. All equipment is designed to function in a wide range of weather conditions, but will not withstand forces that stress the parts beyond their elastic limit. Care needs to be taken to not overstress equipment beyond the intended use.

9. Electronic equipment should not be subjected to extended periods of time in wet weather due to possible damage to the electronics.

10. Equipment left set up during rain showers shallbe covered with a waterproof covering. Equipment that becomes wet shall be allowed to dry prior to storing in its case.

11. Equipment should never be left unattended in areas where it might be knocked over or disturbed by pedestrians, animals, motor vehicles, wind, falling rocks, tree limbs or other causes.

12. Whenever possible, select instrument setup locations to minimize the exposure of the instrument operator, other members of the crew, and the instrument to danger. Select stable ground for the tripod feet.

13. All instruments shall be stored in a safe, secure area when not in use.

2.1.8 Routine Instrument Maintenance

Before using any survey instrument, visually inspect it for damage. Check all machined surfaces including the polished faces of lenses and mirrors. Snug up all clamps and check tangent motions for smooth operation. These should move freely with the absence of binding or gritty sounds.

Clean the instrument exterior frequently. Accumulation of dirt and dust can scratch or mar machined polished surfaces and cause friction and sticking in the motions. Remove dust with a camel's-hair brush and clean soiled non-optical parts with a soft cloth or with a clean chamois. Clean the external surfaces of lenses with a fine lens brush. If necessary, use lens tissue. Do not use silicone treated tissue that can damage coated optics. Do not use any liquids other than pure alcohol. Take care not to scratch lenses or their coating. Never touch optical glass with your fingers. Always use a lens cover when storing in the instrument case. Do not loosen or attempt to clean the internal surface of any lens.

If any instrument or equipment becomes wet, unpack it at the end of the day and after wiping it dry with a soft towel or cloth, leave the instrument and any of its accessories outside of the case to dry. Also, leave the case open to dry. If the foam inserts for the case are wet, remove them for drying. Do not replace the instrument in the case until completely dry.

For GPS equipment see Chapter 3 - GPS Surveys, for additional information.

2.1.9 Equipment Maintenance

At the beginning of any survey all survey equipment needed to perform the survey shall be checked and adjusted by the professional land surveyor in responsible charge of the survey under his/her direct supervision. All survey equipment shall be checked once every six months thereafter and as needed during the course of the survey, whichever comes first.

Checks shall include but are not limited to the following:

1. GPS equipment – No cracks or visible signs of damage to the receivers or any cabling.

2. Electronic Total Stations and Robotic Total Stations or Terrestrial Scanners– No cracks or visible signs of damage. Leveling screws and tangent screws are in adjustment and operate smoothly. Level bubbles are in adjustment and operational. Optical sights are clear, clean, not cracked or chipped. Optical plummet is in adjustment. Bottom of base mount is smooth and not damaged. Total Station screens should be cleaned daily with a soft cloth

3. Electronic / Automatic Levels – No cracks or visible signs of damage. Leveling screws and tangent screws are in adjustment and operate smoothly. Level bubbles are in adjustment and operational. Optical sights are clear, clean, not cracked or chipped. Two Peg tests or other tests as recommended in the manufacturers owners/operating manual should be performed and adjustments made as needed. (See Chapter 5 – Preliminary Surveys, for additional information.)

4. Level Rods - Maintain level rods as you do other precise equipment. Accurate leveling is as dependent on the condition of rods as on the condition of levels.

5. Prism Poles - Level bubbles are checked and are in adjustment, rod is not bent or damaged, height of rod is correct as reportedly measured, and adjustable rod height clamps are secure.

6. Tribrachs - Optical plummet is in adjustment, level bubble is in adjustment, no loose legs, no loose or missing screws, bottom head is flat and not damaged.

7. Adjustable Leg Tripods - Nuts and bolts are tight, no loose or broken legs, tripod head is tight, flat, and not damaged. A tripod is the base on which your instrument sits and should be kept in good condition so that the instrument can be depended on for the accuracy that it was built to obtain. When the tripod is not in use, the tripod head cap should be used to protect the tripod head.

8. Fixed Height Tripods - Level bubbles are in adjustment, rod is not bent or damaged, height of rod is correct as reportedly measured, legs are secure.

9. Collimators - Level bubble is in adjustment, top and bottom heads are both flat with no damage.

10. Cables - No cuts, breaks, pinch marks or damage.

11. Hand Levels - The hand level should be kept in adjustment per manufacturer's guidelines.

12. Power and hand tools such as hammers, shovels, picks, axes, brush hooks, hatchets, etc., should be kept sharp, clean, and the handles in good repair. Broken or cracked handles are to be replaced. Mushroomed heads on chisels and punches must be ground off as flying pieces of steel can cause serious, even fatal injuries. Each member of the survey crew shall assure that all miscellaneous tools are returned to the vehicle and put in their proper place prior to leaving the work site.

13. Vehicles - The care, organization, and general housekeeping of a vehicle are good indications of the attitude of the entire crew. Keep the cab and passenger compartment free of unnecessary clutter and equipment. Store all equipment in designated places in compartments. Any equipment or material stored in the passenger compartment should be neatly and firmly secured. A good rule to follow is "A place for everything and everything in its place." Vehicles must be kept in good running condition. A regular maintenance program for the vehicle is essential. Needed repairs should be taken care of as soon as possible. Driving in a safe and defensive manner is required of employees operating state vehicles and of contract consultant survey crews.

    For GPS equipment, see Chapter 3 - GPS Surveys, for additional information.

2.2 Calibrations

2.2.1 General

A calibration check on all types of electronic survey instrumentation is essential to obtain and maintain the tolerances required in this manual. At the beginning of any survey all survey equipment needed to perform the survey shall be calibrated by the professional land surveyor in responsible charge of the survey under his/her direct supervision and/or checking. All survey equipment shall be calibrated once every six months thereafter and as needed during the course of the survey, whichever comes first.

For GPS equipment see Chapter 3 - GPS Surveys, for additional information.

2.2.2 Federal Published Calibration Baseline Check

The National Geodetic Survey (NGS) conducts a cooperative program that provides surveyors with a means for checking and calibration of errors in Electronic Distances Measuring Instruments (EDMI). Publications are available for the procedures for checking of EDMI against a Federal Calibrated Baselines from NGS. The unadjusted baseline length accuracy tolerances shall meet or exceed the manufacturers ratings for the equipment used when checked against a calibrated baseline length for both horizontal and vertical.

The checking and calibration of an EDMI involves the determination or verification of instrument constants and the assurance that the measured distances meet required accuracy specifications. Although it is not necessary to utilize a measured distance to determine or verify instrument constants, the verification effort is reduced when an accurately measured distance can be used. However, to assure that the measuring capabilities of an instrument have not significantly deteriorated, a known distance of high accuracy or, preferably, a sequence of distances forming a calibration range or base line is required. Experience shows that a base line consisting of four on-line monuments spaced at intervals of 150 m, 400 to 430 m, and 1000 to 1400 m will meet the needs of users for the checking and calibration of EDMI.

National Geodetic Survey/National Oceanic Atmospheric Association
https://geodesy.noaa.gov/CBLINES/index.shtml

The above link provides information and downloads of Federal Published Calibrated Baselines.

For GPS equipment see Chapter 3 - GPS Surveys, for additional information.

2.2.3 Practical Use and Application of a Calibrated Baseline

I. The primary purpose for comparing a total station's EDMI over a calibrated base line is to make sure it is performing within the manufacturer's stated accuracy. Secondly, it is to determine the instrument constants. The constants should be applied to measured distances only after a sufficient history of baseline comparisons have been made. This assumes the optical plummets and plate levels of the equipment are in good adjustment.

   The optical plummet in the alidade or tribrach needs to be checked before going out to the baseline. An adapter is available for adjusting tribrachs in the office, but a plumb bob can be used to check a tribrach in the field to look for gross errors. This is a very important adjustment and care should be used in doing this adjustment by following the instructions in the manual or with the adapter. Check the tribrach for missing screws or for looseness from wear. Clean the tribrach optics so you can better see the point the instrument is supposed to be over.

   The weather equipment should be in good condition and adjusted. The barometer should be set for uncorrected pressure, not corrected to sea level as given on the radio. The thermometer should also

be checked. There should be no air bubbles where the mercury is in the thermometer. The local weather station can check the barometer and thermometer in five or ten minutes for free. If only a dry bulb thermometer is at hand, just record that information.

Remember to record the height of instrument and prism to the center of the instrument and the prism and measure this carefully. This is the least accurate part of this operation, but if done with care the highest level of accuracy can be achieved. While on the Base Line, a Meter tape is to be used, because all differences in elevation Mark to Mark are in Meters. Conversion can be made after you finish by the factor derived from: one meter = 3937/1200 Feet. Also all distances should be taken in Meters and Feet to check the internal workings of the Total Station Instrument.

Most baselines have supports for the feet of the tripod to insure that the instrument or any of the reflectors will not settle off the mark causing erroneous readings. If there are not supports provided, stakes should be driven into the ground and the legs of the tripods set on these. This is also recommended in the field especially while doing control work. The saying "A building is no better than the foundation it set upon," is especially true in precision surveying.

The bull's-eye bubble that comes on tribrachs is at best a good way to get close to the point, for precision a vial bubble that attaches to the tribrach should be used. This gives the tribrachs the same accuracy as the total station that has a vial bubble to level with. This should also be used on all control surveys to achieve the desired accuracy.

For a total station, the instruments EDMI should be checked not only directly to the calibrated baseline itself, but also in conjunction with the methods that will be used to perform the survey such as with a data collector and downloading the data into a survey processing surveying program. The primary purpose for comparing a total station's EDMI over a calibrated base line is to make sure it is performing within the manufacturer's stated accuracy. Secondly, it is to determine the instrument constants. The constants should be applied to measured distances only after a sufficient history of baseline comparisons have been made. This assumes the optical plummets and plate levels of the equipment are in good adjustment.

II. A comparison can only be achieved if the "operator" induced errors are minimized. These include:

1. Leveling instruments and reflectors.
2. Centering or plumbing instruments and reflectors.
3. Applying meteorological (weather) observations.

1. Leveling instruments and reflectors - on the surface this would appear inconsequential, but accumulatively, it is not. Assume the instrument plate bubble is 20" of arc per division. Also, assume the target level used for setting up the reflector is 60" of arc per division. If the instrument and reflector are at a height of 1.5 meters (4.92 ft.) over the marks and one division out of level, then the equipment can be off the point by 0.14 mm (0.0005 ft.) and 0.43 mm (0.0014 ft) respectively, or a total of 0.57 mm (0.0019 ft.).

2. Centering or plumbing the instrument should be done with care. In calm conditions, the instrument can be plumbed over the mark to within 0.02 mm (0.00007 ft.) using a plumb bob.

Most equipment today utilizes optical plummets, which should be good to within 0.500 mm (0.0016 ft.). Optical plummets should be checked regularly to ensure they are in adjustment, otherwise considerable error can be introduced.

3. If not taken with care, meteorological observations can induce a significant error in distance measurements. A good rule of thumb is that an error of 1 degree Celsius (1.8 deg. f.) will induce a 1 PPM or 1 mm per 1000 m (0.0033 ft.) error in the measured distance. For microwave instruments the error is even greater. Therefore, to ensure good results, the thermometers should be of a quality to give at least 1 deg. accuracy. Equally critical are the barometric pressure observations. An error in pressure of 0.1 in. of mercury will result in the same 1 PPM error in the measured distance.

4. Each of the above errors is small when considered individually, but assuming the following situation and combining them indicates the necessity to do all operations as accurately as possible.

    a. Leveling error of instrument (1 div.) 0.140 mm = 0.0005 ft.
    b. Level error of reflector (1 div.) 0.430 mm = 0.0014 ft.
    c. Optical plummet (adjusted) 0.500 mm = 0.0016 ft.
    d. Temp. error 1 deg. C. (1000 m line) 1.000 mm = 0.0033 ft.
    e. Pres. error 0.1 in Hg. (1000 m line) 1.000 mm = 0.0033 ft.

    Total possible error ±3.070 mm = 0.0101 ft. (Nearly half of the single measurement rejection limit of ± 0.02 ft. on any individually measured distance.)

III. The basic observation procedures are outlined as follows:

1. Raw observations are collected on either a Calibrated Baseline Worksheet (See References: Calibrated Baseline Worksheet) or in a hardbound field book labeled Total Station Log Book along with the instrument's serial number.

2. Setup the instrument and reflectors over all the marks using care to minimize centering and leveling errors. This allows you to apply the method of forced centering in your calibration. This method allows you to move the total station throughout the course without resetting any tripods. This will enable you to distinguish operator problems from equipment problems.

3. Measure and record instrument and reflector heights above the marks.

4. Let the instrument acclimatize in accordance with manufacturer's instructions prior to making any measurements.

5. Observe and record meteorological observations. Since ambient meteorological conditions have a direct bearing on the results of distance observations and the near topography atmosphere is the most turbulent, all precautions should be taken to secure accurate data. When making temperature observations, the thermometer should be kept in the shade. Leaving it in the sun will cause significant error. Likewise pressure observations are raw pressure altitude data, not corrected to sea level. Ideally, meteorological observations are made along the entire line, but

this is not feasible so the second most desirable method is to make simultaneous observations on each end of longer lines, so the data as observed at the instrument site, and reflector can be averaged.

6. Record the instrument model number, serial number and manufactures specifications, and the reflector model and offset constant, also any instrument constants.

7. Record general weather conditions (*i.e*. clear, overcast, partly cloudy, rain, wind, etc.).

8. Record any unusual or problematic conditions (*i.e*. frozen ground, muddy, dusty, loud traffic noise, etc.)

9. Observe and record two (2) sets of forward and reverse measurements to and from all stations, so that a mean and standard deviation can be derived for all measurements, including slope distance, horizontal distance, and vertical difference.

   The zenith angle is to be recorded for both face 1 and face 2 observations to determine that the culmination is correct. The forward and reverse readings totaled should equal 360 Degrees. For a complete calibration test, the recommended procedure is to perform both forward and backward observations over each section of the base line on separate days. This is a recommendation of NOAA and is not a requirement but might be done prior to setting or resetting NOAA markers.

IV. After all observations are completed and the data is recorded it may be worthwhile to make a comparison set on a long and near distance with a zero weather setting or zero PPM correction dialed in and calculate the corrected slope distance and convert to horizontal distance or mark to mark distance utilizing the instrument and reflector heights and the station elevations as compared with those taken in the calibration test.

V. The first step in analyzing the results is to compute the differences between the published and observed distances. These differences should then be compared to the manufacturer's accuracy statistic, which is given in terms of standard error, or one-sigma, this value is used to test whether your instrument is in true adjustment. The results should also be compared to three-sigma, or three times the manufacturers accuracy specifications.

Prior to continuing, a little background is in order to understand what we are doing. One-sigma means that statistically 68.3% of the differences between a "true value" and the observed value should fall within these limits. However, this is only true for large samples and for known standard errors. Rarely are both of these criteria satisfied. By using the value of one-sigma as a limit for rejecting observations, it is possible that a valid observation may be rejected. To reduce this possibility, a limit of three-sigma is selected to decide if an observation is acceptable or not. Theoretically, 99.7% of the differences should fall within this limit. Most equipment accuracy is stated something like ± (5mm + 5ppm). What the latter term refers to is an additional error dependent upon the distance measured; or in this case the slope error is an additional 5 mm + 5/1,000,000 x the length measured.

Getting back to analyzing the observational results, once the difference, one-sigma, and three-sigma are plotted, it is a matter of simple computations. If 68.3% of the differences fall within the

manufacturer's stated accuracy, one-sigma, and 99.7% fall within three-sigma, the instrument can be accepted as working accurately and reliably. If this is not the case then the baseline should be run again, using care to minimize the errors, and the results computed and analyzed. If the results are similar to the first time, then there are two options available. Preferably return the instrument to the manufacturer, (a service center), or through a least square analysis compute the new instrument corrections.

VI. The conclusions that can be drawn from the foregoing are:

1. In order to get a valid base line comparison, the human induced errors have to be minimized.

2. If the results meet the sigma and three-sigma tests, then the instrument is working accurately and reliably.

3. If the results do not meet the sigma and three-sigma tests then before doing anything with the instrument, re-run the base line. If the results are similar, then the first thing is to check with other users to see if there is a problem in the base line. If not, it is recommended to return the instrument to the manufacturer or a service center. This is also assuming that all the tribrachs used on the base line are in adjustment. This can be tested by switching the tribrachs to different stations during the second run of the base line.

4. The above develops a history for the instrument as well as the base line. This is necessary before computing any new constants through least squares analysis.

VII. Procedures on the calibration base lines are more complex than just taking a total station, setting it up, and taking the distances the machine gives out. Several problems may exist with the equipment the total station sits upon. The tripod is an important part of observations at any time, yet is so often abused and out of adjustment that it is amazing any survey works out. The critical areas of the tripod are the head, the dowels (legs), the hinges/clamps, and the shoes. The head of the tripod should be flat, so an instrument set on it does not rock back and forth. The wooden legs should not be broken and should bear the weight of the instrument without moving. The hinges and clamps should be tight and doing the job of moving yet holding the tripod together. The shoes should be holding the legs and the instrument in the ground without any movement. A test of the tripod will give some indication of any problems it might have. First set up and level the instrument, then point to a well defined point over 500 feet away. Second, twist the tripod head both ways and sight, if the horizontal angle changes after pointing, the tripod needs adjusting, repairing, or replacing.

2.2.4 NGS Calibrated Baseline Program CALIBRAT

This program is available through NGS and is used to determine the scale and constant corrections for electronic distance measuring instruments by making measurements over previously determined base lines. The formulas used in the program are found in NOAA Technical Memorandum NOS NGS-10, "Use of Calibration Base Lines."

NGS CALIBRAT

http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml#CALIBRAT
The above link provides for downloading of NGS CALIBRAT program.

2.3 Error Sources in Surveying

2.3.1 General

Although measurement errors in surveying can never be completely eliminated, through proper planning, procedures redundant checks, and common sense errors can be isolated, identified, and kept to a minimum. The ultimate responsibility for providing surveys that fulfill required Minimum Horizontal and Vertical Accuracy Tolerances remains with the field personnel. To meet this responsibility, the survey crew chief and members of the crew must understand the various types and sources of errors, the effect of possible errors upon each surveying task, and the procedures that will eliminate or minimize errors. The use of the term "errors" is included in many surveying textbook. This term has some unfortunate negative connotations but is used throughout the industry.

The two sources of inaccuracies in surveying are:

1. Blunders
2. Errors

2.3.2 Blunders / Human Errors

A blunder, also called a mistake, is an unpredictable, human mistake. It is not an error, although a small blunder may remain undetected and have the same effect as an error. All blunders must be eliminated prior to correcting and adjusting a survey for errors. Blunders are caused by carelessness, misunderstanding, confusion, haste, or poor judgment.

