The Office of Highway Development
Plats and Surveys Division

Field Procedures Manual – 2020

Consultant Version

REVISION NOTES

Version	Date	Update Description
Field Procedures Manual 2020.1	Updated 2/5/2021	Section 8.B.viii (PG.66); “Hydraulic Cross-Section Template” updated to show additional detail for required shots.

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Office of Highway Development - Plats and Surveys Division

Field Procedures Manual - Consultant Version

Table of Contents

Preface

This manual was created to establish uniform standards for the performance of field surveys conducted to capture and deliver geodetic, topographic, planimetric, and cadastral data for transportation projects for the Maryland Department of Transportation State Highway Administration (MDOT SHA) Office of Highway Development (OHD) Plats and Surveys Division (PSD). The guidelines presented in this manual apply to MDOT SHA in-house field crews and all consultant field crews that perform work for PSD or for other state agencies. Crews are expected to place an emphasis on productivity, accuracy, and consistency without compromising safety. Safety on MDOT SHA projects is of the utmost importance. The roadway can be a dangerous workplace. Field personnel must be aware of their environment and they shall exercise caution at all times while in transit or on a project's site. Time should be taken to develop operational safety plans in advance of field activities. All field staff are responsible for safety. **If it doesn't feel safe, don't do it.**

The information that our crews provide is vital to the process of every MDOT SHA project. Our surveyors are typically the first people to set foot on the site and often the last to leave. Information provided through preliminary surveys sets a foundation for each project, complimented by a framework of site surveys that take place throughout the life cycle of the work to be performed. The details and procedures necessary for each assignment may vary. It is always important to consider the end use of the survey being requested**. If any details about a survey task are unclear it is a best practice to ask questions to obtain clarity and understanding.**

The intention of this manual is to present expectations, guidelines, and necessary information to help guide field crews through their survey tasks and shape the deliverables that are turned in to PSD. Our intention is to follow or exceed the guidelines set in the Code of Maryland Regulations (COMAR). If any procedures herein are in conflict with the rules, regulations, and procedures established in COMAR, then COMAR shall take precedent.

The practices set forth in this manual are, in part, the result of the history of land surveying operations performed by PSD and its direct predecessors dating to 1908. Augmenting these traditions are the influences of technological evolution. Many aspects of land surveying have changed over time, but the fundamentals have remained. Surveyors are primarily concerned with collecting and reporting what they find and providing this information to our customers for use in planning, design, and construction. If we execute our profession in a properly documented and efficient manner, future surveyors will be able to successfully follow in our footsteps. These standards are subject to revisions based on technological developments and as experience may dictate. This office is always grateful to receive comments and suggestions from the greater Land Surveying community. Our mailing address is located at the end of the Works Cited section.

Introduction

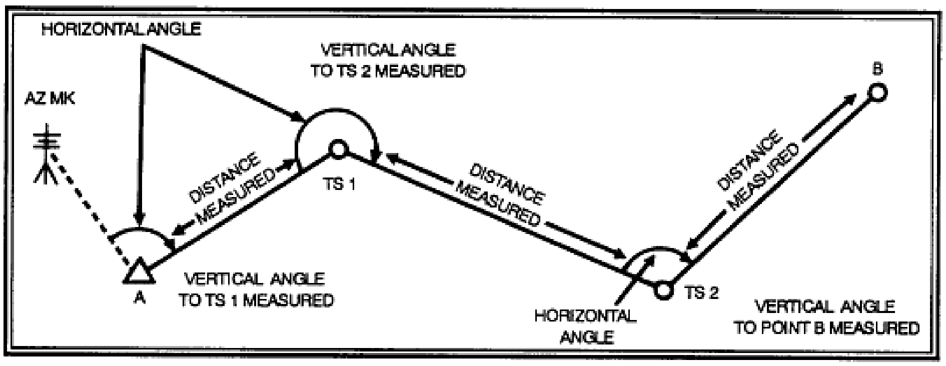
The services provided by the Plats and Surveys Division (PSD) are a cornerstone of the highway development process. PSD's services provide essential geospatial information required for planning, design, and construction at the MDOT SHA and other state agencies. This office performs control surveys, topographic surveys, construction layouts, route and boundary surveys by utilizing the talents of in-house personnel and a network of Consultant Surveyors. PSD employs relevant techniques and innovative technologies to ensure the quality, accuracy, and efficiency with which this information is obtained and delivered, while maintaining the safety of its field personnel and the public at all times. These technologies include Aerial Photogrammetry, Light Detection and Ranging (LiDAR) systems, Hydrographic Systems, Global Navigation Satellite Systems (GNSS), Robotic and Conventional Total Stations, and Differential Leveling Systems.