Examples of blunders are:

1. Transposition of two numbers
2. Neglecting to level the instrument
3. Misplacing the decimal point
4. Misunderstanding a call to be "7" when it is "11"

2.3.3 Detection of Blunders

Blunders are detected and eliminated, for the most part, by the following:

1. Standard procedures
2. Redundancy of measurements
3. Independent checks
4. Proper checks of recorded and calculated data
5. “Closing” each survey
6. Electronic equipment and data files
7. Crew and individual alertness / awareness
8. Common sense and good judgment

2.3.4 Errors

An error is the difference, after blunders have been eliminated, between a measured or calculated value of a quantity and the true established value of the quantity. The true value is the actual value existing in nature, which is seldom known except when fixed by mathematics or by authority. The observed value is generally called the reading in surveying. It is what is read directly or accumulated on the scales of the equipment.

From the above definition, the following simple equation can be written:

Error = Reading - True Value

Errors are of two general types:

1. Systematic
2. Accidental.

2.3.5 Systematic Errors

A systematic error is an error, which will always have the same magnitude and same algebraic sign under the same conditions. Also known as cumulative errors, they can be computed and their effects eliminated by applying corrections. In most cases, systematic errors are caused by physical and natural conditions that vary in accordance with fixed mathematical or physical laws. A systematic error, of a single kind is cumulative. However, several kinds of systematic errors occurring in any one measurement could compensate for each other.

Some examples of systematic errors are:

1. Improper set up and leveling procedure of equipment
2. Refraction
3. Failure to equalize foresights and backsights when leveling
4. Failure to consider slope in measuring horizontal distances
5. Failure to calibrate measuring devices such as rods, tapes, and EDMI (Electronic Distance Measuring Instruments.

It is imperative that each operation of a survey and any imperfections or instability of equipment be thoroughly considered. The surveyor must recognize the conditions (instrument imperfections, atmospheric temperature and pressure, personal habits, etc.) that cause such errors. Once the conditions are known, the effects can be minimized. Using correct procedures will automatically eliminate many systematic errors.

Some examples of procedures to follow that will eliminate systematic errors are:

1. Balance foresights and backsights when leveling.

2. Turn angles the required number of direct and reverse (face 1 and face 2) pairs to achieve the required accuracy for the type of survey being performed so that a mean and standard deviation can be calculated.

3. When using an EDMI, measure the distances from both ends of the line with enough

repetitions so as to achieve a mean and standard deviation of the distance.

4. Use standardized tapes.

5. Regularly calibrate all instruments.

2.3.6 Accidental Errors

An accidental error is an error, which does not follow any fixed relation to the conditions or circumstances of the observation. These errors are produced by irregular, complex causes that are beyond the control of the observer. Their occurrence, magnitude, and algebraic sign cannot be predicted and each is truly random. In theory an accidental error has an equal chance of being negative or positive. Thus, errors of this type tend to be compensating. However, since the magnitude is also a matter of chance, accidental errors will not totally compensate for one another. According to the mathematical theory of probability, accidental errors tend to increase in proportion to the square root of the number of opportunities for error. Thus, if the accidental error in turning one angle were ± 2" the chances would be equal that the total accidental error due to measuring 100 angles would not exceed ± 20" (± 2 · 100=203). A systematic error of the same magnitude would produce a total error of 3' 20" (200") (2 · 100 = 200). Accidental errors to a small degree remain in the inability to point a theodolite exactly or setup exactly over a point. However, if personal habits make one consistently point off to the same side of the sight line, this error becomes a systematic error. Corrections cannot be computed for accidental errors as for systematic errors.

In more precise surveys, the least squares method shall be used for adjustment of accidental errors. All blunders and systematic errors must first be eliminated because this method of adjustment is applicable only to truly random accidental errors. Any standard survey textbook can further explain the principles of "Least Squares adjustments".

No adjustment of any survey data is to be performed in the field.

2.3.7 Sources of Errors

There are three general sources of errors:

1. Personal
2. Instrumental
3. Natural.

2.3.8 Personal Errors

Personal errors are caused by the observer's lack of knowledge, failure to apply knowledge, physical limitations, and personal habits. They can be either systematic or accidental. Each observer, whether he/she believes it or not, makes personal errors of a small degree on each individual observation. Exact, correct observations are impossible because of the human limitation of sight and touch. Fortunately, such errors are minimized by proper procedures.

Examples of personal errors are:

1. Inability to observe and hold plumb over the point
2. Inaccurate mathematical calculations
3. Poor instrument sighting of a point
4. Erroneous readings of scales, tapes, rods and screen output
5. Failure to hear, understand or record verbally stated data
6. Use of improper methods

Continually practicing careful, conscientious survey techniques will substantially reduce personal errors. Several hours spent training inexperienced help is worth the time and effort in the reduction of errors. When the work is knowingly done haphazardly, costly errors will occur.

2.3.9 Instrumental Errors

Instrumental errors are caused by imperfections in the design, construction, and adjustment of instruments and other equipment. Most instrumental errors are eliminated by using standard procedures, such as observing angles direct and reverse, balancing foresights and backsights when leveling, and repeating measurements. Instrumental errors that are not eliminated by procedures must be minimized. This can be accomplished by maintaining a regular program of periodically checking and calibrating instruments and other equipment. Whenever new or used instruments or equipment are initially assigned, they must be checked and calibrated prior to using them.

2.3.10 Natural Errors

Natural errors, or external errors, result from natural physical conditions, such as atmospheric pressure, temperature, humidity, gravity, wind, atmospheric refraction, and type of soil the instrument is being set up on. Natural errors are removed from measurements by determining corresponding corrections from known relationships between an error and the natural phenomena. A familiar example is the correction for atmospheric temperature and pressure, which is applied to EDMI settings. Sometimes the effect of natural errors can be eliminated by using certain procedures, such as setting stakes for the tripod to set on due to thawing conditions or even in other unstable soils that occur all year long such as blow sand or swamps.

2.3.11 Detection of Errors

The accuracy of all survey work shall be checked by a closure to detect any errors that are greater than the stated Minimum Horizontal and Vertical Accuracy Tolerance.

This is to be done mathematically with the use of statistical analysis. All checks are to be made before errors are carried ahead to other work. When checks are neglected, erroneous information and costly errors usually result. In most cases it is economical and practical to apply methods that will result in near perfect results. The first return trip to the project to correct sloppy and careless work will pay for the initial proper procedures having been used. This is especially true if the initial control is lost and the whole survey has to be redone.

2.3.12 Mathematical Checks

Traverse, triangulation, and level work have definite requirements for closures. The determination of the error of closure requires a great deal of calculation not usually done as fieldwork progresses. There are, however, many mathematical and geometric checks that shall be used as the work progresses. Too often simple checks are not made as the work progresses, and result in the necessity of returning to the field for clarification.

Checks are to include but not limited to the following:

1. Sufficient redundant and repeat measurements shall be made to determine if the Minimum Horizontal and Vertical Accuracy Tolerance as stated for the survey are being met at the ninety-five percent (95%) confidence level (See Chapter 5 - Preliminary Surveys, Minimum Horizontal Accuracy Tolerance Table and Minimum Vertical Accuracy Tolerance Table for additional information).

2. Instrument horizontal and vertical columniations shall be checked daily and adjusted as needed.

3. Level two peg test or other test as recommended in the manufacturers owners/operating manual shall be performed daily and adjustments made as needed.

4. The sum of the horizontal angles around a point should equal 360 degrees within the horizontal accuracy tolerance of the instrument. This is achieved by the operation commonly referred to as "Closing the Horizon" when an angle right and an angle left are used to find the sum of the total angle.

5. The mean and the standard deviation shall be calculated on all multiple measurements, and compared to the 3 sigma values of the instruments being used before moving to the next instrument location.

6. In a closed polygon, the sum of the interior angles equals 180 degrees times the number of sides minus two (Required degrees = 180(n-2))

7. The hypotenuse of a right triangle is equal to the square root of the sum of the squares of the other two sides.

8. In leveling, the algebraic sum of foresights and backsights should equal the difference in elevation between the starting point and closing point.

9. The zenith or vertical angle of the forward sighting and the zenith or vertical angle of the reverse or inverted sighting shall equal 360 degrees within the vertical accuracy tolerance of the instrument.

2.3.13 Visual Checks

Visual checks shall be made, by observing such things as disturbed control monuments. Control monuments shall be checked before final values or positions based on them are established.

2.4 Field Notes

2.4.1 General

Field notes are prepared to record all pertinent information, measurements, calculations, sketches, and observations made by the surveyor during the course of a survey. These notes become the permanent record of the survey. The continuous practice of keeping good field notes is imperative. Notes should be examined and checked for accuracy, legibility, completeness, and clarity before leaving the field. They must be recorded in such a way that someone outside the original crew could clearly understand how, when, where, for what purpose and by whom the original survey was done.

The individual recording the field notes may not be the same person reading the field notes at a later date. The notes must be taken so that individuals with similar technical backgrounds can properly interpret the notes, correctly read the numbers, and understand their meaning. The Region Survey Coordinator will reject any field notes found to be unacceptable.

2.4.2 Types of Field Notes

CDOT accepts three types of field notes as follows:

1. Handwritten field notes in hardbound survey fieldbooks.

2. Electronically recorded field notes printed in a field book format in a stamped and sealed in a smart scanned pdf format.

3. Electronically recorded field notes copied project data files in text format, to be read in a standard word editor program. This option may only be used when approved in advance by the Region Coordinator.

2.4.3 Survey Field book / Electronic Field Notes Submittal

All field notes from hard bound and/or electronic, shall be submitted in a protected pdf format, electronically stamped and sealed by the Professional Surveyor in responsible charge of the work, and become the permanent legal record of the work performed for the project.

All field notes shall be taken in accordance with this Survey Manual and CRS 12-120-302, Part 3: Professional Land Surveyors Section of Practice Act. All field notes if not taken electronically, shall be recorded in a standard hardbound survey fieldbook, scanned into a pdf format and electronically stamped and sealed by the PLS in responsible charge. All electronically generated field notes shall contain the information shown on the examples in this Chapter (Section 2.4.12). After the pdf is electronically sealed it will be copied into the Projectwise/Survey_ROW/Survey folder for permanent record retention.

2.4.4 Survey Fieldbook Database

Original field notes and/or unedited electronic notes are the permanent record of the survey and shall become the property of CDOT. All certified scanned pdf copies of hardbound survey fieldbook and/or original electronic field notes taken by either CDOT or contract consultant survey crews shall be submitted to the Region Survey Coordinator at the end of the project or at the time as specified. These records shall be included with the project files and/or cataloged in a fieldbook database in Projectwise under ROW_Survey /Survey.

Each Region shall maintain a database of fieldbooks for reference and retrieval of the fieldbooks. This will expedite the process of providing fieldbooks when request are made.

Such request may come from the following sources:

Attorney General's office
Court summons
Condemnation court cases
Contract consultant records research
CDOT records research
Private survey records research
Open records request made in accordance with 244-72-101 CRS, to 4-72-402 CRS.

Before submittal of fieldbooks and/or electronic field notes to CDOT, the surveyor should make copies for inclusion into their own project files. If it becomes necessary for either CDOT or contract consultant surveyors to obtain original survey fieldbooks the Region Survey Coordinator should be contacted and arrangements made.

2.4.5 Survey Fieldbook / Electoronic Field Notes

Survey fieldbooks and electronic field notes shall be indexed individually for each element of a project and shall contain only that particular portion of the survey that pertains to the fieldbook as indexed. It is generally the responsibility of the survey crew chief to index the fieldbooks upon completion of each survey or each appropriate element of the survey.

The following survey elements of a project shall be indexed by feldbooks and/or electronic field notes:

1. Horizontal Control (Primary and Secondary)
2. Vertical Control, *i.e*. Bench Books (Primary and Secondary)
3. Property Pin Ties (*i.e.* Right of Way, Public Land Survey System, easement and boundary monuments)
4. Alignment
5. Grading
6. Slope staking
7. Minor structures
8. Major structures
9. One electronic book for each work category as shown on the Survey Tabulation Sheet.

See Chapter 6 - Construction Surveys, for additional information.

2.4.6 Original Field Notes

Original notes are those recorded at the time the measurements are being taken. Time must be taken during the survey to record neatly and accurately all notes. Transcribing originally recorded field notes and measurements from peg books or other sources shall not be accepted by CDOT. This practice causes mistakes, omissions and makes then inadmissible as trial court evidence. In addition, it is an unnecessary duplication of work.

2.4.7 Erasures

Erasures are not permitted in fieldbooks. If an item has been recorded incorrectly, draw a single line through it without destroying its legibility and record the correct item directly above. If an entire page is to be omitted, draw diagonal lines across the page from opposite corners and write "VOID" conspicuously across the page. When changing data onto new field pages, the corrected data and the voided data must be referenced back to each other. State the date and crew information on the corrected data as if it were original data.

2.4.8 Calculations

Field calculations should be included on the appropriate pages in the notes. Book covers or flyleaves should never be used for calculations, notes, additions, etc. If the possibility of error arises, the computations for the survey can then be easily retrieved for checking.

2.4.9 Electronic Field Notes

Electronic field notes gathered using electronic survey equipment should have the same credibility as field notes taken in a fieldbook, therefore they must be in a smart scanned pdf format which can be electronically stamped and sealed by the Professional Land Surveyor in responsible charge. Electronic field notes may be substituted for fieldbook notes called for elsewhere in this manual if the electronic notes contain all the information specified. The same care and procedures used with hardbound fieldbooks shall be followed with electronic field notes. The major advantages of electronic field notes are that mistakes in reading and recording measurements in the field are eliminated and the time to process, display, and archive the notes is reduced.

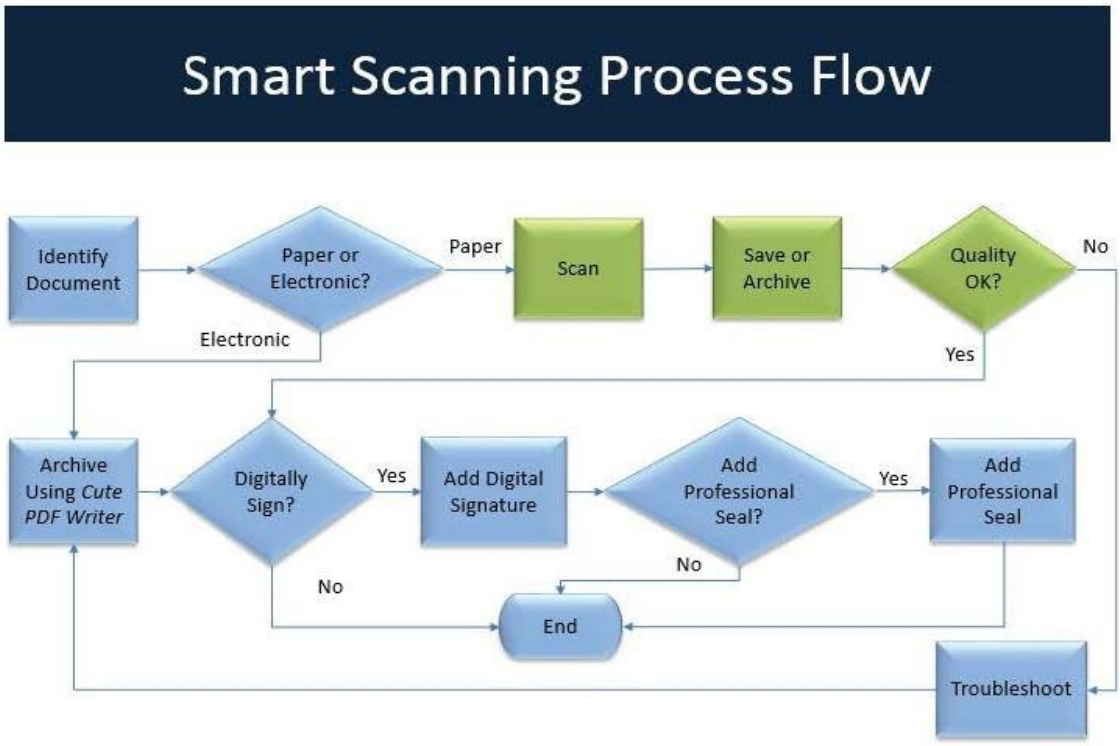
Per PD 21.1 all electronically generated field notes shall be electronically Stamped and Sealed by the Professional Land Surveyor in responsible charge of the work. These will become a permanent record of the project files and stored in the current CDOT records retention format and location.

PD 21.1 Requirements for the Retention of Records

June25, 2019 PD 21.1 was updated to formalize CDOT's move to a decentralized system whereby specified design, construction, engineering, and specialty group records with a short retention period (3.5 years or less) may be retained by the regions then destroyed.
Updated PD 21.1 requires Smart Scanning of records with a retention period longer than 3.5 years. Smart Scanning preserves the record in digital format assuring the ability to read it regardless of the

hardware or software, which was used to create the original files for decades to come. This method (Adobe PDF/A 1-b) replaces the use of microfilm, and is recognized world-wide by the International Standards Organization ("ISO") as being a reliable medium for document archiving. As directed by Chief Engineer Memos dated September 11, 2017, and May 17, 2019, CDOT "Project Records" (defined in the PD) must be stored in ProjectWise as CDOT's chosen Electronic Document Management System.
This Directive allows for the use of Adobe Sign for "Project Records" including Contract Modification Orders, given that Adobe Sign is fully integrated into ProjectWise and can be utilized with large construction records such as plan sets.

Below is a workflow summarizing these procedures as directed by PD 21.1:



2.4.10 Original Electronic Field Notes

The information gathered in the unedited electronic field notes are the original field notes, and shall not be changed at any time. Copies of all original notes shall be converted to a pdf format which can be electronically stamped and sealed by the Professional Land Surveyor in responsible charge then forwarded to the Region Survey Coordinator for review and approval. Sketches and additional information should be included in fieldbooks if it will help to clarify the notes in the collector. These sketches should be referenced in the collector and in the fieldbook.

Just as with fieldbooks, the date, crew, weather, and project description must be included at the start of each file. This should be done in the electronic notes prior to the start of the job. Notes should be kept in the collector if they will help in the explanation of the data.

2.4.11 Electronic Field Notes Downloaded Daily

At the end of the day the raw data from the collector shall be downloaded into a survey processing software program for editing and processing. At this time a hard copy of the non-edited raw file should be acquired and signed by the survey crew chief. This will help with the legality of the survey should a problem arise. A copy of the non-edited file should be stored with the project data files in the current electronic filing system used by CDOT. As of 2020, that data management system is Projectwise.

2.4.12 Electronic field book (set-up Example)

See Appendix C

2.4.13 Field Note Check List- For Hardbound Fieldbooks

The following is a checklist of important procedures to follow in note keeping for both fieldbooks and/or electronic field notes. It is advisable to review this from time to time to insure good habits of taking field notes.

1. Always enter data directly into the fieldbook. Never use scrap paper for recopying later.

2. Include sketches whenever in doubt as to the clarity of the tabulated information.

3. Sketches can be drawn in general proportion, rather than exactly to scale.

4. Exaggerate details on sketches if more clarity is needed.

5. Always avoid overcrowding. Keeping the number of fieldbooks to a minimum is not important. The cost of fieldbooks is inexpensive compared to the value of the information they contain.

6. Sketches and descriptions should be carefully lined up on the right hand page with the corresponding numerical data on the left hand page.

7. Always use explanatory notes wherever needed.

8. Use customary symbols and signs when possible to conserve space.

9. Tabulated figures should be kept inside the column rulings with the digits and decimal points in line vertically.

10. For number less than one, a zero must be placed before the decimal point. For example, record 0.15 instead of .15.

11. Always record significant zeroes to show precision of measurements. For example, record 6.40 instead of 6.4 if actually measured to hundredths.

12. All possible checks on the notes should be done and recorded before leaving the field.

13. All possible ratios of errors and closures should be computed before leaving the field.

14. Include all essential computations with field notes, so they can be easily checked later.

15. The person performing the computations shall initial the field computations on the lower right hand side of the page.

16. All field computations shall be checked by a second person and initialed by the person who performed the check on the lower right hand side of the page.

17. Repeat out loud the numbers given for recording. For example, before recording a measurement of 97.48 feet, call out "nine, seven, point, four, eight" for verification by the tape person who submitted the distance.

18. Try to make a mental estimation of all measurements before receiving them, to eliminate large errors.

19. Lettering should be neat and printed.

20. Carry a straight edge in the survey vehicle for ruling lines.

21. Do not erase. Draw a single line through an erroneous value and record the correct value above it.

22. Begin each day's work on a new page.

23. Record date, weather, and crewmembers' names and duties at the top of the right hand page.

2.4.14 Setting Up Hardbound – Specifications on CDOT Projects

See Appendix B Figures 2-1 through 2-16

2.4.15 Daily Field Notes

For each day of the survey, the date, weather conditions, unadjusted barometric pressure, any unusual conditions such as wind, dust, or fog, instrument number, names of the crew and their duties shall be recorded on the upper right hand page.

The left page is normally ruled in six columns and is normally used for tabulations only. Column headings should be placed between the first and second horizontal line and should follow from left to right in the anticipated order of reading and recording. A title of the work being performed and recorded should be noted at the top of the left hand page.

2.5 Preliminary Survey Scope Form 1217 PM-Web

2.5.1 General

Any request for survey activities shall be coordinated through the Region Survey Coordinator by issuing a Preliminary Survey Scope Form 1217 now avaialble on PM-Web and the Project Manager.

All possible improvements should be anticipated when the project scope is being prepared. It is prudent to include all identified deficiencies when preparing the Preliminary Survey Scope Form 1217, so that enough information is gathered to allow the designer the ability to analyze the data, and decide if changes are needed to the final design. Form has been updated to include more current technologies such as LiDAR, and UAS

2.6 Preliminary Survey Scope Conference

2.6.1 General

Prior to any survey work being performed a Preliminary Survey conference shall be held. Any known problems or oversight issues with the proposed plans or specifications shall be discussed at the Preliminary Survey conference. The Preliminary Survey conference shall include at a minimum the appropriate Preliminary Survey Conference Form for the type of survey being performed as follows:

1. Preliminary Survey Conference
2. Presurvey Conference – Construction Survey

2.6.2 Preliminary Survey Conference

A Preliminary Survey Conference – form 1217 shall be held prior to the beginning of the following types of preliminary surveys as defined in Chapter 5 – Preliminary Surveys:

1. Reconnaissance Survey
2. Control Survey
    a. Horizontal
    b. Vertical
3. Right of Way Survey
4. Topographic Survey
    c. TMOSS
    d. Mobile LiDAR, terrestrial LiDAR, UAS- LiDAR and Photogrammetry
5. Drainage Survey
6. Utility Survey-SUE Quality level C only.
7. Staking for appraisal

The Preliminary Survey conference at a minimum shall include a Preliminary Survey Conference Form for Preliminary Survey, CDOT Standard Specifications for Road and Bridge Construction, Section 629 – Survey Monumentation, Subsection 629.02 – Materials and Subsection 629.03 - Construction Requirements shall be included as part of this Preliminary Survey conference.

Review Survey Tabulation Sheet at FOR, *prior to* Final Advertised Project plan sets

See Chapter 5 – Preliminary Surveys, for additional information.

2.6.3 Preliminary Survey Conference – Construction Survey

Review Survey Tabulation sheet as shown in Advertised Project Plan set (Awarded)

A Preliminary Survey Conference – Construction Survey shall be held prior to the beginning of any construction survey as defined in Chapter 6 – Construction Surveys for the following sections of CDOT Standard Specifications for Road and Bridge Construction as deemed pertinent for the project by the Region Survey Coordinator:

1. Section 625 – Construction Surveying- note requirements by Structure and Utility Specialites
2. Section 629 – Survey Monumentation

The Preliminary Survey conference at a minimum shall include a Preliminary Survey Conference Form for Construction Survey. CDOT Standard Specifications for Road and Bridge Construction, Section 625 – Construction Surveying and Section 629 – Survey Monumentation shall be included as part of this Preliminary Survey conference.

See Chapter 6 – Construction Surveys, for additional information.

2.7 Special Use Permit

2.7.1 General

Private surveyors or contract consultant firms working in the existing CDOT Right of Way shall obtain a Special Use Permit with the survey option completed.

2.8 Manual on Uniform Traffic Control Devices (MUTCD)

2.8.1 General

All work performed in or near to any traveled roadway shall follow the latest Manual on Uniform Traffic Control Devices (MUTCD).

https://www.codot.gov/safety/traffic-safety/assets/documents/mutcd
See Chapter 7 – Safety, for additional information.

2.8.2 PD 1502.1 Traffic Control for Planned and Unplanned Work:

COLORADO
Department of Transportation
Office of the Executive Director

RELEASE MEMORANDUM

TO: All CDOT Employees

FROM: Shoshana M. Lew, Executive Director
Herman Stockinger, Deputy Director & Director of Office of Policy & Government Relations
Natalie Lutz, Rules, Policies, and Procedures Administrator

RE: **Updated Procedural Directive 1502.1 "Traffic Control for Planned and Unplanned Work"**

DATE: June 29, 2020

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1. Name of Updated Procedural Directive:

   Procedural Directive (PD) 1502.1 "Traffic Control for Planned and Unplanned Work"

2. Executive Summary:

   Procedural Directive 1502.1 "Traffic Control for Planned and Unplanned Work" establishes CDOT's operational requirements for the use of traffic control equipment and necessary safety procedures when working in the roadway.

   The Updated PD 1502.1 promotes consistency between engineering and maintenance use of work zone traffic control. The Updated Procedural Directive 1502.1 builds upon the Manual on Uniform Traffic Control Devices (MUTCD) and goes higher in several requirements for the safety of our maintenance and construction workers, whether CDOT or contractor, as well as travelers. Key updates include:

   - Short-Term Duration and Mobile Work: The Updated PD 1502.1 more clearly differentiates between the work zones of Short-Term Duration and Mobile Work, and the requirements are more clearly stated.
   - Unplanned and Emergency Work: The Updated PD 1502.1 provides key decision-making information when responding to unplanned work and emergency roadway situations by including both best practices supported by CDOT and prohibited actions associated with increased risk to roadway workers.
   - Positive Protections: The Updated PD 1502.1 provides specific guidance on required positive protection between roadway workers and live lanes of traffic, such as shadow vehicles, during unplanned and emergency activities.
   - Training for Front-line Workers: In order to promote a "living" practice for preparing every front-line worker with the proper safety precautions, clear connections have been drawn between this Updated PD 1502.1 and the required CDOT training that influences real-time actions in the field.

2829 W. Howard Place Denver, CO 80204-2305 P 303.757.9011 www.codot.gov

- Communication Protocol: The Updated PD 1502.1 establishes a communication protocol for unplanned and emergency work. The traffic engineer and/or senior foreman must be informed upon detection of unplanned and emergency incidents and, in areas with CDOT Traffic Incident Management (TIM) coverage, TIM responders must also be notified.

- For clarification purposes, "Flagging" was added as a new defined term and other minor and non-substantive revisions were made.

3. Offices to Contact with Questions:

   The Office of Policy and Government Relations at:
   303.757.9441 or natalie.lutz@state.co.us.

   The Division of Maintenance at:
   303.319.5121 or wes.maurer@state.co.us

4. Effective Date of Updated Procedural Directive: June 23, 2020

2.9 Permission to Enter Property

2.9.1 General

A property owner or occupant shall be contacted before a survey crew enters the property. The purpose of this contact is to inform the owner or occupant that an entry is required, to identify what survey activities are to be performed, to indicate the duration of the survey. The Letter and form 730 should included to obtain Permission to Enter Property in *writing*. The letter and form should be filled out in order that survey crews will have permission for performing their assigned functions. The owner or occupant at this time are to be advised of their rights and allowed to use section "Conditions requested by Owner" of the permission form to place certain restrictions on the activities (*i.e.* time limitations, where vehicles may drive, cutting of brush, digging holes or if notice needs be given before entering property).

2.9.2 Exception to Criminal Trespass

18-4-515 CRS contains an exception to the trespass laws for boundary survey evidence investigation and to utilize such evidence.

2.10 Underground Utility Locates Prior to Installing Monumentation

https://www.codot.gov/business/permits/utilitiesspecialuse/colorado-811

2.10.1 General

As of 2020, CDOT as constructed Utilities will be collected to create a database of utilities within CDOT ROW.
Additionally, Colorado SB 93-155 requires that anyone that engages in any type of excavation must provide advance notice to the underground facility owners. The notice must be at least two business days, not including the day of the call, prior to any excavation. A precise definition of excavation is included in the state law as follows: "Excavation" means any operation in which earth is moved or removed by means of any tools, equipment, or explosives and includes augering, backfilling, boring, ditching, drilling, grading, plowing-in, pulling-in, ripping, scraping, trenching and tunneling.

After monumentation sites are identified on the ground for installation of monuments each site shall be marked with a lath, and white paint and/or flagging and underground utility locates shall be called for. The lath should be marked as "Utility Locate" with it's appropriate Milepost, and radius necessary for the area of the utility locate. Underground utility locates shall be called for by contacting the following:

Contact

16361 Table Mountain Pkwy, Golden, CO 80403

Phone: (303) 232-1991

Email: administrator@co811.org

Website: colorado811.org

The above utility locate contact number is primarily for the front-range area only. This may not be the only number you will need to call to obtain utility locates. For additional information on utility locates in your area contact your local utility companies and/or municipalities.

Utility locates for design engineering work may be difficult to obtain. Private utility locate companies may need to be contracted with for performing these types of locates in a reasonable amount of time.

2.10.2 Information Needed to Provide for Utility Locates

When calling in your utility locates the following information will be helpful to provide to the utility locate company or municipality with the information necessary for each point:

1. Your contact information
2. Alternate contact information
3. Description of the monument rod length and diameter to be set
4. No explosives will be involved
5. Installation method (hand or power tools)
6. Utility locate to be performed by a 30 foot radius around the marked point
7. Description of how the point is marked
8. Highway number and mile post
9. County and/or City
10. Distance and cardinal direction to the nearest intersection
11. Distance and cardinal direction to the nearest town or city
12. Distance and cardinal direction from edge of asphalt or concrete of the highway to the point
13. Section, Township, and Range

If the description of the points to be located are confusing to the utility locate company or if there are many points to be located a meeting with the surveyor and the utility locate company may be needed to allow the surveyor to assist the utility locator with finding the points.

2.10.3 Utility Locate Color Codes and Tolerance

See Figure 2-17 for information on underground utility color codes:


COLOR CODE
FOR MARKING
UNDERGROUND UTILITY LINES
PROPOSED EXCAVATION
TEMPORARY SURVEY MARKINGS
ELECTRIC
GAS-OIL-STEAM
COMMUNICATION CATV
POTABLE WATER
IRRIGATION, RECLAIMED WATER, SLURRY LINES
SEWER
Dig Safely.
BEFORE YOU DIG CALL:
1-800-922-1987 www.uncc.org
UTILITY NOTIFICATION CENTER OF COLORADO
REQUIRED LOCATION
REQUEST INFORMATION
PHONE#
NAME OF CALLER
WORK BEING DONE FOR
TYPE OF WORK
COUNTY CITY
ADDRESS OR JOB LOCATION
EXTENT OF WORK
TOWNSHIP RANGE SECTION
Dig Safely. CALL UNCC
THREE WORKING DAYS BEFORE YOU DIG
1-800-922-1987 www.uncc.org
UTILITY NOTIFICATION CENTER OF COLORADO

Figure 2 – 17

See figure 2-18 for information on underground utility locate tolerance zone:

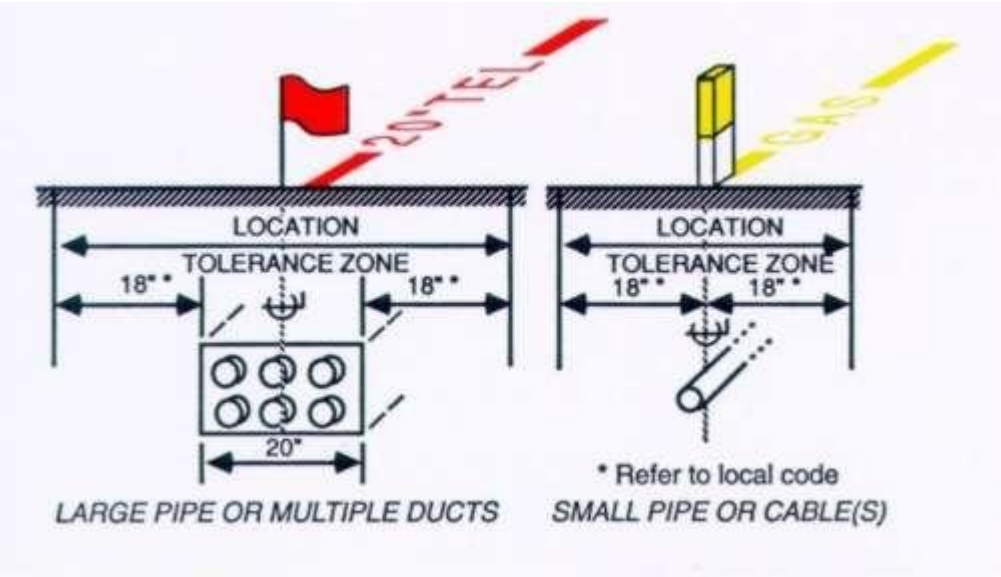


Figure 2 – 18

2.11 References

CDOT Survey Manual – CDOT, 1992

CDOT Right of Way Manual – CDOT, 2020

CDOT Standard Specifications for Road and Bridge Construction – CDOT, 2019

Board of Registration for Professional Engineers and Land Surveyors, Land Surveying Laws and Board Rules – November 2020
https://dpo.colorado.gov/AES/Laws

National Geodetic Survey – November 2020
https://www.ngs.noaa.gov/

Colorado Revised Statures –
https://www.codot.gov/library/crs

Manual on Uniform Traffic Control Devices (MUTCD) –
https://www.codot.gov/safety/traffic-safety/assets/documents/mutcd

PD 1502.1 Page 25

https://www.codot.gov/business/manuals/survey/survey-forms
Calibrated Base Line forms
Permission to Enter forms
Preliminary Survey form
Special use Permit form

2.2 Appendix A

Procedural Directive 1502.1

Colorado Department Of Transportation Policy Directive	Procedural Directive	
Subject Traffic Control for Planned and Unplanned Work	Number 1502.1	
Effective 06.23.20	Supersedes 04.08.19	Originating Office Division of Highway Maintenance Division of Engineering

I. PURPOSE

This Procedural Directive establishes procedures for the management of temporary traffic control zones, the safe and efficient movement of both motorized and non-motorized traffic through or around temporary traffic control work zones, and the protection of workers and equipment located within those work zones in conformance with 23 C.F.R. § 630.1006. The procedures may vary based on the characteristics and expected work zone impacts of individual projects or classes of projects. The Department also sought to set forth guidance regarding unplanned emergency work, including which employees should respond to the immediate need and what processes should be followed to address the need. This Directive emphasizes the Department's commitment to a comprehensive, unified maintenance and engineering approach to safety in all types of temporary traffic control zones.

II. AUTHORITY

Executive Director pursuant to § 43-1-105, C.R.S.

23 USC § 109 (b)(c)(n)(o) and (p)

23 C.F.R. 630.1006

Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD) of the latest and approved edition and the Colorado Supplemental thereto and Section 42-4-104, of Colorado Revised Statutes,

23 USC, 109(d), 315 and 402(a), 23 CFR 1.48(b).

DOT's Region Lane Closure Strategies CDOT Flagger Training Manual
Traffic Controls for Highway Construction, Standard Plan No. S-630-1

Work Zone Safety and Mobility Procedures (CDOT) (Revised March

2018) Procedural Directive 1502.2 “Temporary Reduction in Speed

Limits”

Form 568 "CDOT Temporary Speed Limit Reduction"

PD 1502.1 Reference Table (attached) (based on the MUTCD)

CDOT Procedural Directive 51.1 “Requirements for the Retention of Documents”

CDOT Record File Plans: Traffic Engineering and Maintenance

III. APPLICABILITY

This Procedural Directive shall apply to all CDOT employees. It shall also apply to contractors, consultants, and those permitted by CDOT to plan, design, install, and maintain temporary traffic control work zones.

IV. DEFINITIONS

“Emergency Roadway Situation” is defined as a serious, unexpected, and potentially dangerous situation discovered by one or more employees that poses an immediate threat to the employee(s) and/or the traveling public. Although CDOT has action plans that detail mitigation of many situations, CDOT's policies, procedures, training or resources may not address every possible situation or specific circumstance that may occur. Examples include: vehicle crash, vehicle fire, stalled vehicle, wildfire, flash flood, civilian in distress (medical), sinkhole, and hazardous material event.