This division establishes horizontal and vertical survey control, prepares topographic mapping, coordinates utility designations and locations, and performs baseline layout surveys for major and minor transportation projects. PSD performs boundary surveys needed in reestablishing existing baselines of rights of way and determining property boundaries. This base cadastral mapping is utilized for the preparation of right of way plats used for the acquisition and disposal of properties used for roadway projects. These critical elements can influence a project's cost, design, and scope, as they identify potential issues recovered in the collection and assessment of data.

As the custodians of field survey information, PSD maintains a current inventory of existing survey data. It is used by both the private and public land surveying and civil engineering communities statewide. PSD's efforts support MDOT SHA's development of transportation solutions and ultimately add to the customer experience that connects our customers to life's opportunities.

1. Control Surveys

Control surveys establish the horizontal and vertical reference for all land surveying activity conducted by and for the MDOT SHA PSD. For this reason, these surveys must be precise and accurate. Control surveys can be terrestrial based traverse surveys and differential leveling surveys, or satellite based such as static or Real Time Kinematic (RTK) GNSS surveys. To ensure that the survey meets accuracy standards set within this document, the equipment manufacturer's specifications should be adhered to and "best practices" methodologies should be employed by the field crew. Additionally, appropriate safety practices should **always** be employed to protect the survey crew and the public.



A. Terrestrial surveys – Traversing:

i. Equipment checks and calibration: The success of a traverse survey is determined by several factors such as using appropriate equipment, using the equipment correctly, proper equipment maintenance, calibration and collimation.

a. Total stations, tribrachs, precision optical or laser plummets, corner cube prisms, tripods, and monopods shall be in good working order and used according to the manufacturer's recommendations.

b. Total stations shall be verified to meet manufacturer's specifications semiannually (or as needed) on calibration baselines (CBL's) that have been established by the National Geodetic Survey (NGS).

c. Total stations are expected to be certified by an authorized manufacturer's repair facility at least yearly. PSD reserves the right to request records of these certifications as needed.

d. Auxiliary equipment (tribrachs, rods, etc.) shall be checked and adjusted regularly.

e. Equipment dropped or damaged during usage shall not be used and shall be reported, repaired or replaced. Ensuring that equipment is in proper working order is the responsibility of each crew member.

ii. Equipment specifications

a. Total stations used for traverse surveys shall have an angular accuracy of 3 seconds or better and distance accuracy greater than or equal to 2mm+2ppm.

b. Tribrachs used with robotic total stations should have a torsional rigidity of 1 second or better.

c. Tribrach centering errors shall not exceed 1 mm.

d. Retroreflectors shall have a centering accuracy not to exceed 1mm.

e. Retroreflector constants (offsets) shall be verified and/or determined on a calibration baseline established by NGS. Best practice is to be consistent when working with retroreflector constants.

f. Heavy duty tripods shall be used for all conventional traverse surveys.

iii. Planning and setting control: Planning, laying out, and setting primary and secondary control for a traverse is a critical part of the survey.

a. Control points shall be evenly spaced (balanced) at a minimum of three hundred feet where practical and easily accessible; set in places not likely to be disturbed and marked out for easy identification.

b. Line of sight between points shall be open and reasonably maintainable for current and near future conditions.

c. Control points shall have at least three measured distance ties.

d. When setting control points, potential sources of heat “shimmer” should be avoided as much as possible.

e. Choosing the material to be set for a new control point (rebar and cap, concrete monument, etc.) is also an important part of planning. For appropriate materials to be set for all MDOT SHA control orders, see section 1.A.vi.

1. For traverses requiring an "A" Traverse classification, cast in place concrete monuments, permanent marks in concrete (x-cuts) or 36-inch rebars with metal caps or discs shall be used (see section 1.A.vi.). Compliance with Miss Utility sweeping guidelines must be considered.

2. For traverses requiring a "B" Traverse classification, cast in place concrete monuments, permanent marks in concrete (x-cuts), 18-inch rebars with caps, railroad spikes with punches or MAG Nails shall be used (see section 1.A.vi). Compliance with Miss Utility sweeping guidelines must be considered.

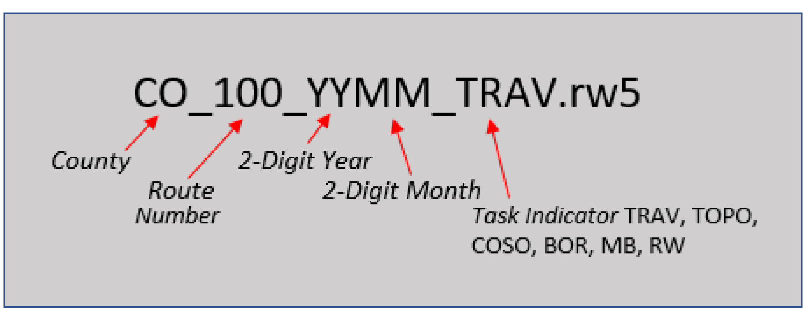
3. For points set as spurs or "fly points", wooden hubs and tacks may be used in addition to the materials listed above for "A" and "B" Traverse control points. See section 1.A.viii. for more information on fly points.