“Flagging” is defined as the necessary act of directing traffic through a work zone when an unknown condition is presented to both vehicle and pedestrian traffic. Flagging is dependent on the presence of unexpected stop or slow conditions. Flagging is required at locations where unexpected stops may be required and optional where unexpected slowing may occur. The most common situations where flagging is appropriate is during one-lane operation on a two lane facility, allowing for the ingress/egress of construction vehicles into the work zone, and detours. Flagging operations shall not override regulatory signing or traffic signals. Flagging is not permitted on interstates unless otherwise approved by the Region Traffic Engineer.

“Prepared Employee” is defined as a CDOT employee who has successfully completed formal training or education on traffic control practices, personal protective equipment (PPE) use, work zone safety processes, CDOT roadway construction practices, incident command (NIMS) and/or emergency operations. In addition to the aforementioned training, to be considered a Prepared Employee, the proper traffic control equipment, vehicle warning lights, tools and proper PPE must also be immediately available to the employee at the time of planned, emergency, or Unplanned Work.

“Unplanned Work” is defined as a situation that is discovered by one or more employees that was not part of the planned work for the day that poses a significant risk to the traveling public without immediate CDOT intervention. CDOT has formal or prescribed training and resources to mitigate these situations. Examples include: road debris, avalanche, animal carcass removal, and small diameter rockfall.

“Unprepared Employee” is defined as a CDOT employee who has not received any formal training or education on traffic control practices, PPE use, work zone safety processes, CDOT

roadway construction practices, incident command (NIMS) and emergency operations. An employee is also considered unprepared if they do not have immediate access to the proper traffic control equipment, vehicle warning lights, tools and proper PPE to mitigate the emergency or Unplanned Work with the least amount of risk to the employee.

"Work Zone" is defined as the area where maintenance, repair, engineering, survey or construction activities are occurring that include temporary traffic control. See 24-4-614(1),
It extends from the first warning sign or flashing lights on a vehicle to the "End of Road Work" sign or the last traffic control device. A work zone may be for short or long durations and may include stationary or moving activities. Work Zone may also be referred to as Temporary Traffic Control (See Part 6 of the MUTCD).
(Definition of "Work Zone" continued below)

CDOT adheres to the MUTCD but sees it as containing minimum requirements. The mobile work zone set forth in the MUTCD required clarification. In order to provide added safety, statewide consistency and clear direction, CDOT has revised the definitions of work duration from the definitions in the MUTCD, and for CDOT work will be defined as follows:

- "Long-Term Stationary Work" means planned work activities that occupy a location within the traveled way or within CDOT's right-of-way for more than three (3) days.

- "Intermediate-term Stationary Work" means planned work activities that occupy a location within the traveled way or within CDOT's right-of-way for more than a single work shift of no more than twelve (12) hours, but for no more than three (3) days.

- "Short-Term Stationary Work" means planned work activities that occupy a location within the traveled way or within CDOT's right-of-way for a single work shift of no more than twelve (12) hours. Most maintenance and utility operations are Short-Term Stationary Work.

- "Short Duration Planned Work" means planned work activities that occupy a location within the traveled way or within CDOT's right-of-way for no more than sixty (60) minutes and may include work activities that move intermittently.

- "Mobile work" means planned work activities in which workers and equipment move along the traveled way or within CDOT's right-of-way continuously without stopping, usually at slow speeds.

- "Unplanned Work and Emergency Roadway Situations" means a serious, unexpected, and potentially dangerous situation discovered by one or more employees that poses an immediate threat to the employee(s) and/or the traveling public. See pages 9-13 for procedures on how to handle these situations.

Work Duration	MUTCD Definition	This PD Definition
Long-Term Stationary	More than three (3) days	More than three (3) days
Intermediate-Term Stationary	One daylight period up to three (3) days, or nighttime work lasting more than one (1) hour	More than one work shift (of twelve hours) but no more than three days
Short-Term Stationary	More than one (1) hour within a single daylight period	A single work shift of no more than twelve (12) hours
Short Duration Planned	Up to one (1) hour	Up to one (1) hour
Mobile	Moves intermittently or continuously	Moves continually
Unplanned and Emergency	Not defined	A serious, unexpected, and potentially dangerous situation that poses an immediate threat to the employee(s) and/or the traveling public

V. PROCEDURES

A. Governing Documents and Requirements

1. All temporary traffic control devices shall conform to the applicable sections of the latest edition of the Manual on Uniform Traffic Control Devices ("MUTCD"), the Colorado Supplement thereto, the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction and the M&S Standards.

2. Work Zones will be monitored for proper operation and to identify and analyze traffic crashes or conflicts. Nothing in this Procedural Directive shall be construed to relieve the responsibility of proper monitoring of traffic crashes and Work Zone safety issues by all parties present.

3. Methods of Handling Traffic (MHT) shall adhere to the most current version of the MUTCD, and the Colorado Supplement thereto, the CDOT Standard Specifications for Road and Bridge Construction, and CDOT M&S Standards, and shall adhere to the appropriate Region Lane Closure Strategy unless a variance is granted through the lane closure strategy process.

4. All Work Zones shall adhere to the provisions of section 630.13 of the Standard Specifications for Road and Bridge Construction regarding removal of signs when conditions no longer require traffic control devices.

5. Maintenance deviations from the examples given in the MUTCD or the CDOT M&S Standards shall be reviewed and approved by the LTC OPS I or higher. Deviations on

engineering activities shall be reviewed and approved by CDOT Project Engineer or personnel's supervisor before implementation.

6. If a Work Zone situation does not provide sufficient room to provide full compliance traffic control, the LTC Ops I or higher, or the Project Engineer shall develop a variance containing a justification to be submitted to the Region Traffic Engineer for review before being implemented. If Work Zone delineation cannot be provided due to the narrow road width, the LTC Ops I or higher or the Project Engineer shall document other means to supplement the lack of Work Zone delineation in the submitted justification.

7. Documentation, including the Form 568, shall be retained according to the CDOT Record File Plans and CDOT's Procedural Directives 51.1 and 21.1. The CDOT Records Management Program shall work with the Division of Highway Maintenance and the Mobility Operations Division to ensure proper retention of records.

8. As a standard practice, local law enforcement or the Colorado State Patrol shall be notified when a speed reduction is in place. When deemed necessary to increase safety and motorist compliance, their presence can be requested within the Work Zone area.

B. Planned Traffic Control Work

1. Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. For each category, see PD 1502.1 Reference Table (Attachment A) detailing the appropriate Temporary Traffic Control devices. The considerations for each of the five categories of work duration are as follows:

a) Long-Term Stationary Work Zone (more than three (3) days)**:**

(i) Includes ample time to install and realize benefits from the full range of traffic control procedures and devices that are available for use.

(ii) Generally, larger channelizing devices should be used, as they have more retroreflective material and offer better nighttime visibility. Larger devices are also less likely to be displaced or tipped over -- an important consideration during those periods when the work crew is not present.

(iii) As long-term operations extend into nighttime, retroreflective and/or illuminated devices are required as specified in the MUTCD. Temporary roadways and barrier should be provided as needed, and inappropriate markings should be removed and replaced with temporary markings as needed.

(iv) Examples of Long-Term Stationary Work include: large obstructions or major damage to pavement, paving, reconstruction, major bridge repair, chip seals, and catastrophic avalanche response requiring road closure.

b) Intermediate-Term Stationary Work Zone (more than one (1) work shift but no more than three (3) days)**:**

(i) The work crew may not be present at all times and may not be able to monitor the temporary traffic control zone. During times when the work crew is not present, an individual who is knowledgeable in the principles of temporary traffic control shall be assigned to check that all temporary traffic control devices are effective and consistent with the MHT. The frequency of these inspections shall be agreed to by the LTC Ops I or higher, or CDOT Project Engineer, but shall generally be every three (3) hours.

(ii) During Intermediate-Term Stationary Work, it may not be feasible or practical to use procedures or devices that would be desirable for long-term stationary temporary traffic control zones such as altered pavement markings, barriers, and temporary roadways.

(iii) Lighting and/or retroreflective devices should be chosen to accommodate varying seasonal, climatic, and visibility situations.

(iv) When practical to do so, conflicting pavement markings should be removed to avoid confusion when channelizing devices are displaced. Temporary pavement markings can be installed, if needed. Channelization shall be made dominant by using a very close device spacing where it is not feasible to remove conflicting markings and install temporary markings. Full-compliance pavement markings are not required until work is completed.

(v) Examples of Intermediate-Term Stationary Work include: minor bridge repair or culvert repair.

c) Short-Term Stationary Work Zone (a single work shift of no more than twelve **hours):**

(i) The work crew is present to maintain and monitor the temporary traffic control zone.

(ii) Lighting and/or retroreflective devices should be chosen to accommodate varying seasonal, climatic, and visibility situations.

(iii) During Short-Term Stationary Work, it may not be feasible or practical to use procedures or devices that would be desirable for long-term stationary temporary traffic control zones such as altered pavement markings, barriers, and temporary roadways.

(iv) Examples of Short-Term Stationary Work include: pothole repair patching with hot mix, repair/replacement/installation of Class I, II or III signs and delineators, utility work, and overhead structure installation.

d) Short Duration Planned Work Zone (no more than sixty (60) minutes):

(i) Traffic control measures that are more closely targeted to the actual work area may be warranted for short-duration work. The type of traffic control will depend greatly on the work location and work duration. A high-intensity light bar or strobe package shall be used on the vehicle for all work operations, while mobile attenuators and a MHT may be required based upon the Work Location. The intent of creating a MHT is to require employees to become more aware of potential safety concerns based upon conditions in the field which are site specific. It is important to note that while following the MHT requirements found in Section 630.10 of CDOT's Standard Specifications for Road and Bridge Construction, some subsections may not be required. In all situations, personnel shall be aware of their surroundings, park as far off of the travel lane as possible, and, if need be, utilize their work vehicle to aid in the protection, noting that work shall not be performed directly in front of the vehicle.

(ii) Examples of Short Duration Work include: bridge inspection, pavement sampling, field inspections, culvert measuring, surveying, minor pothole repair, cold mix, patching, repair or replacement of single post signs, clean-up of debris outside of travel lane, and changing a LED traffic signal.

e) Mobile Work Zone (moving continuously):

(i) Work is continuously moving and workers typically remain inside the vehicle while in the traveled way and clear zone.

(ii) Items marked as optional in Cases 34 through 39 of the S Standards are required for all CDOT projects unless approval is obtained by the LTC Ops I or higher or the Region Traffic Engineer. Shadow vehicles, without an attenuator, shall not be used in a live lane of traffic; in this case, a mobile attenuator truck shall be used. A mobile attenuator truck (a/k/a truck mounted attenuator or TMA) must be rated for the posted speed if used in the traveled way. A trailer mounted attenuator shall not be used in a mobile operation nor in a live lane of traffic unless approval is obtained by the LTC Ops I or higher or the Region Traffic Engineer. On interstates, mobile attenuators are required for mobile operations, work in lanes and shoulder work within fifteen (15) feet of the traveled lane.

(iii) Examples of Mobile Work include: pavement sweeping, pavement marking, mowing, roadside clean-up, and chemical machine spraying of vegetation areas.

f) **For Unplanned Work and Emergency Roadside Situations:** See below at pp. 9-13.

C. Devices and Equipment

1. The following devices are the minimum measures for each planned traffic control situation. Additional safety devices, if available and applicable, should be used as a supplement to these devices. Note that work within the median may require traffic control for both directions of traffic. Work in an intersection or interchange may also require additional traffic control. *See Attachment A, the MUTCD, and Standard S-630-1 for signing and equipment requirements as Typical Applications are unique*.

2. Based upon equipment availability, the Shadow Vehicle and Signage listed in Typical Applications 34-39 can be combined to facilitate the work.

3. The Application Vehicle is often referred to as an employee's work vehicle in the field, these terms are interchangeable. When an Application Vehicle is not accompanied by a Mobile Attenuator, the Application Vehicle shall be placed as far from edge-of-roadway as possible.

4. All light fleet vehicles being used for traffic control shall display high-intensity rotating, flashing, oscillating or strobe lights at all times during the work duration.

5. Based upon equipment availability, Signing, Shadow, Cone Pickup, Cone Placement, and Application Vehicles should include an attenuator on the vehicle.

6. Local traffic signals and non-CDOT signage cannot be used as a method of controlling traffic.

7. Use of temporary traffic signals shall be reviewed and approved by the Region Traffic Engineer. While typically addressed in the design phase, if, during construction, a temporary traffic signal is proposed, it must be approved by the Region Traffic Engineer in case there are possible impacts to safety and operations.

D. Full Road Closure

1. A full road closure is a divided highway or interstate closed in one or both directions, or an undivided highway closed in both directions.

2. The LTC Ops I or higher or CDOT Project Engineer shall submit a request to the Region Traffic Engineer for their approval prior to any full closure.

3. The request shall include at a minimum: reason for the need to close the entire roadway, location and duration of planned closure, detour route and supporting MHT around closure, impacts to local communities identified and discussed with impacted communities.

4. Final approval is contingent upon preparation of a complete road closure package with the identified elements addressed in the package.

E. Unplanned Work & Emergency Roadway Situations

1. The following procedures include Unplanned and Emergency Roadway Situations wherein work must be performed immediately for the safety of the travelling public.

2. Unplanned and Emergency situations may pose severe and unpredictable hazards to employees. In this case, the ability to install proper traffic control may be greatly reduced, and any CDOT devices on hand may be used for the initial response as long as they do not themselves create unnecessary additional hazards. If the situation is prolonged, standard procedures and devices for planned work-duration events and road closures shall be established as soon as practical.

3. This Directive does not apply to the actions of a CDOT employee in a personal vehicle who is not on CDOT time, when acting in their private capacity. There is no expectation that employees take any action when off-duty or traveling in a private capacity.

4. Examples of Unplanned Work include debris in the travel lane, small diameter rock fall, avalanche, and animal carcass removal.

5. Examples of Emergency Work include: vehicle crash, vehicle fire, stalled vehicle, wildfire, flash flood, civilian in distress (medical), sinkhole, and hazardous materials events.

F. Employee Work Procedures for Unplanned Work & Emergency Roadway Situations

1. Directions for all CDOT Employees

g) There is no expectation that employees shall take action or place themselves in an unsafe environment to mitigate any unplanned or emergency situations they discover. Unprepared Employees shall not attempt to personally mitigate unplanned or emergency situations.

h) Employees shall perform a pre-job hazard assessment to determine if they are prepared or unprepared to mitigate the Emergency Roadway Situation or Unplanned Work (see Attachment B). When determining preparedness levels, all employees shall prioritize their risk of injury or death in this order: 1) personal safety; 2) the safety of my work peers; and 3) the safety of the traveling public/civilians.

i) All employees (Prepared and Unprepared) shall attempt to communicate the location and any known details of the situation by contacting local emergency services (911) or CDOT dispatch.

2. Unprepared CDOT Employees shall:

a) Use the resources available to them to provide basic traffic notification and control but shall in no way put themselves in a position that increases the likelihood of personal or civilian injury or inflating the severity of the incident.

b) While in a CDOT vehicle equipped with a high-intensity light bar or strobe package (not including the vehicle's standard hazard lights), move to a safe location and provide warning notification to traffic until the necessary resources arrive to mitigate the situation.

c) Position their vehicle in such a way to provide both high visibility of the vehicle and adequate notification of the situation to oncoming traffic.

d) Remain in the vehicle if possible until adequate resources arrive unless doing so poses an imminent life threat.

e) Only exit the vehicle if they have a CDOT-approved, ANSI 107 Type III vest and headwear.

3. Prepared CDOT Employees shall:

a) Determine the method of response and the amount of temporary traffic control necessary to isolate the work area from oncoming traffic.

b) Not override traffic signals; by law, only law enforcement is authorized to direct traffic at active traffic signals. Flaggers shall not be used when a signal is active.

c) Vary the response depending on the preparedness level of the employee, the traffic volume and the extent and urgency of the incident.

d) Assess the current traffic volume, density and speed when determining if they can provide adequate notification to oncoming traffic of the situation as well as positive protection while working in the roadway. Such assessment includes:

(i) Having adequate lighting, line-of-sight visibility, traffic control and notification methods before blocking a lane of traffic.

(ii) Temporarily blocking the road with a CDOT vehicle equipped with oscillating/flashing lights if this is the best way to provide protection to employees and the traveling public.

(iii) Blocking the road on the other side of the incident location through established communication protocols.

(iv) Taking into account roadway and weather conditions.

e) When possible, use a spotter posted in a safe place to provide early warning of possible traffic encroachment into the Work Zone.

f) Make reasonable efforts to mitigate the hazard with the least amount of impact to normal traffic patterns without increased risk of injury to themselves.

G. Protocol for Positive Protection During Short-Term, Unplanned and Emergency Events

1. Response and Communications Protocol

a) Unlike planned work, unplanned and emergency events are handled in real-time. Traffic engineers and/or senior foremen (LTC Ops) should be informed of unplanned and emergency incidents upon detection.

b) As the duration and severity of an unplanned or emergency event escalates, CDOT responders shall begin to adhere to the guidelines for planned work outlined this PD.

c) In areas with CDOT Traffic Incident Management (TIM) coverage, available TIM responders should also be notified when relevant. TIM responders work with the Colorado State Patrol (CSP) and local agencies and can bring additional resources where needed.

2. Required Positive Protection for Short-Term, Unplanned and Emergency Events

a) Purpose: This section provides guidance on where and how positive protection is typically used for unplanned and emergency activities.

b) Positive Protection: For the purposes of Short-Term Unplanned and Emergency Work, positive protection is defined as equipment which contains and redirects vehicles, preventing their intrusion into the workspace. This equipment may also be used to protect motorists from entering other hazardous areas in a highway Work Zone, such as pavement edge drop-offs, and to shield pedestrians and workers.

c) CDOT-approved positive protection equipment available to enhance worker and motorist safety in unplanned and emergency work areas includes, but is not limited to: shadow vehicles (including those with truck-mounted attenuators and/or mobile barriers that prevent road users from entering a closed section of roadway), ballast-filled barriers (also known as Triton barriers). These various configurations of shadow vehicles have unique characteristics and there are different roadwork situations that can benefit from the use of these distinct characteristics.

3. Shadow Vehicles

a) Definition: For the purposes of this protocol, a shadow vehicle is defined as a truck or trailer used to protect workers or work equipment from errant vehicles. Shadow vehicles must be equipped with arrow panel, and/or changeable message

signs, and/or high-intensity rotating, flashing, oscillating, or strobe lights, and must be located in advance of the workers and/or equipment that they are protecting. Shadow vehicles themselves should be equipped with truck-mounted attenuators given that non-attenuator vehicles have an increased chance to cause injuries to occupants of errant vehicles. Truck-mounted attenuators are energy- absorbing devices attached to the rear of the shadow vehicle that are designed to lessen impact severity for occupants of the impacting vehicle and, to some extent, potential occupants of the shadow vehicle.

b) Shadow Vehicle Use: In the case of mobile and constantly moving operations, such as mowing and striping operations, a shadow vehicle, equipped with appropriate lights and warning signs, shall be used to protect the workers from impacts by errant vehicles. Whenever available and possible, the shadow vehicle should be equipped with a rear-mounted impact attenuator. Applications for shadow vehicles in short-term unplanned and emergency events include, but are not limited to, moving or mobile operations, maintenance operations, and other short duration operations. In all cases, they shall be positioned upstream of workers in stationary Work Zones. When used in stationary applications, shadow vehicles shall be positioned in the work space and not in the buffer space.

   Shadow vehicles may be displaced forward by the force of an impacting vehicle – otherwise known as roll-ahead distance. Adequate roll ahead distance shall be provided between the shadow vehicles and the workers or equipment it protects according to the corridor speeds of any particular short-term unplanned and emergency work area.

4. Ballast-Filled (or Triton) Barrier

a) Definition: This type of barrier is defined as “longitudinal barriers of segmented, polyethylene plastic shells (with a steel framework for NCHRP TL3), designed for use with a ballast, that have been successfully crash tested to NCHRP or MASH requirements.” Ballasts may be water (summer application) or deicing liquid (winter application).

b) Ballast-Filled Barrier Use and Considerations: This type of barrier is easier for placement due to lower weight during installation. Empty barrier sections can be placed by hand without the need for heavy lifting equipment, thus permitting its use where the use of heavy equipment may be impractical or impossible. Once the plastic sections are installed, water can then be typically used as ballast to help anchor the barrier.

   Ballast-filled barriers can be used safely only where the expected lateral deflection can be accommodated without conflicting with workers or other potential hazards behind the barrier. Ballast-filled barriers are designed for use in low speed urban areas and to contain vehicles with a weight of 4,000 pounds or

less. These barriers may have large deflection (6 to 25 feet) when impacted. Vehicles can be expected to penetrate completely through ballast-filled barriers.

Another important consideration for this system is the effect of the water ballast when impacted. It may create a hazardous situation in the Work Zone, especially in cold temperatures if displaced water forms ice on the pavement. Further, the means to dispose of the ballast water when the barrier is removed should also be considered. While it may be possible to drain the water onto the ground in many locations, some location may require that the water is pumped out and transported offsite, thus adding to the time and cost to remove the barrier. Additionally, sodium chloride or environmentally friendly antifreeze can be used to keep the water from freezing while inside the barrier. Consequently, environmental guidelines and restrictions should be adhered to when draining barriers.

VI. IMPLEMENTATION PLAN

This Procedural Directive shall apply to all planned projects upon the execution of this Directive. The Procedural Directive shall be implemented by the Division of Highway Maintenance. The Office of Policy and Government Relations shall post this Procedural Directive on CDOT's intranet as well as on public announcements.

Review Date

This Procedural Directive shall be reviewed on or before February 2022.

June 23, 2020

Shoshana M. Lew Date of Approval
Executive Director

Attachment A

PD 1502.1 Reference Table

The procedures may vary based on the characteristics and expected work zone impacts of individual work/projects or classes of work/projects.
Speed reductions shall be requested when appropriate; please see PD 1502.2. If necessary, consult with the Region Traffic Engineer.

All light fleet vehicles shall be equipped with a high-intensity light bar or a strobe light package if being used for traffic control.
Signing, shadow vehicles, traffic cone vehicles and application vehicles should include an attenuator when available.

Work Duration:	**Examples of Planned Work:**	**Work Location: more than 30 feet from travel lane**	**Work Location: between 10 feet and 30 feet from travel lane**	**Work Location: less than 10 feet from the travel lane**	**Work Location: inside travel lane**
Long-term Stationary Planned Work (more than three days)	large obstructions or major damage to pavement paving reconstruction major bridge repair chip seals catastrophic avalanche response requiring road closure	***Advanced Warning*** *(MUTCD TA-1)* flagging, as needed two warning signs, minimum high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Shoulder Closure*** *(S-630-1 Case Nos. 11, 16, 26-27)* flagging, as needed larger channelizing devices retroreflective/ illuminated devices at night temporary roadways and barrier, as needed remove and replace markings, as needed	***Lane Closure*** *(S-630-1 Case Nos. 5-10, 12-14, 17-19, 22-24, 29-33)* flagging (or temp signal), as needed larger channelizing devices retroreflective/ illuminated devices at night temporary roadways and barrier, as needed remove and replace markings, as needed *note: follow CDOT's Region Lane Closure Strategy*	***Full Closure or Lane Closure*** *(S-630-1 Case Nos. 1-10,12-15, 17-25, 28-33)* flagging (or temp signal), as needed larger channelizing devices retroreflective/ illuminated devices at night temporary roadways and barrier, as needed remove and replace markings, as needed *note: follow CDOT's Region Lane Closure Strategy*

Work Duration:	Examples of Planned Work:	Work Location: more than 30 feet from travel lane	Work Location: between 10 feet and 30 feet from travel lane	Work Location: less than 10 feet from the travel lane	Work Location: inside travel lane
Intermediate- term Stationary Planned Work (more than a single work shift, but no more than three days)	minor bridge repair culvert repair	***Advanced Warning*** *(MUTCD TA-1)* flagging, as needed two warning signs, minimum high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Shoulder Closure*** *(S-630-1 Case Nos. 11, 16, 26-27)* flagging, as needed inspect every 3 hours when work crew isn't present retroreflective/ illuminated devices at night remove and replace markings, as needed, or use closely spaced devices	***Lane Closure*** *(S-630-1 Case Nos. 5-10, 12-14, 17-19, 22-24, 29-33)* flagging (or temp signal), as needed inspect every 3 hours when work crew isn't present retroreflective/ illuminated devices at night remove and replace markings, as needed, or use closely spaced devices *note: follow CDOT's Region Lane Closure Strategy*	***Full Closure or Lane Closure*** *(S-630-1 Case Nos. 1-10,12-15, 17-25, 28-33)* flagging (or temp signal), as needed inspect every 3 hours when work crew isn't present retroreflective/ illuminated devices at night remove and replace markings, as needed, or use closely spaced devices *note: follow CDOT's Region Lane Closure Strategy*

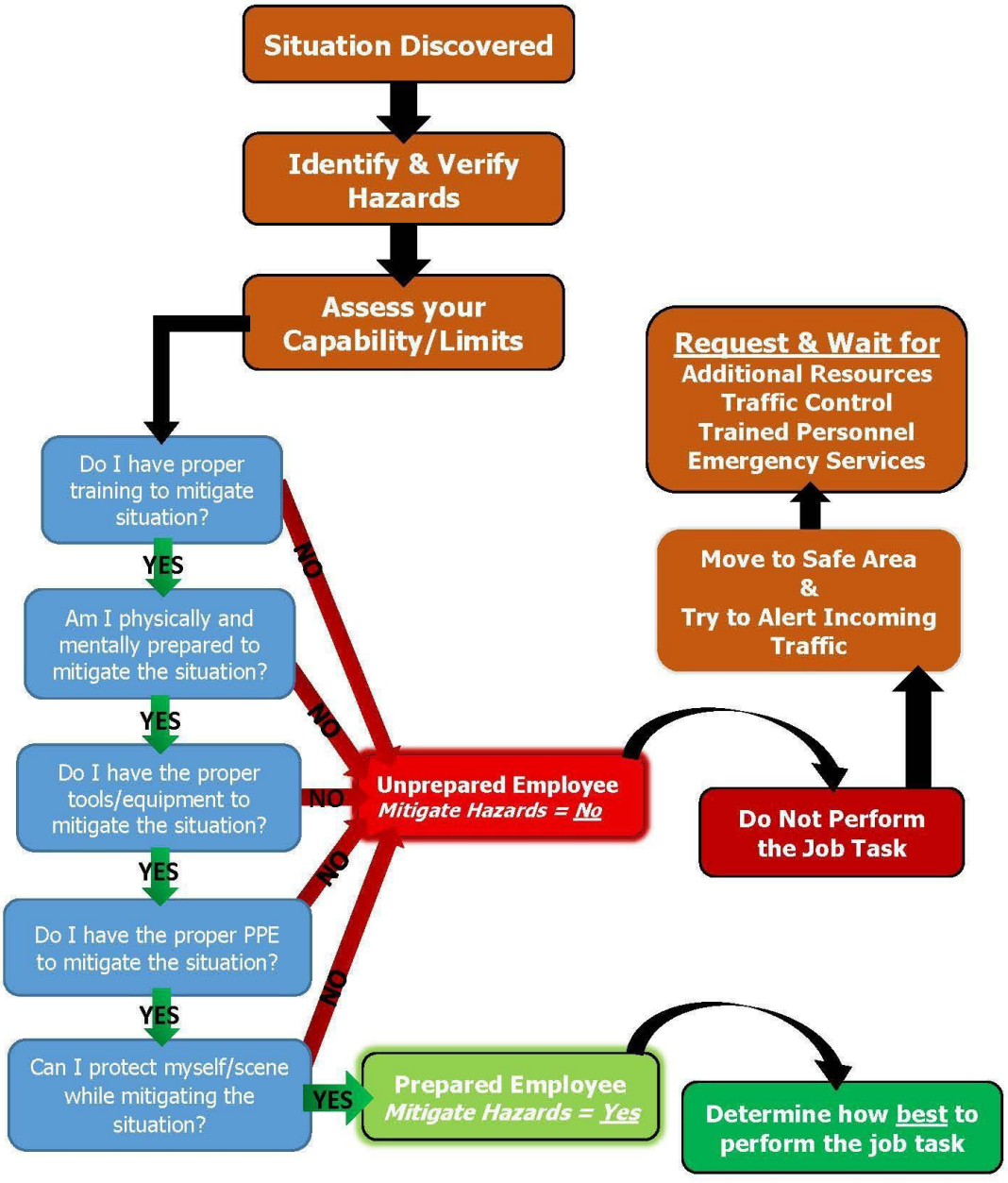
Work Duration:	**Examples of Planned Work:**	**Work Location: more than 30 feet from travel lane**	**Work Location: between 10 feet and 30 feet from travel lane**	**Work Location: less than 10 feet from the travel lane**	**Work Location: inside travel lane**
Short-term Stationary Planned Work (a single work shift of no more than 12 hours)	major pothole repair patching with hot mix repair/ replacement of Class I or II signs and delineators	***Advanced Warning*** *(MUTCD TA-1)* flagging, as needed two warning signs, minimum high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Shoulder Closure*** *(S-630-1 Case Nos. 11, 16, 26-27)* flagging, as needed retroreflective/ illuminated devices at night	***Lane Closure*** *(S-630-1 Case Nos. 5-10, 12-14, 17-19, 22-24, 29-33)* flagging (or temp signal), as needed retroreflective/ illuminated devices at night *note: follow CDOT's Region Lane Closure Strategy*	***Full Closure or Lane Closure*** *(S-630-1 Case Nos. 1-10,12-15, 17-25, 28-33)* flagging (or temp signal), as needed retroreflective/ illuminated devices at night *note: follow CDOT's Region Lane Closure Strategy*
Short Duration Planned Work (no more than 60 minutes)	minor pothole repair patching with cold mix pavement sampling repair or replacement of single post signs clean-up of minor debris in travel lane changing a LED traffic signal	***Advanced Warning*** *(MUTCD TA-1)* high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Temporary Encroachment*** *(MUTCD TA-4)* MHT required and approved by LTC Ops I or higher or Resident Engineer Mobile Attenuator, as needed high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Temporary Encroachment*** *(MUTCD TA-4)* MHT required and approved by LTC Ops I or higher or Resident Engineer Mobile Attenuator, as needed high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Temporary Encroachment*** *(MUTCD TA-4)* MHT required and approved by LTC Ops I or higher or Resident Engineer. Mobile Attenuator high-intensity light bar or strobe package retroreflective/ illuminated devices at night *follow CDOT's Region Lane Closure Strategy*

Work Duration:	Examples of Planned Work:	Work Location: more than 30 feet from travel lane	Work Location: between 10 feet and 30 feet from travel lane	Work Location: less than 10 feet from the travel lane	Work Location: inside travel lane
Mobile Planned Work (moving continuously)	pavement sweeping pavement marking mowing roadside clean-up chemical machine spraying of vegetation areas	***Advanced Warning*** *(MUTCD TA-1)* two warning signs, minimum high-intensity light bar or strobe package retroreflective/ illuminated devices at night	***Mobile*** *(S-630-1 Case Nos. 34- 39)* S-standard items marked "optional" are required unless otherwise approved no shadow vehicles in live lanes or within 15 feet of lane on interstates, use TMA retroreflective/ illuminated devices at night	***Mobile*** *(S-630-1 Case Nos. 34-39)* S-standard items marked "optional" are required unless otherwise approved no shadow vehicles in live lanes or within 15 feet of lane on interstates, use TMA retroreflective/ illuminated devices at night	***Mobile*** *(S-630-1 Case Nos. 34-39)* S-standard items marked "optional" are required unless otherwise approved no shadow vehicles in live lanes or within 15 feet of lane on interstates, use TMA retroreflective/ illuminated devices at night *note: follow CDOT's Region Lane Closure Strategy*

Attachment B

Unplanned Work & Emergency Roadway Situations

Pre-Job Hazard Assessment Workflow



Attachment C

Examples of Truck-Mounted Attenuator & Mobile Barrier

Truck-Mounted Attenuator

Mobile Barrier

Appendix B

2.2.1 Figures 2-1 through 2-16 Hardbound field book example

Below are guidelines for hard bound fieldbooks retained by the PLS is Responsible Charge of the work within;
If hardbound fieldbooks are used, the formatting shall be discussed and agreed upon during the Pre-survey Preliminary survey meeting and contained in the Project Scope of Services.

Templates for hardbound set up is as follows:

1. Contact information shall be contained immediately inside of the book's front cover stating the CDOT region, region address, Region Survey Coordinator and phone number. If the book is for a contract consultant survey the consultant information shall also be included for the consultant company name, address and phone number. If the book is lost, the finder will then know whom to contact to return it to. This also provides CDOT with an immediate record for consultant contact information for cataloging and records research. (See Figure 2-1)

2. All pages in a book shall be numbered before the work begins. Only the right-hand pages in the upper right-hand corner shall be numbered. (Figure 2-1 through 2-16)

3. Page 1 shall contain the title page showing the following (See Figure 2-2):

    a) CDOT Project Number
    b) CDOT Project Code
    c) State highway number and highway and mile post
    d) Location
    e) County
    f) Type of field book
    g) Units of measurement (International survey feet or US survey feet)
    h) Starting and ending dates of the survey
    i) State of Colorado Map Number (such as F-17 for the location of Colorado's State Capital building)

4. Page 2 shall contain a roster of the persons who worked on the survey along with their titles and initials. (See Figure 2-3)

5. Page 3 shall contain an index of all the project fieldbooks denoting the general kind of notes contained in each book for the survey elements for each particular portion of the survey (See Figure 2-4)

6. Pages 4 through 7 shall contain a table of contents for the book along with the appropriate page numbers. The table of contents should be kept current daily. (See Figure 2-5 through 2-8)

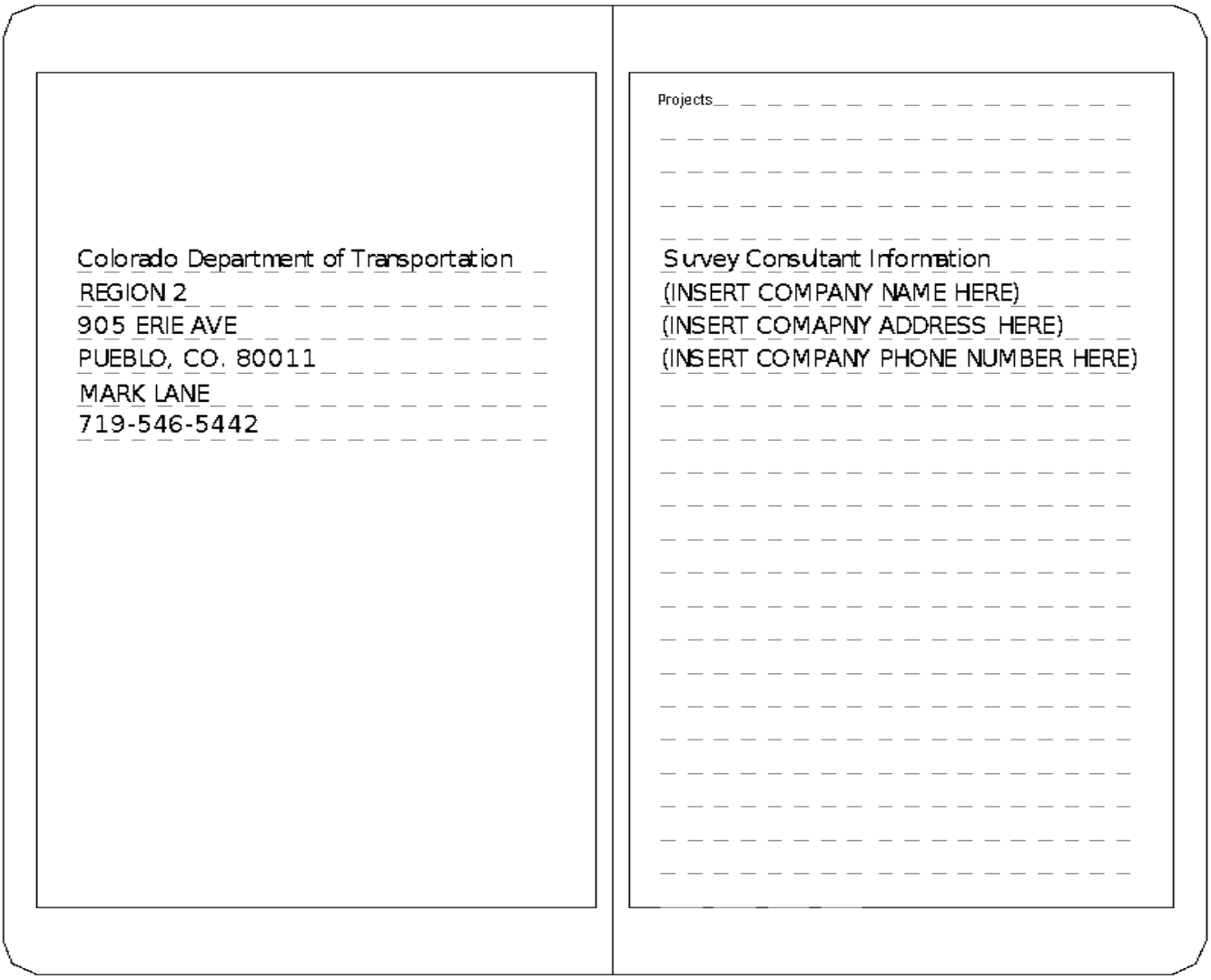
7. Pages 8 and 9 shall be reserved for general explanations or other remarks. If no other remarks are made the pages should remain blank except for the remarks title at the top of the page. (See Figure 2-9 through 2-10)