4. There may be some instances (e.g. farm fields, sports fields) where it is appropriate to use wooden hubs and tacks for traverse points with prior approval from PSD.

iv. Control point naming convention:

a. All new traverse points set will be named sequentially starting from SHA100. In the case of an existing project you may be given a different starting point name. In the case that work is being performed by a consultant they may use a naming convention to indicate their firm's name. (e.g. AECOM would use AEC100).

b. All field run traverse files shall be named to indicate county, route number, year, month, and type of work (TRAV) as follows:



c. Any fly points will be named for the source point and have a letter at the end of the point name. (e.g. Fly point SHA103A would be set from SHA103).

d. If multiple fly points are set, the names will advance alphabetically (e.g. If three fly points were set from SHA103 they would be named SHA103A, SHA103B, and SHA103C).

e. If a fly point was eventually adjusted, the point name would retain this letter in its name. Differential levels will be required for all control points, including fly points.

v. Starting control: The same way that traverse points are the foundation for all survey deliverables, the starting control must be well founded and accurate in order to produce sound new control for our tasks.

a. Existing control points used to establish a traverse line or loop (e.g. NGS monuments, SHA control points, etc.) must have an accuracy standard greater than or equal to the "B" Traverse classification.

b. All existing control points shall be verified with field checks for condition and accuracy before use to establish new control points.

c. Any condition issues with control points or significant control discrepancies must be reported to the MDOT SHA Area Engineer or Task Manager for the project before proceeding with the task. It may be necessary for supplemental control observations to be performed to eliminate error.

vi. Control orders: MDOT SHA and consultant run traverse shall adhere to the standards of the two following classifications established by the MDOT SHA for field surveys**.**

Order	Measurements	Materials Required	Minimum Distance Accuracy
"A" Traverse	6 Direct and Indirect Angle Sets	Cast in place concrete monuments, permanent marks in concrete (x-cuts), or 36" rebars with metal cap or disc	1:50,000
"B" Traverse	4 Direct and Indirect Angle Sets	Cast in place concrete monuments, permanent marks in concrete (x-cuts), 18" rebars with cap, railroad spikes with punches, MAG Nails or Hubs and Tacks (as authorized).	1:20,000

An example of one "set" of traverse observations is as follows:

1) Direct Observation (Backsight) – 0-00-00
2) Direct Observation (Foresight) – 100-00-00
3) Indirect/Reverse Observation (Foresight) – 280-00-00
4) Indirect/Reverse Observation (Backsight) – 180-00-00

All traverse work shall be done at least in accordance with the "B" Traverse standard unless otherwise directed by PSD. If an "A" Traverse (used for long term projects along major corridors) is required, it will be designated at the time a task is assigned.

<u>vii. Traverse establishment procedures:</u> The following procedures are standards or practices that are expected to be performed when taking observations to set control points. There may be exceptions to these procedures based on site conditions, but those exceptions must be pre-approved by an Area Engineer or Task Manager.

a. Prior to starting a traverse survey, equipment shall be given enough time to acclimate to the local ambient temperature (about 1 minute for every 5 degrees Fahrenheit of difference from stored to ambient temperature).

b. Records shall be submitted containing the starting and ending time for each setup, and the equipment used including make, model and ID number. This info may be submitted in your RW5 files, documented in the field book, or observation log supplied at the time of assignment.

c. Tripods shall be firmly set into the ground to avoid settlement during the survey. Precautions shall be taken to ensure a stable setup. (e.g. using sandbags in windy conditions, covering the tripod feet with snow to prevent settling on frozen ground, removing debris from the setup area, etc.).

d. Precisely sight the center of the retroreflector both horizontally and vertically when taking each observation.

e. All observations needed for traverse establishment shall be taken in a timely manner to avoid excess settling of the instrument or change in weather factors.

f. Use care when inverting the scope of the instrument and stepping around the instrument to take angular measurements. Any bumps or jars could have a major effect on the accuracy of your observations.

g. Accuracy standards (rejection limits) for angular and distance measurements shall be set according to the following parameters:

Horizontal angle rejection limit = 10"
Vertical angle rejection limit = 15"
Distance rejection limit 0.005'+/-2ppm.

h. When each setup is completed, the setup shall move forward while preserving the placement of the tripods and tribrachs as much as possible to simplify the setup and minimize error.

i. The traverse shall be closed back into primary control monumentation of equal or greater order than the point of beginning.

j. If other existing control or monumentation are encountered during the survey, efforts shall be made to tie these into the current survey.

k. Using an instrument's EDM or reflectorless capabilities, distance ties for reference sketches can be measured with the instrument in lieu of manually chaining distances after all other measurements have been completed.

l. At the end of the workday or at the start of the next workday, all data shall be downloaded by either the crew chief or office personnel. Data should not be deleted from the data collector until quality control has been performed and the data successfully imported into the processing software. All field documentation shall be given to office personnel with the delivery of the other assignment data.