8. Page 10 through 13 shall be reserved for the survey equipment and instrument identification used to perform the survey such as brand, model and serial number along with statements of certification that the instruments, tribrachs, tripods and any other surveying equipment have been

successfully checked against a calibrated baseline and regularly checked, maintained and adjusted in accordance with this manual. (See Figure 2-11 through 2-2-14)

9. Pages 14 shall be reserved for the Surveyor's Certification statement as to the accuracies of the survey. This is to be accompanied by the professional land surveyors seal and original signature of the surveyor in responsible charge. (See Figure 2-15)

10. Page 15 is the first page for the recording of the actual survey field notes. (See Figure 2-16)



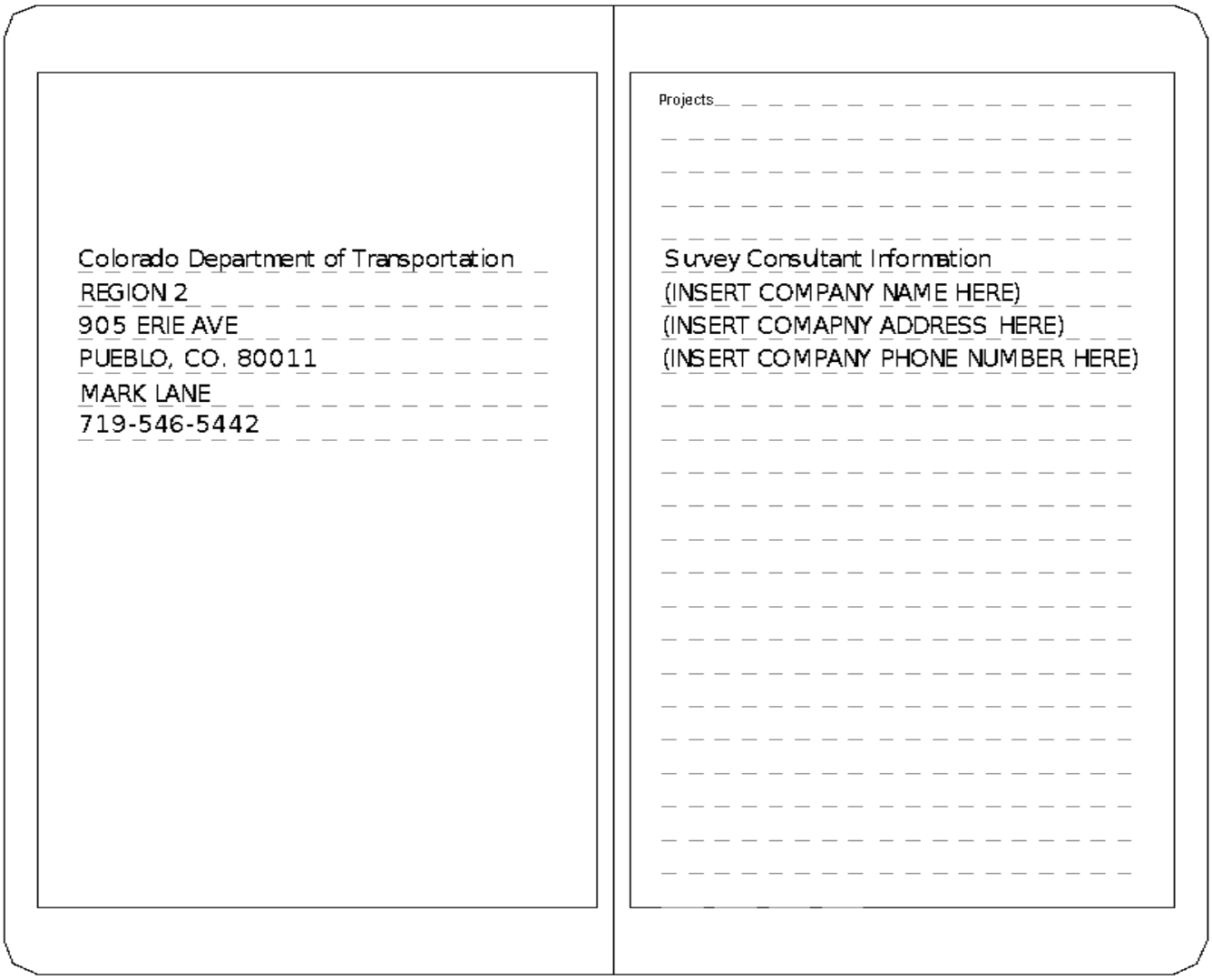

Colorado Department of Transportation
REGION 2
905 ERIE AVE
PUEBLO, CO. 80011
MARK LANE
719-546-5442
Projects
Survey Consultant Information
(INSERT COMPANY NAME HERE)
(INSERT COMAPNY ADDRESS HERE)
(INSERT COMPANY PHONE NUMBER HERE)

Figure 2 – 1

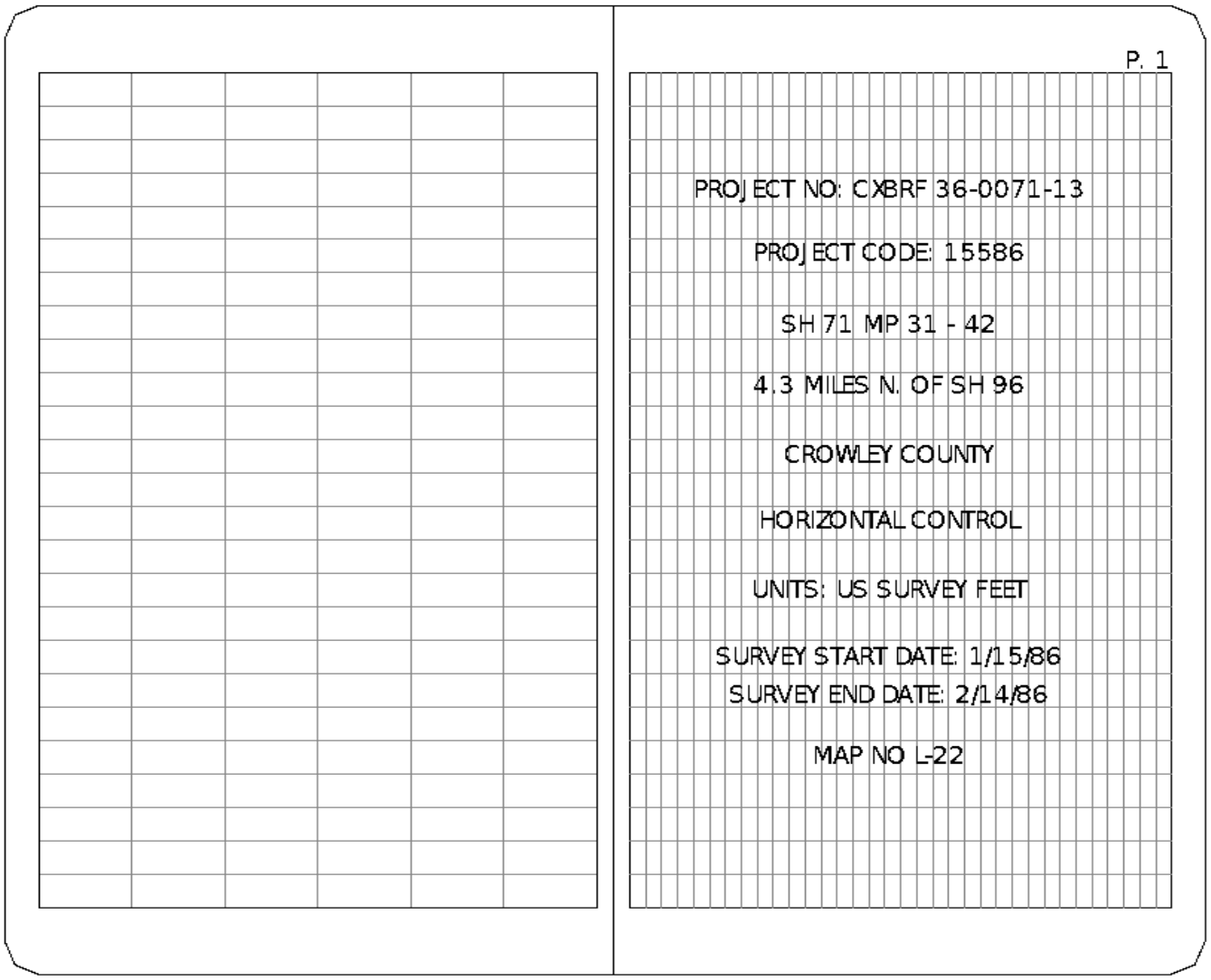

P. 1
PROJECT NO: CXBRF 36-0071-13
PROJECT CODE: 15586
SH 71 MP 31 - 42
4.3 MILES N. OF SH 96
CROWLEY COUNTY
HORIZONTAL CONTROL
UNITS: US SURVEY FEET
SURVEY START DATE: 1/15/86
SURVEY END DATE: 2/14/86
MAP NO L-22

Figure 2 – 2

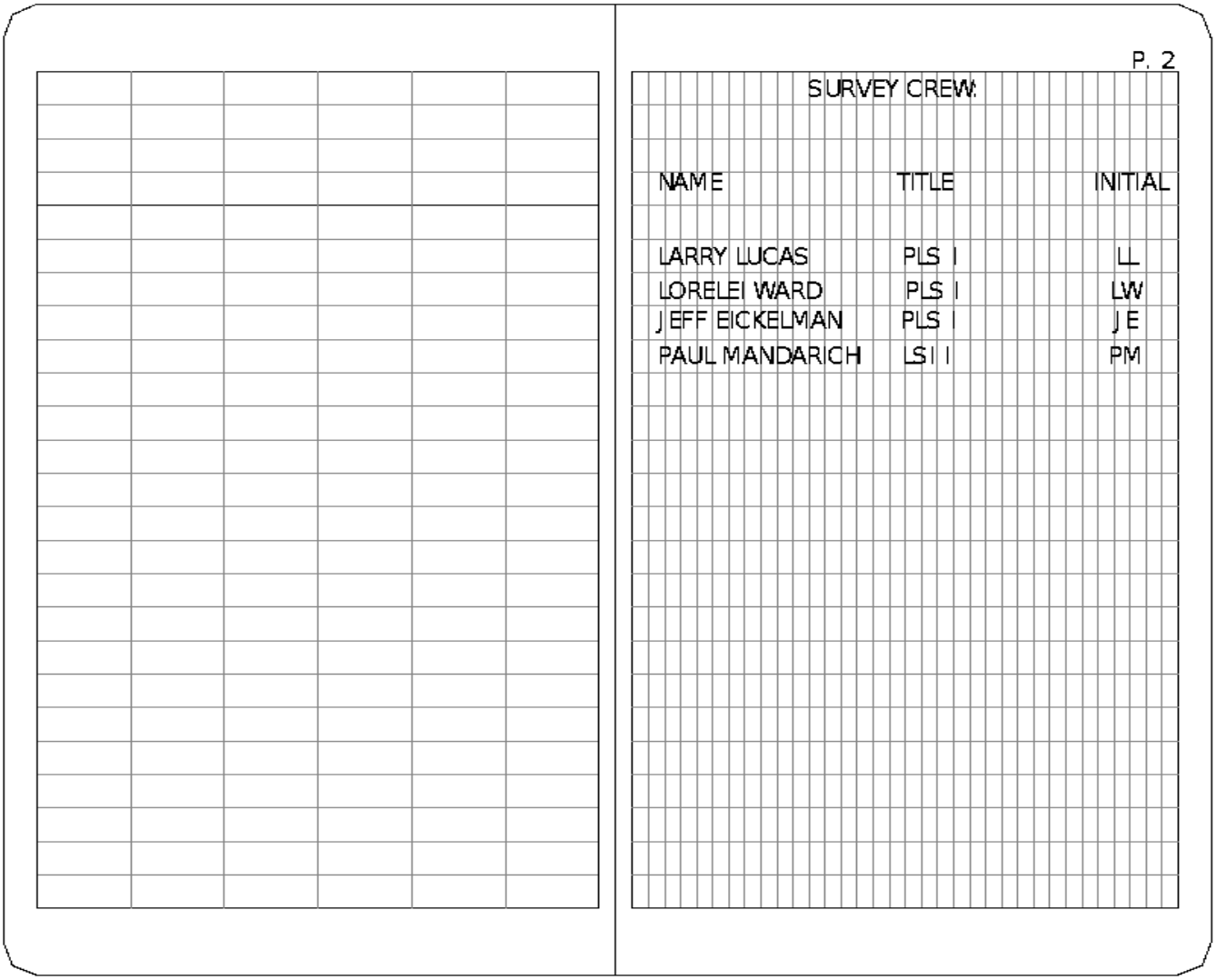

P. 2
SURVEY CREW:
NAME
TITLE
INITIAL
LARRY LUCAS
PLS I
LL
LORELEI WARD
PLS I
LW
JEFF EICKELMAN
PLS I
JE
PAUL MANDARICH
LSI I
PM

Figure 2 – 3

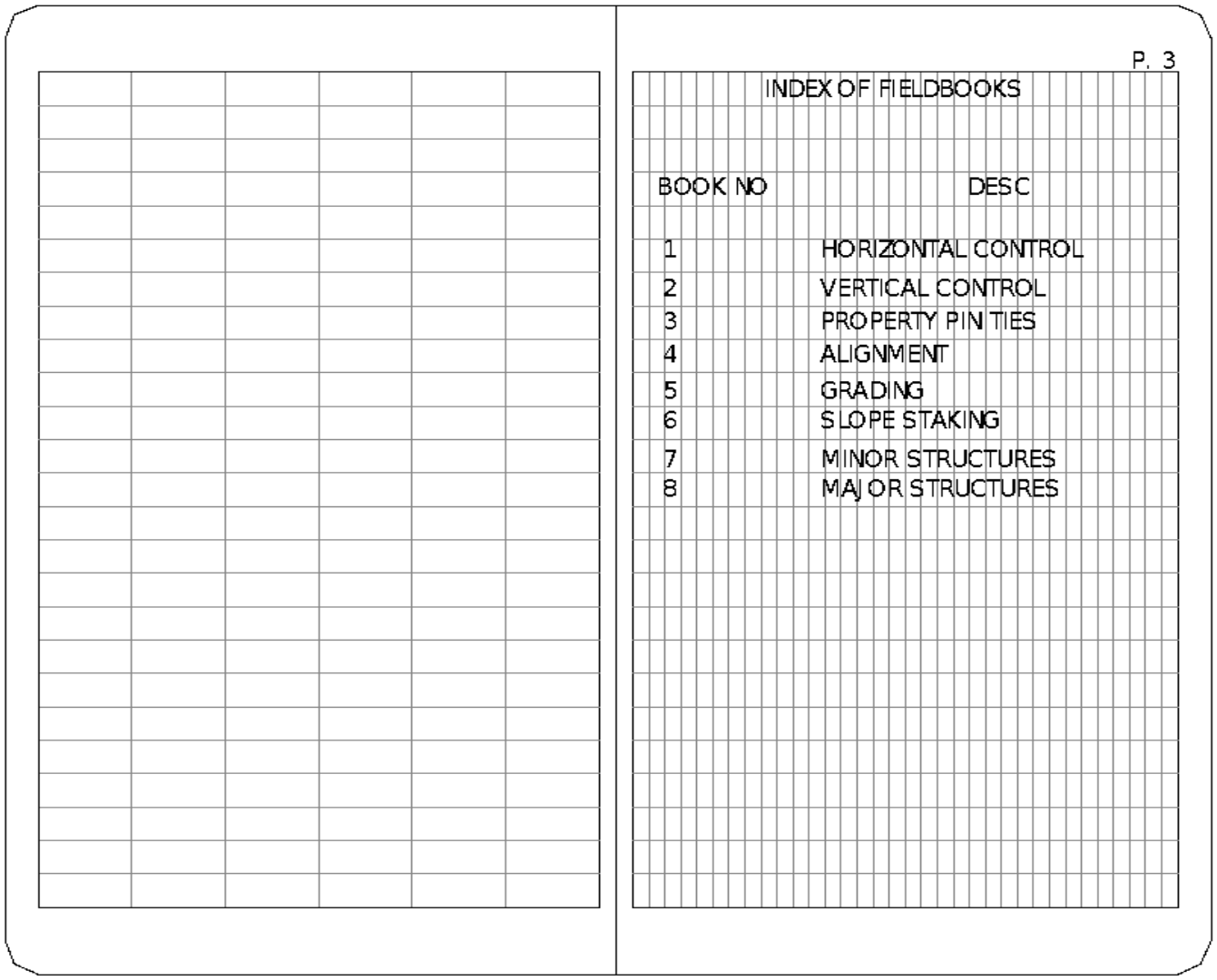

P. 3
INDEX OF FIELDBOOKS
BOOK NO
DESC
1
HORIZONTAL CONTROL
2
VERTICAL CONTROL
3
PROPERTY PIN TIES
4
ALIGNMENT
5
GRADING
6
SLOPE STAKING
7
MINOR STRUCTURES
8
MAJOR STRUCTURES