viii. Spurs or fly point guidelines:

a. Spurs or fly points shall be established in the same manner as all main line traverse points, including the same number of observations and procedures. These points may be turned through in the future and adjusted, so it is important to have all the necessary information collected.

b. Secondary traverse points (spurs, fly points, etc.) can be located from the current setup **after** measurements to primary traverse points are completed.

c. The MDOT SHA PSD does not allow fly points to be set in succession from other unadjusted fly points. An exception may be granted by PSD Task Managers in the case of a stream channel cross section assignment.

d. Differential levels must be run to all spur or fly points. Elevations established through trigonometric measurements taken during traverse establishment will not be accepted as a means of establishing final elevations.

e. In addition to the materials allowed for a "B" Traverse, wooden hubs may be used for any fly point that is set for temporary use. However, any point set as a wooden hub may not be turned through or turned into an adjusted traverse point.

B. Terrestrial surveys – Leveling: Differential leveling is used to establish elevations on unknown marks by using elevations from known benchmarks and to determine elevation differences between unknown marks which can then be input into a least squares adjustment software to strengthen elevations established through GNSS observations.

i. Leveling requirements

a. Levels must be performed to accompany any traverse point, line or loop that will be used to establish elevations for the project. **Trigonometric levels from traverse turns are not accepted as a stand-alone means of establishing elevations for control points.**

b. Each level run shall start and end on a vertical benchmark of equal or greater order then the project specifications.

c. All level runs are expected to close vertically. The following vertical orders shall be adhered to when performing leveling, whether differential or precise. If tolerance is not met, the run must be extended back to an additional benchmark or the point of origin to assure that the run meets accuracy requirements. Level runs that do not meet the project specifications for closure must be run again. On the chart below, the formula may be used to figure out the allowable error.

Order	Error Tolerance
"A" Levels	0.035 ft **x** square root of the total length of the run, in miles.
"B" Levels	0.050 ft **x** square root of the total length of the run, in miles.

d. General differential levels shall be performed for day to day projects, with a "B" Levels accuracy requirement.

e. Tasks requiring an "A" Levels accuracy requirement will be designated at the time of assignment. This may be necessary for long-term projects along major corridors.

f. The MDOT SHA Area Engineer, Task Manager or Project Manager will determine which method and requirement is appropriate for each assignment.

g. Leveling notes shall be documented in a field book in the standard MDOT SHA PSD format (See example in section 1.F.iv.). Additional information such as equipment make and model used, and equipment serial numbers, etc. shall also be documented.

ii. Leveling equipment

a. All equipment used to perform levels shall be checked and in good calibration prior to beginning the survey.

b. Manufacturer's equipment specifications shall always be followed.

c. Peg tests shall be performed regularly. Best practice is to perform a peg test before each level run.

d. Peg tests shall be performed on level ground. Most electronic level manufacturers provide an on-board program to help facilitate this procedure.

e. If the level is roughly handled it is necessary to perform checks to verify its accuracy. If any damage occurs, it shall be reported.

f. General differential leveling equipment consists of the following:

1. Heavy-duty adjustable tripods
2. Electronic or optical levels
3. Sectional wooden or fiberglass rods and rod levels
4. Leveling turning plates (turtles), nails, stakes other turning points as deemed appropriate
5. Hand-held weather meters

g. Precise differential leveling equipment consists of the following:

1. Heavy duty fixed height tripods
2. Electronic levels
3. Single piece bar coded invar rod
4. Leveling pins or heavy duty (7kg) steel turning plates (turtles) a rod level if a fiberglass or wooden rod is used
5. Magnetic (or other) spacers for recessed benchmarks
6. Tripod mounted air aspirated thermistors or a handheld weather meter.
7. Sectional or two-piece leveling rods shall not be used for precise leveling. If available, leveling struts should be used on bar coded rods.

iii. Leveling procedure planning

a. Prior to starting a leveling section, known benchmarks should be recovered and clearly marked.

b. During recovery, any benchmarks that are recessed (i.e. the leveling rod cannot be placed directly on the benchmark) shall be notated so magnetic (or other) spacers can be included in the leveling plan.

c. A leveling path to and from known benchmarks and unknown points should also be determined. This should be done with balanced rod spacing in mind.

d. Temporary benchmarks may be necessary for long level runs.

e. If the rod spacing for the survey was not preplanned, the back and fore rod person's pacing should be compared for consistency to ensure a balanced survey.

f. Prior to starting a leveling survey, equipment shall have sufficient time (about 1 minute for every 5 degrees Fahrenheit of difference from stored to ambient temperature) to acclimate to the local ambient temperature.

g. At the beginning of each day, and if a large change in temperature is encountered throughout the day a peg test shall be performed.

h. If leveling across hot mix asphalt is necessary, it should be planned for times when heat shimmer is low, like early mornings or overcast days.