Figure 2 – 4

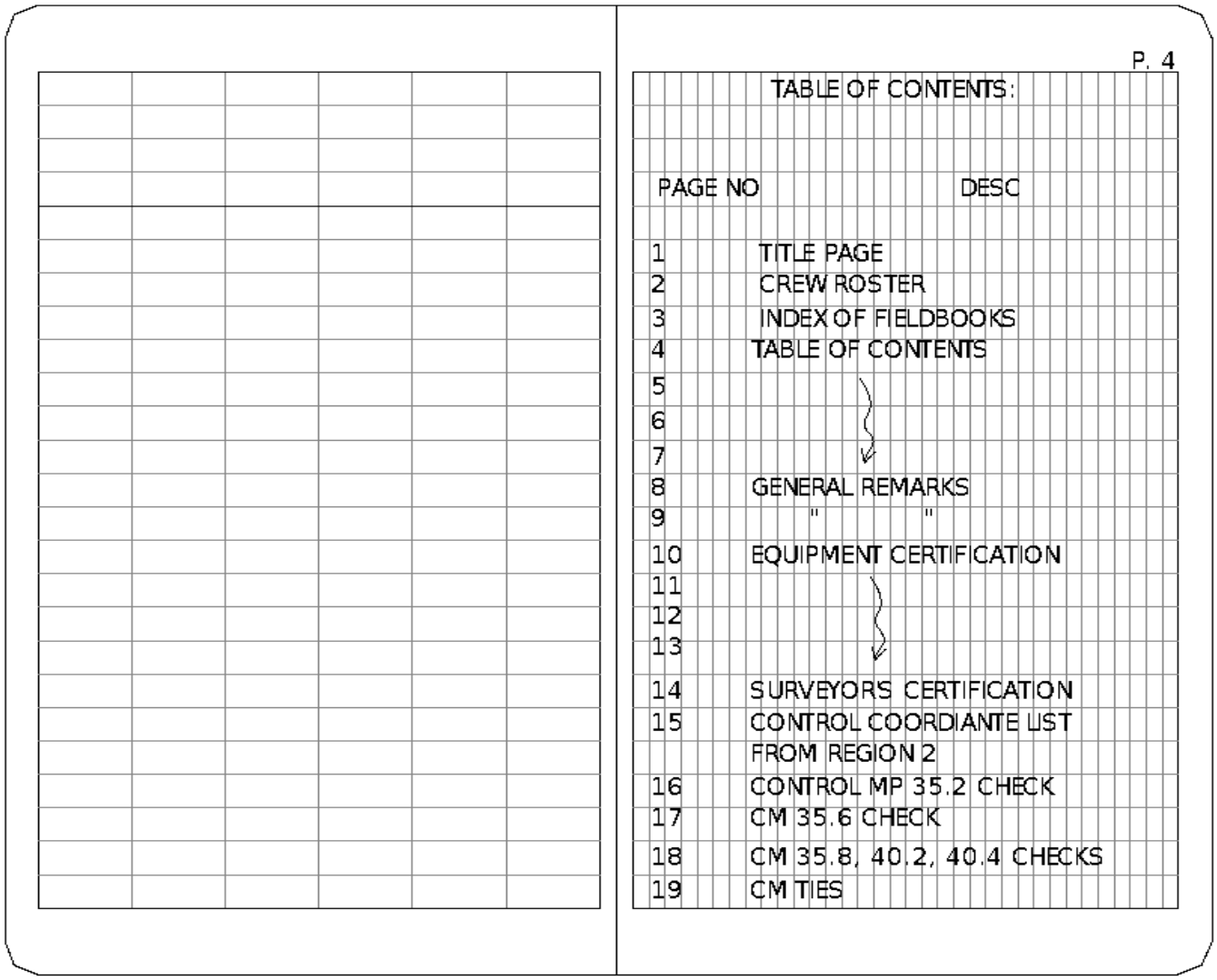

P. 4
TABLE OF CONTENTS:
PAGE NO
DESC
1 TITLE PAGE
2 CREW ROSTER
3 INDEX OF FIELDBOOKS
4 TABLE OF CONTENTS
8 GENERAL REMARKS
9 " "
10 EQUIPMENT CERTIFICATION
14 SURVEYORS CERTIFICATION
15 CONTROL COORDIANTE LIST
FROM REGION 2
16 CONTROL MP 35.2 CHECK
17 CM 35.6 CHECK
18 CM 35.8, 40.2, 40.4 CHECKS
19 CM TIES

Figure 2 – 5

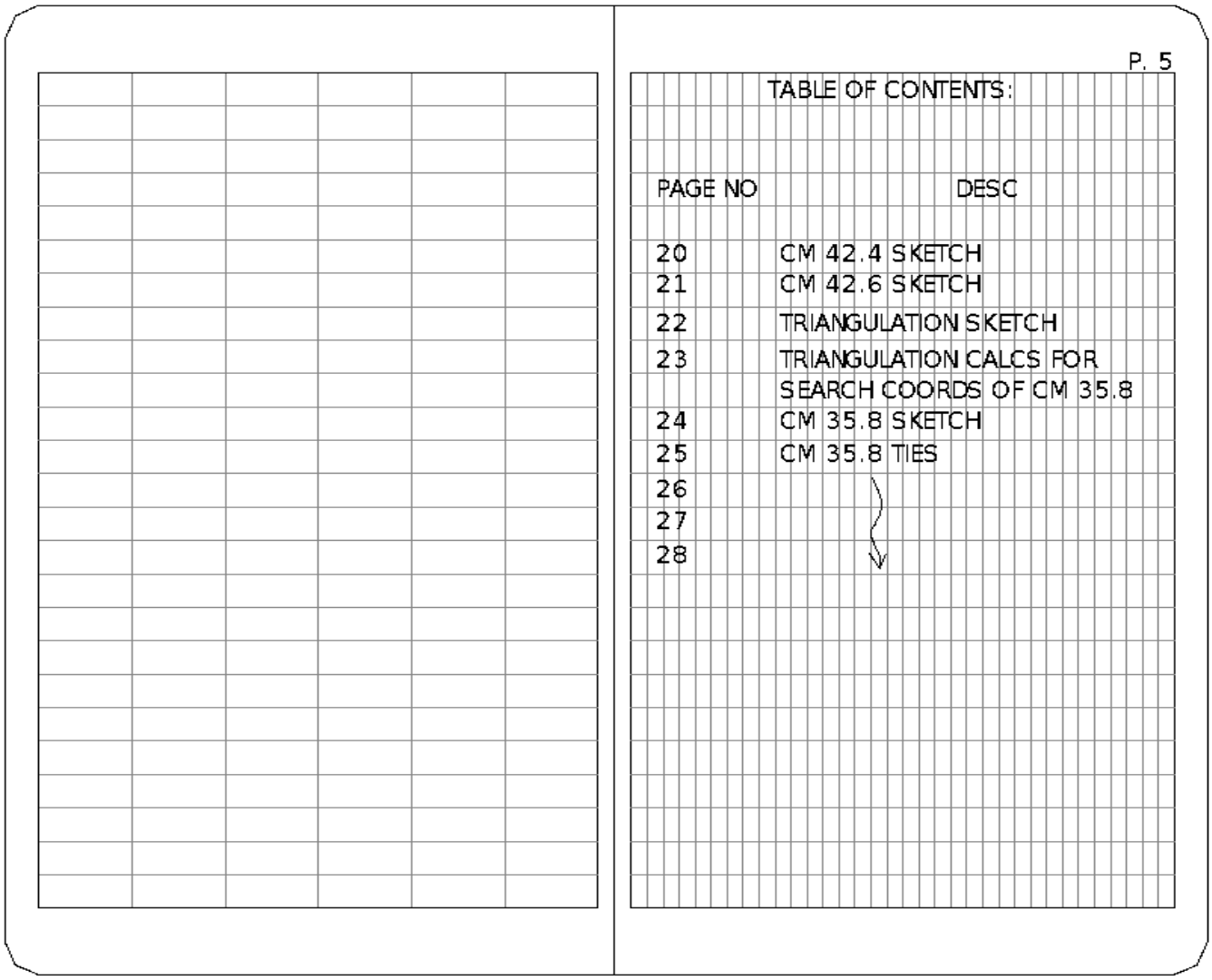

P. 5
TABLE OF CONTENTS:
PAGE NO
DESC
20
CM 42.4 SKETCH
21
CM 42.6 SKETCH
22
TRIANGULATION SKETCH
23
TRIANGULATION CALCS FOR
SEARCH COORDS OF CM 35.8
24
CM 35.8 SKETCH
25
CM 35.8 TIES
26
27
28

Figure 2 – 6

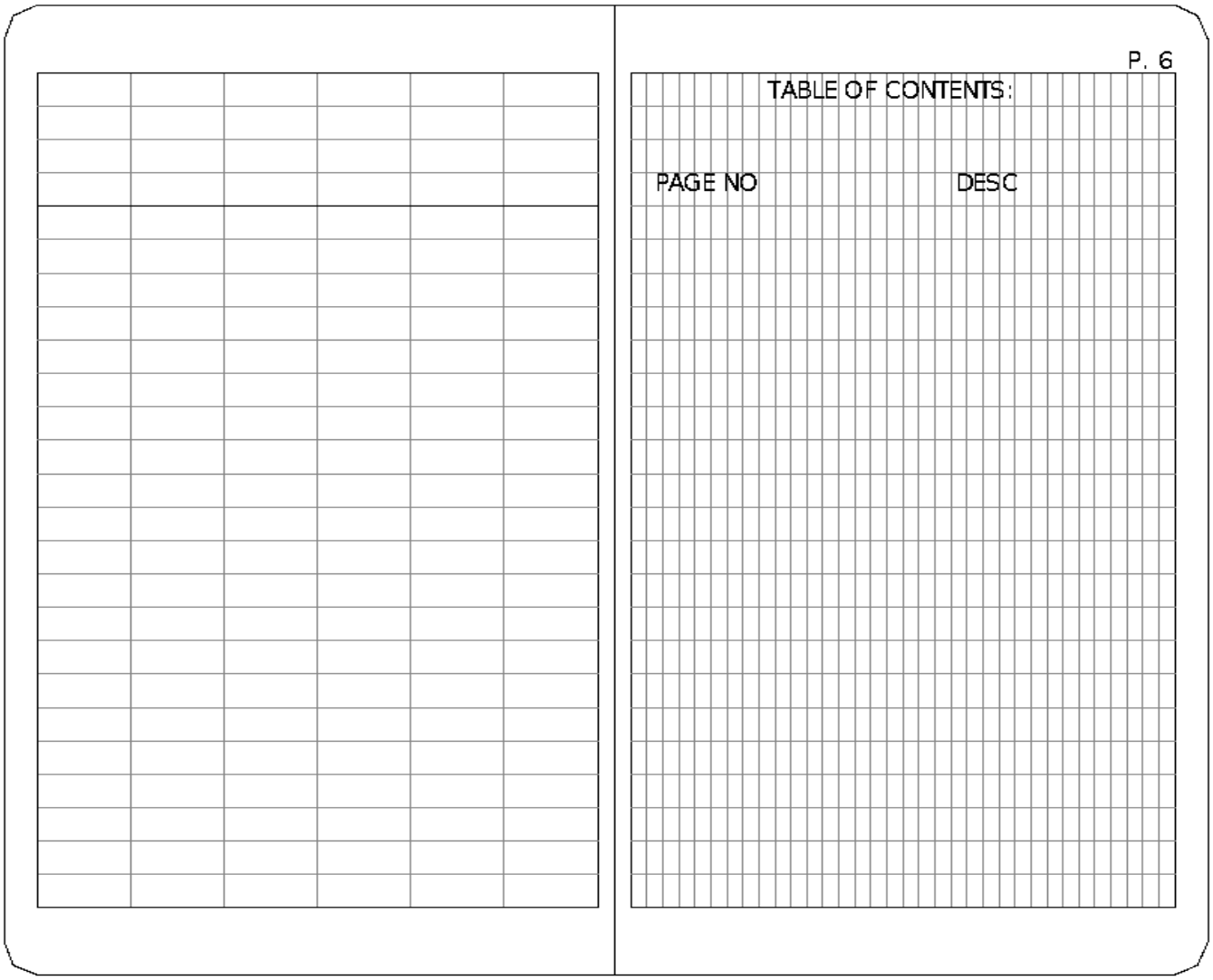


Figure 2 – 7

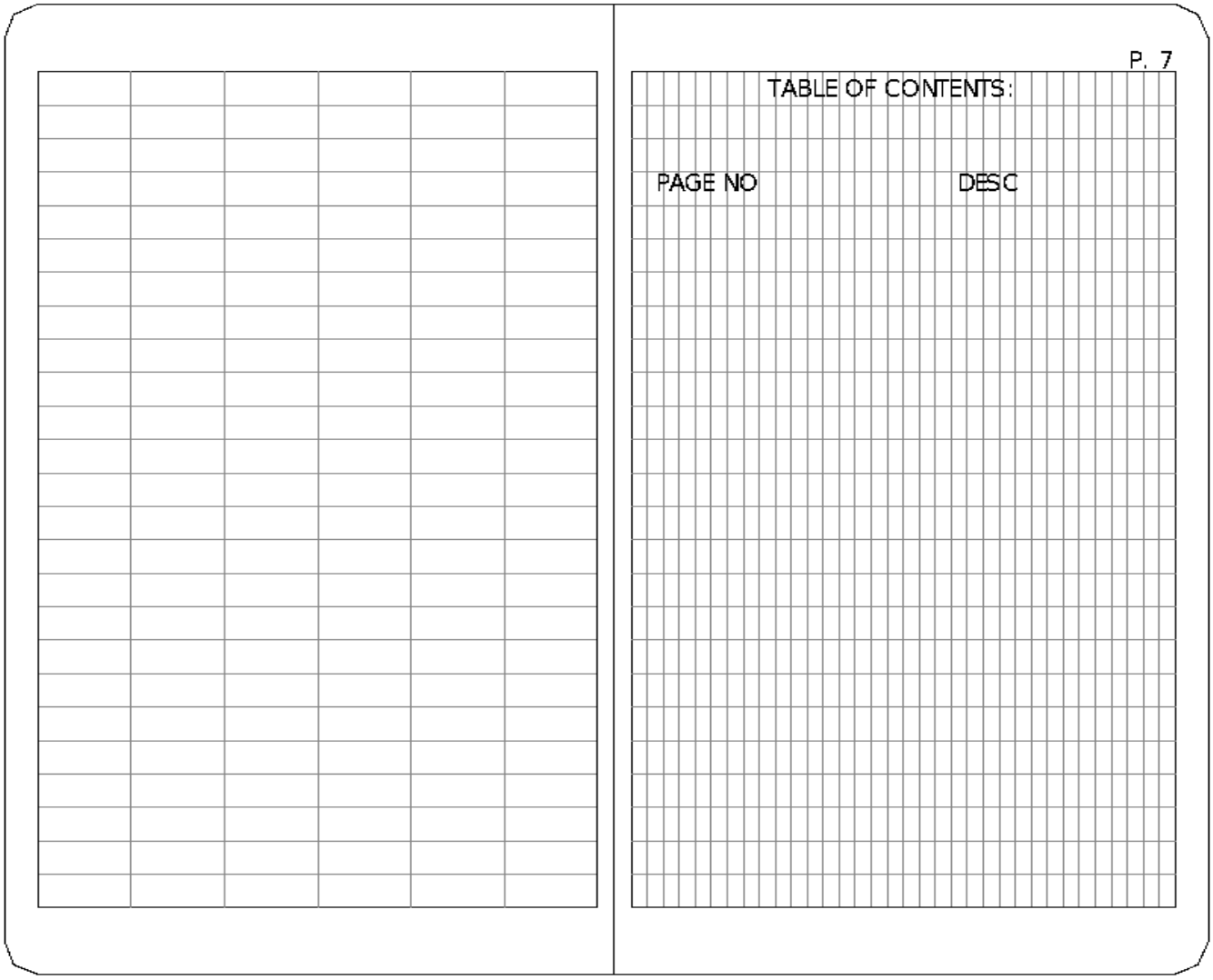


Figure 2 – 8

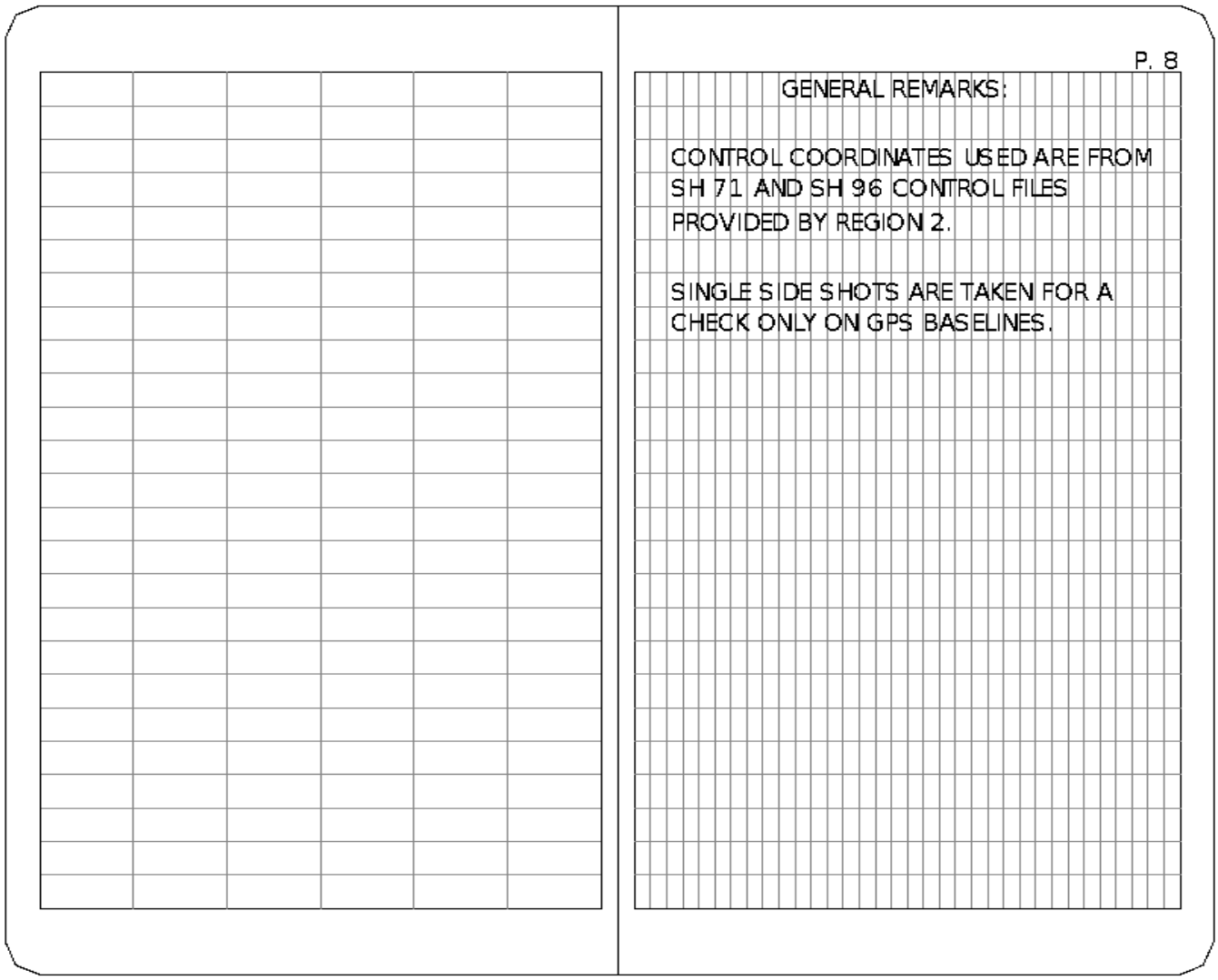

P. 8
GENERAL REMARKS:
CONTROL COORDINATES USED ARE FROM SH 71 AND SH 96 CONTROL FILES PROVIDED BY REGION 2.
SINGLE SIDE SHOTS ARE TAKEN FOR A CHECK ONLY ON GPS BASELINES.