i. The level run shall be setup in the field book to facilitate the leveling procedure.

iv. Leveling procedure

a. The instrument operator shall start at the benchmark and pace the predetermined distance (not to exceed 45 meters/150 feet) to where the instrument will be set up.

b. The forward rod person shall then pace the equal distance along the horizontal sight line.

c. Once a location for a turn has been established, the rod person will drive the turning pin firmly into the soil using a rubber mallet or firmly set the turning plate on the ground. A turning plate should only be set on firm soil.

d. At this point, the instrument operator shall measure and record meteorological data in the field book or on the observation log and input the information into the electronic level, if applicable.

e. Once the instrument is leveled, the operator shall make sure that the top and bottom crosshairs (or wires) are on the rod. The minimum for all readings shall be taken above 1-foot and below the top 10% of the rod's standing height at the time or measurement. (e.g. If your rod is 16-foot tall, your maximum height reading shall be 14.40'.)

f. When using an electronic level, a minimum of three readings shall be made to each rod. These readings should be averaged into one observation record. This is a setting that can be setup in a digital level.

g. Once the measurements have been recorded, the operator can motion or call the back-rod person to advance to a forward position. The fore-rod person shall not remove the rod from the turning pin or turtle while the back-rod person and operator move forward.

h. After all observations have been taken and the back-rod person has moved forward, the instrument operator shall move forward with the leveling instrument to the next balanced turning point. When the observer is advancing, the level shall be carried vertically and **not** rested on the observer's shoulder.

i. This process shall be repeated until the leveling section is completed.

j. At the end of the day or at the start of the next day, all data shall be downloaded by either the crew chief or office personnel. Data should not be deleted from the data collector or instrument until quality control has been performed and the data successfully imported into the processing software. All field documentation shall be given to office personnel.

v. Leveling procedure guidelines

a. All precise leveling surveys shall be double run (forward and backward).

b. Measuring over hot mix asphalt shall be avoided when possible.

c. If nails or stakes are used as turning points, they must be driven at an angle and set firmly in soil or hot mix asphalt so that a high point of the turning point is easily defined.

d. Hand-held weather meters should be used to record atmospheric conditions.

e. If there is a distance imbalance in any setup, the instrument operator should tell the crew members and their pacing should be adjusted accordingly to compensate for the imbalance.

f. When leveling the equipment, the level bubble should be shaded from direct sunlight to ensure the bubble is not influenced by the sunlight.

g. The same rod that was used on the benchmark at the start of the run shall be used to check back into the starting benchmark or a benchmark of equal or greater accuracy.

h. Precise levels shall require two rod persons. If a task requires precise levels, it will be designated at the time of assignment. For general leveling procedures, the back and forward rod person may be the same person.

<u>C. GNSS Control Surveys – Static GPS:</u> Static Global Navigation Satellite System (GNSS) surveys are typically utilized when conventional traversing methods are not conducive to project timelines or considerate of safety concerns. GNSS receivers record signals from one or more satellite constellations such as NAVSTAR, GLONASS, Galileo, and BeiDou to determine horizontal and vertical positions on the earth. GNSS receivers are simultaneously set up on control points with known coordinates (rebars and caps, monuments, etc.) and points with unknown coordinates. Satellite signals are recorded by the receivers and through post processing, values are established on the unknown marks.

<u>i. Static GPS equipment:</u> Specific equipment used to perform static GPS observations consists of the following:

a. GNSS receivers
b. Fixed height or conventional heavy-duty tripods
c. Tribrachs
d. Precise optical or laser plummets
e. Tape measures
f. Compasses
g. Data collectors
h. Other equipment may be utilized for projects with special requirements

<u>ii. Static GPS planning:</u>

a. Suitable existing survey control points in the vicinity of the project shall be researched and selected based on order, classification, stability, and condition. Obstructions near the marks, proximity to the project site, and geometry around the project site is also considered during this selection.

b. Coordinates, survey control point data sheets, field book notes and/or sketches shall be researched, recovered and given to the field crew to recover the selected points. This process may include recovery and/or conversion of superseded values for control established on a datum that is not the same as the project datum. Any control conversions shall be coordinated with and pre-approved by PSD.

c. Field recovery shall then be performed using references including GIS tools, Google Earth, DS World, US Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA) tide data, and MDOT SHA field book reference sketches.

d. Field recovery of control points includes checking the condition of a point. If there are any condition issues (cracked or loose cap, loose rebar, looks like it was hit) with a point it must be reported as soon as possible and before continuing to establish new control.

e. Space weather (presence of solar flares), current or predicted atmospheric conditions (passing weather fronts, inclement weather, etc.), predicted satellite geometry, and other factors shall be considered during session planning.

f. If possible, new control points should be set ahead of time so that session plans can be tailored to the actual point locations where observations will take place.

g. All equipment shall be checked and calibrated prior to beginning the survey. The equipment manufacturer's recommended operating procedures shall be followed.

iii. Static GPS procedure:

a. Tripods shall be firmly set into the ground to avoid settlement during the survey. Precautions shall be taken to ensure a stable setup, like using sandbags in windy conditions, covering the tripod feet with snow to prevent settling on frozen ground, removing debris from the setup area, etc.

b. Prior to final the leveling of the tripod, the operator shall thread the brass collet into the bottom of the receiver, seat the receiver on the fixed height tripod or a tribrach and heavy duty tripod, then **orient the receiver to north** based on the receiver's orientation point as specified by the manufacturer.

c. It is at this point that the final leveling of the setup should occur.

d. The operator shall then fill out the observation log, set up the project in the data collector, then start the survey.

e. Unless otherwise specified, the recording rate shall be set to five seconds and the horizon mask shall be set to 10 degrees.

f. The observation log must be filled out completely and must be legible.

g. Several times during the session, and at the end of the session, the operator should check to make sure the tripod remains plumb and note any changes on the observation log.

h. Using the data collector, the operator shall check satellite geometry, Positional Dilution of Precision (PDOP), Horizontal Root Mean Square (HRMS), and Vertical Root Mean Square (VRMS) values throughout the session and make any necessary notations on the observation log.

i. Using a total station, the field crew shall measure distances between new control points and record them in the field book. When post processing is completed, this info serves as a check against the inversed distances of the adjusted points.

j. This procedure shall be repeated for all planned sessions.

k. At the end of the day or at the start of the next day, all data shall be downloaded from the receivers by either the crew chief or office personnel. Data should not be deleted from the receivers until quality control has been performed and the data successfully imported into the processing software.

l. All field documentation shall be given to office personnel.

iv. Static GPS guidelines:

a. The field crew shall set project control in suitable locations, draw the field sketches, and make a minimum of three distance ties to all new control points set.

b. Start and stop times for sessions must be well communicated by the crew members and should be as coincident as possible.

c. Survey vehicles shall not be parked near the GNSS receiver as this may introduce multipath into the survey.

d. If severe weather is encountered during the survey, the session should be ended, and equipment put away. If the weather delay is short lived such as a quick moving thunderstorm, the session can be restarted, and the down time can be added to the end of the session. Make sure this extension is communicated to the other crew members and they adjust their session time accordingly. This should occur in a **separate** data collection file and be documented and conveyed to office personnel.

e. When setting the project control points, overhead obstructions or other potential sources of multipath shall be avoided. Multipath occurs when satellite signals deflect off nearby obstacles such as signs, buildings, trees, etc., which alters the path of the signal from the satellites to the antenna thus degrading of the accuracy of the survey.

f. If necessary, obstruction logs shall be filled out. The crew then reports their findings to office personnel who can then plan out the sessions. The operator shall note any critical events that occur during the session such as change in the weather or a vehicle being parked near the receiver.

D. GNSS Control Surveys - Real Time Kinematic (RTK) and Post Processed Kinematic (PPK) Surveys: RTK and PPK surveys utilize two GNSS receivers in base and rover positions to update and produce "real time" measurements without being constrained to limits of a conventional instrument setup. PPK surveys are similar to Static surveys in that data is collected simultaneously at the base and rover positions and post processed by office personnel. The largest difference between these techniques and Static is that the data set is considerably shorter and a monopod/bipod configuration can be used.

RTK and PPK survey methods may be utilized for smaller assignments or short-term projects where the acceptable accuracy standards do not call for Static observations. RTK and PPK surveys are very convenient but may yield less accurate results than static surveys. Observation times are significantly less than Static methods, resulting in lower solution confidence. Careful consideration to project requirements shall be taken before employing these survey methods.

If this technique is intended to be used to complete a task it needs to be communicated with and approved by the Area Engineer or MDOT SHA Task Manager assigning the task. Best practice is to coordinate accuracy requirements when performing any RTK/PPK survey pertaining to hard surfaces. There may be special requirements necessary to assure that a proper level of accuracy is achieved for an assignment.

i. RTK and PPK equipment:

a. GNSS receivers
b. Fixed height or conventional heavy-duty tripods
c. Tribrachs
d. Precise optical or laser plummets
e. Monopods
f. Bipods
g. Tape measures
h. Compasses
i. Data collectors

Additional equipment may be utilized for projects with special requirements.

ii. RTK and PPK planning:

a. PPK and RTK planning procedures are relatively identical to static planning procedures with the exception that with Static and PPK surveys, known control marks can be several kilometers from the project site, whereas with RTK surveys, known control is relatively close to the project site. An exception to this would be when a radio (Code Division Multiple Access (CDMA) or other) is used for real time corrections.

b. MDOT SHA RTK observation log sheets shall be used.

iii. RTK and PPK procedure:

a. A GNSS receiver (base) is set up precisely and plumbed over a known control point, with values to match the datum for the project. Currently, MDOT SHA projects are done using NAD 83/91 and NAVD 88. Any deviation from the current datum or realization shall be specified when an assignment is made. See information about datums in section 2.A.