Figure 2 - 9

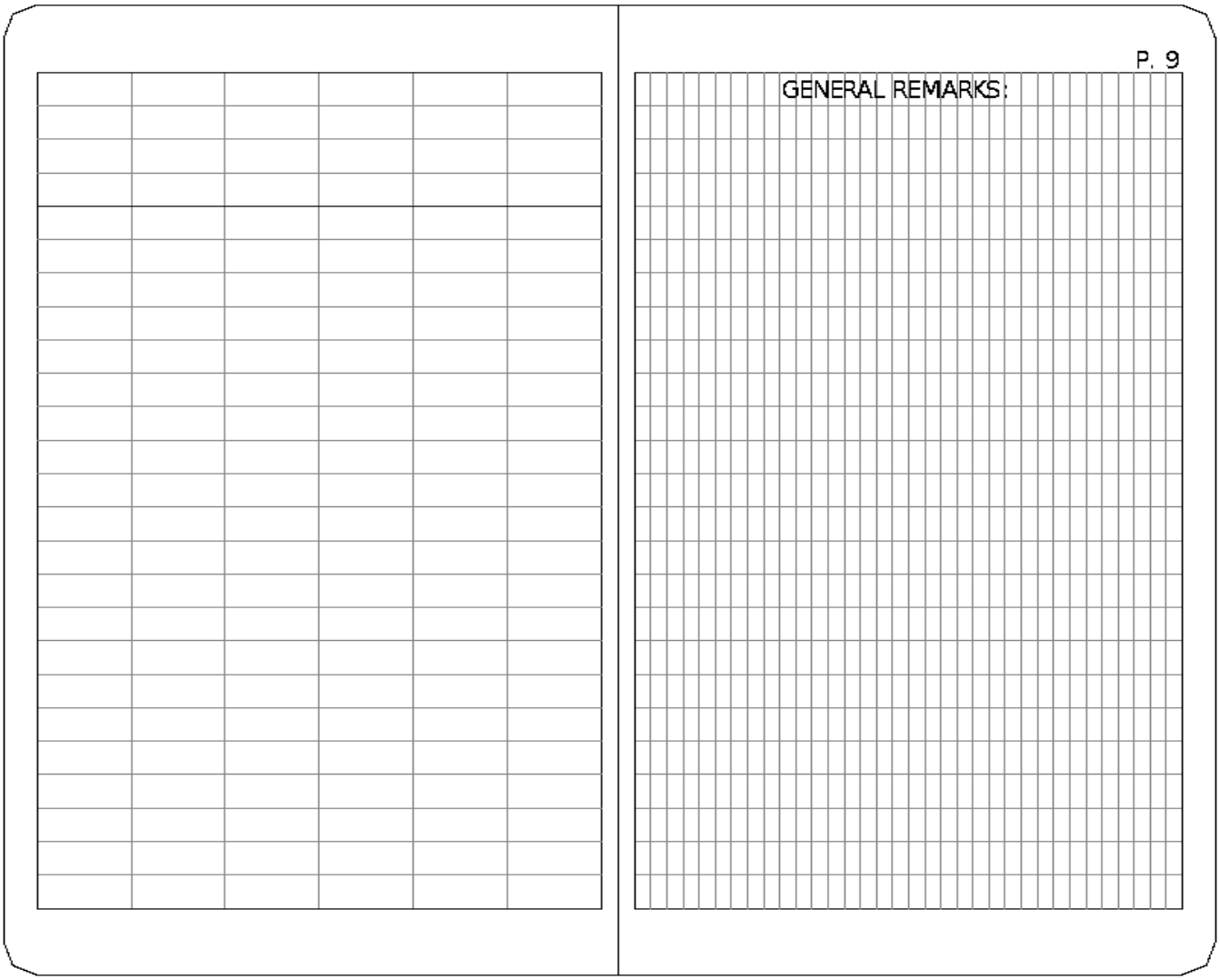


Figure 2 – 10


P. 10
EQUIPMENT CERTIFICATION:
INSTRUMENT TYPE: TRIMBLE 5700 WITH
GEODETIC ANTENNA
INSTRUMENT SERIAL NUMBERS:
0220264927
0220262567
0220262789
0220262101
DATE CHECKED: 1/05/86
CALIBRATED BASELINE: PUEBLO
CHECKED BY: LARRY LUCAS
LORELEI WARD

Figure 2 – 11

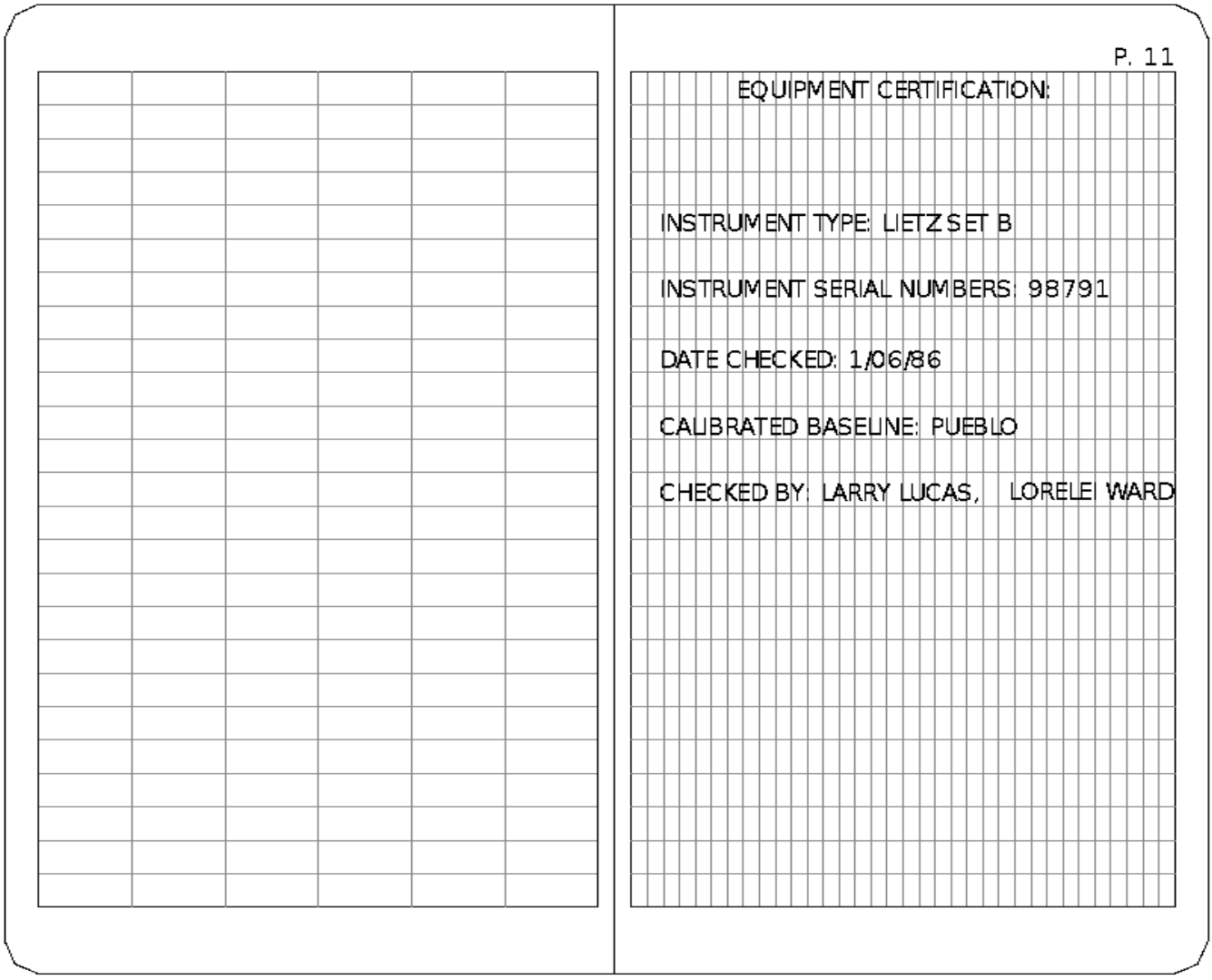

P. 11
EQUIPMENT CERTIFICATION:
INSTRUMENT TYPE: LIETZ SET B
INSTRUMENT SERIAL NUMBERS: 98791
DATE CHECKED: 1/06/86
CALIBRATED BASELINE: PUEBLO
CHECKED BY: LARRY LUCAS, LORELEI WARD

Figure 2 – 12

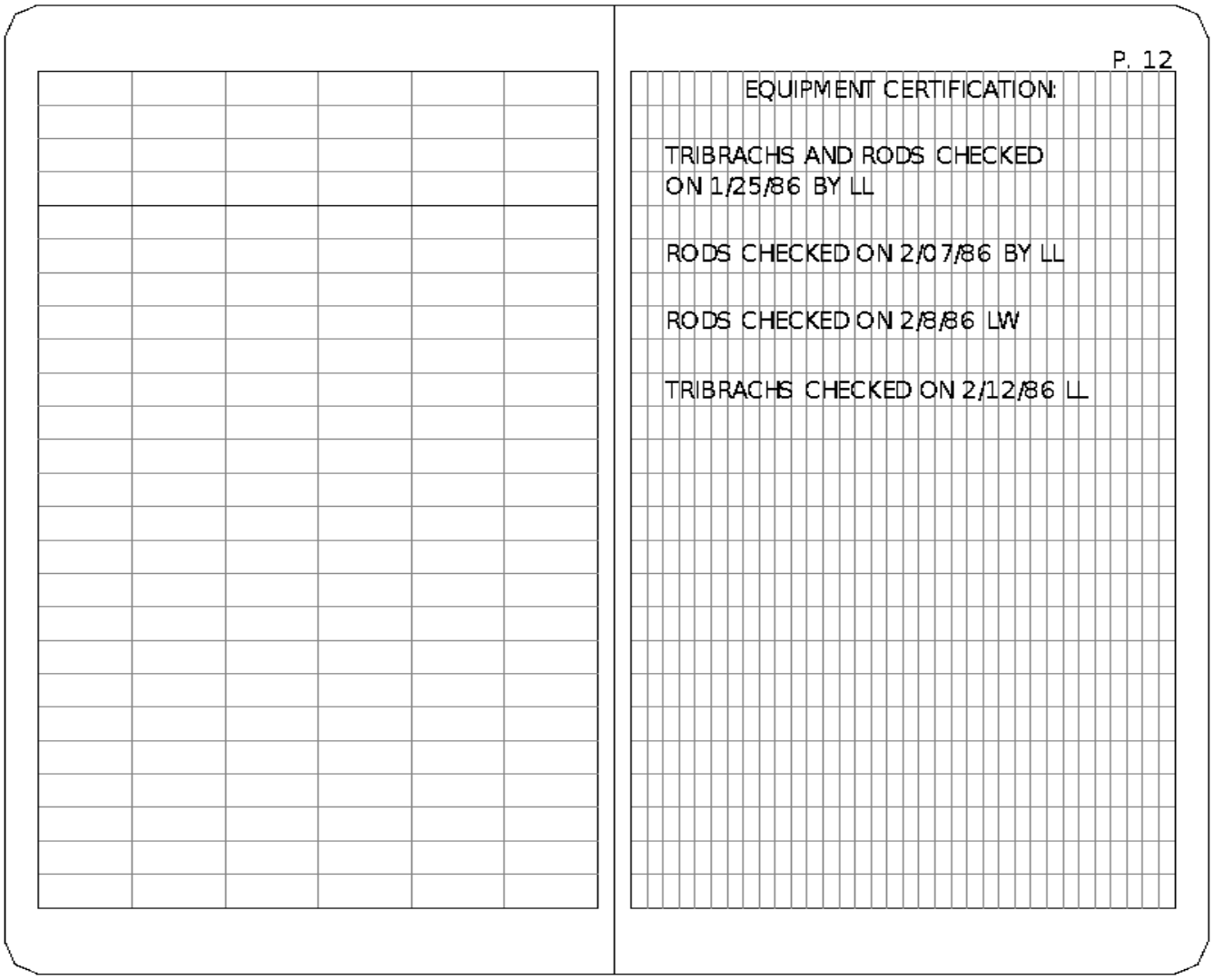

P. 12
EQUIPMENT CERTIFICATION:
TRIBRACHS AND RODS CHECKED ON 1/25/86 BY LL
RODS CHECKED ON 2/07/86 BY LL
RODS CHECKED ON 2/8/86 LW
TRIBRACHS CHECKED ON 2/12/86 LL

Figure 2 – 13

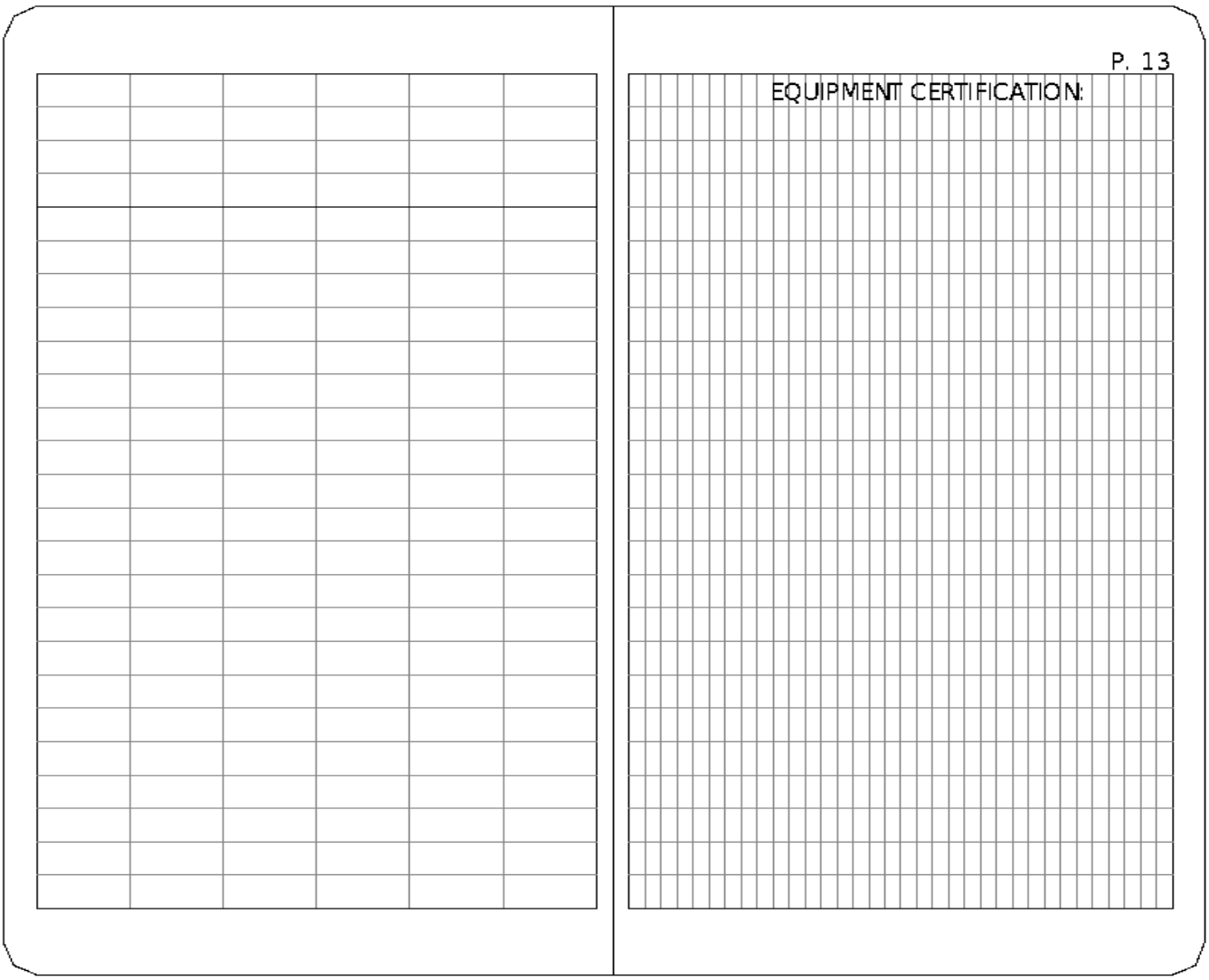


Figure 2 – 14


P. 14
SURVEYOR'S CERTIFICATION:
(INSERT SURVEYORS SEAL AND SIGNATURE HERE)
I _____, HEREBY CERTIFY THAT THIS SURVEY FIELDWORK WAS DONE IN ACCORDANCE WITH A CDOT CLASS A - PRIMARY SURVEY.

Figure 2 – 15

Figure 2 – 16

APPENDIX C

CDOT ELECTRONIC FIELD BOOK FORMAT FOR SUBMITTAL

COMPANY NAME
CDOT PROJECT CODE
PROJECT NO.
REGION #
HWY # MP#-MP#

PROJECT NO: XXXX XXXX-XXX PROJECT CODE: XXXXX

COUNTY
UNITS: US SURVEY FEET
INTERNATIONAL FEET
SURVEY START DATE:
SURVEY END DATE:

Survey Fieldbook Table of Content

Equipment Certification

Instrument Type:

Instrument Serial Numbers:

Date Calibrated:

Calibrated in accordance which meets or exceeds the manufactures procedure.

Calibration perform by:

Tribrachs and Rods Checked on (Date) By (Initials)

Survey Crew

NAME	TITLE	INITIAL
	PARTY CHIEF	
	INSTRUMENT TECH	
	INSTRUMENT TECH	
	PARTY CHIEF	

Colorado Professional Land Surveyors Certification:

I (Colorado Professional Land Surveyor Name), hereby certify that this survey fieldwork was done in accordance with CDOT class A – primary survey standards.

Survey Seal of Professional Land Surveyor In Responsible Charge

Daily log of survey field work							
Date and Highway number and project code							
Task:							
File name in Trimble business center data collector file							
Crew Initials							
Global Position System set up					(Model)		
Data Collector: Serial Number (last 4 #'s) d					Data Collector Model		
Instrument (@ control point number)					HI=_____		
PT ID	CODE	NORTHING	EASTING	ELEV	Δ N	Δ E	Δ EL

Daily log of survey field work							
Date Projecy Number							
Task:							
File Name in Trimble Business Center							
Crew (Initials)							
Total Station Set Up					(Sec) Model		
Datan Collector: Serial Number (last 4#'s)					Data Collector (Model)		
Instrument (Point #)					Height of Intrument=____		
Back sight (Point #)					Height of Back sight=____ foresight=_____		
PT ID	CODE	NORTHING	EASTING	ELEV	Δ N	Δ E	Δ EL