b. A second receiver (rover) is mounted on a fixed height tripod or a monopod which is fixed to a bipod for stability and is plumbed over an unknown control point.

c. Prior to starting an observation, the operator should view the positions of the satellites using the Sky Plot tab in data collector software such as Carlson Surv CE.

d. A minimum of 180 epochs (3 minutes) must be recorded for each observation.

e. After the new control points have been located, the rover shall be re-initialized.

f. New control points shall be established by at least 3 observations of at least 180 epochs.

g. If possible, different existing control points should be occupied for the base position for each round of observations.

h. Best practice includes performing subsequent locations with the rover set at different heights to provide a check on the control elevations.

i. The observations shall be recorded at different times of day for variation in satellite constellation configuration. If possible, without adding workdays to a task, best practice will include observations for control points from different days.

j. The operator shall check into at least one, and when available, two known control points at the start and after all project marks are located. Check shots shall be stored, recording 30 epochs (30 seconds) for each shot. Data shall be recorded at the base and rover positions for all check shots.

k. Check shots shall be taken at least twice, preferably three times, throughout the period when occupations are performed. These checks should be done before work starts, mid-day, and at the end of the workday.

l. MDOT SHA RTK observation log sheets or assignment specific bookwork shall be filled out **completely and must be legible**.

m. When the survey is completed, all data shall be downloaded from the base and rover receivers by either the crew chief or office personnel.

n. Data shall not be deleted from the receivers until quality control has been performed and until all data has been successfully imported into the processing software.

o. All field documentation shall be given to office personnel.

iv. RTK and PPK Guidelines:

a. The monopod and bipod configuration shall not be used in adverse weather conditions (especially high winds).

b. Unless otherwise specified, the recording rate for the base and rover shall be set to one second and the horizon mask shall be set from 12-15 degrees depending on satellite availability.

c. The operator must use the compatible geoid file for the project as described in section 2.A. This needs to be setup in the job file before any field work is performed.

d. The following observation constraints shall be set in the data collector:

PDOP threshold = 2.00
Horizontal precision = 0.03 feet
Vertical precision = 0.06 feet

e. As stated above in the procedures for RTK/PPK control establishment, 3 observations of at least 180 epochs are required to establish a new control point. In each round of observations, the following configuration items shall be changed to produce checks through comparison of data recorded.

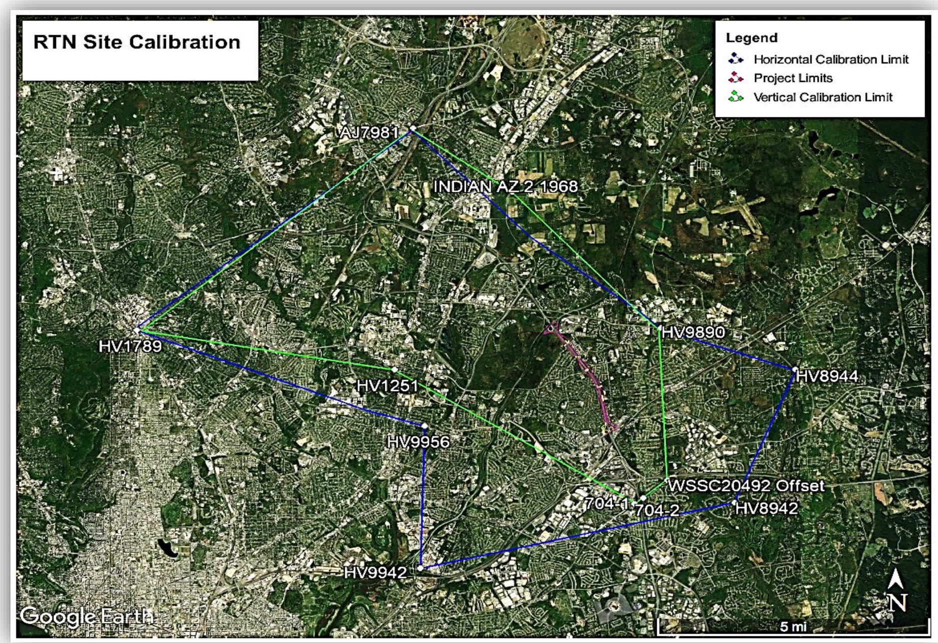
1. Different existing control points shall be utilized for a base position as much as possible in the 3 observations.

2. For each observation the rover height shall be different for a check on control elevations. Preferred difference is about 0.50 feet.

3. Observations shall be taken at different times of day to allow for different satellite constellation configuration. If possible, without adding workdays to a task, best practice will include observations for control points from different days.

E. GNSS Control Surveys – Real Time Network (RTN) Surveys: Real Time Network (RTN) survey methods utilize satellite triangulation to establish a position for one GNSS receiver operating as a rover. The RTN rover receives corrections from network stations (TopNet, Smartnet, etc.) instead of using a base station set up over a known point. Corrections are broadcast to the rover, usually from a station closest to the project site.

i. RTN Planning and Localization: The planning phase for RTN is similar to that of RTK and Static GPS as far as control recovery and session planning is concerned. The big difference associated with RTN surveys is the need for a localization, also known as a site calibration. This is done by observing existing horizontal and vertical control that surround the job site or area of interest for a survey task.



a. All observations for RTN localizations shall be in accordance with the RTK control establishment procedures and guidelines.

b. A **minimum of 5 horizontal and 5 vertical control points** that create a balanced envelope around the project site shall be observed. Larger projects may require more than five points for observations.

c. The points to be used in the localization may be provided by an Area Engineer or MDOT SHA Task Manager.

d. Best practice is to use more than five points for observations as some points with high residuals may need to be omitted from the final localization file.

e. Typically, the points chosen for a localization are some distance from the actual project site. This is done to create a large and stable footprint for the localization, ensuring the best solution possible. This measure is also taken to address potential increases in the scope or size of a project. The larger the localization, the better the chance that an expanded version of a project will remain within the localization envelope.

f. A localization is performed to help establish a relationship between latitude, longitude and ellipsoidal height and the northing, easting and orthometric height that are to be used on a specific project. This process is essentially used to adjust projected grid coordinates into best fit local control coordinates.

g. Localization points shall be observed one time at a one second recording rate for 180 epochs, provided that acceptable results are achieved. The elevation mask shall be set to 15 degrees. Repeat observations may be necessary to meet standards.

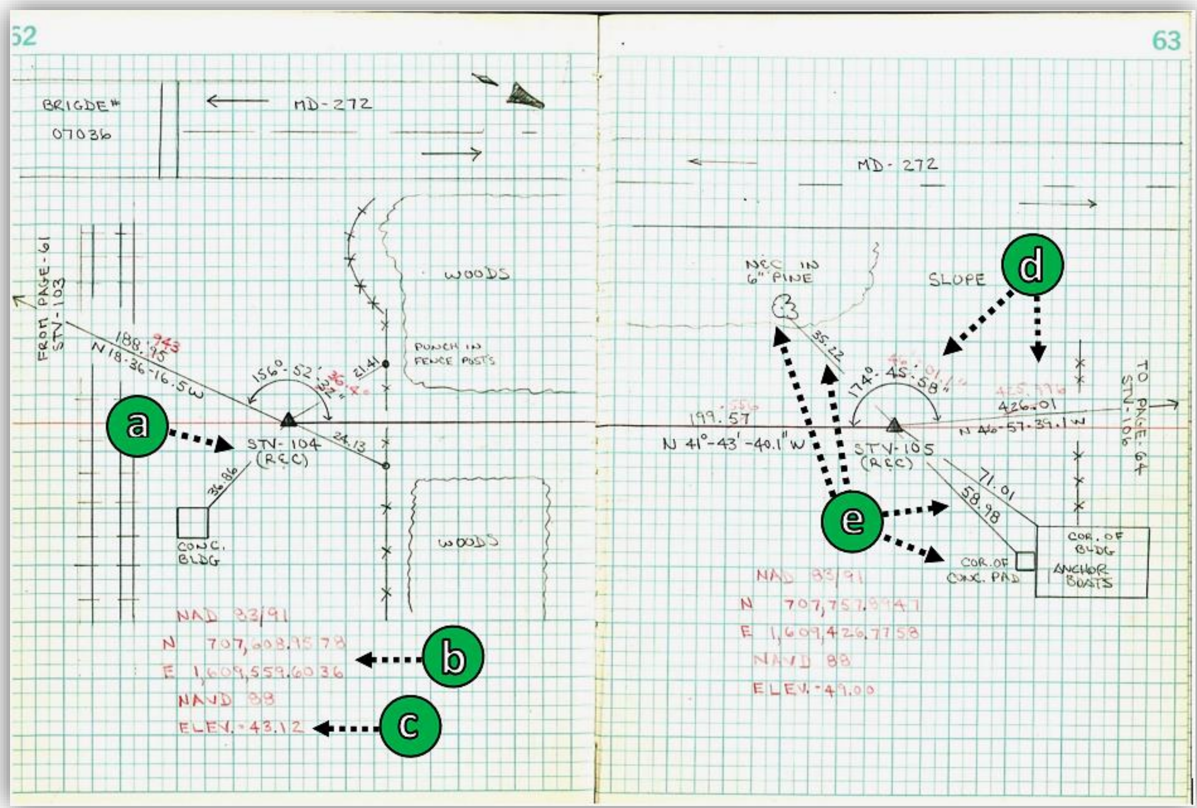
h. Once all the localization points have been occupied, the project RW5 file, localization report, and localization file shall be submitted to office personnel who will compute the final localization and review the report.

i. Additional localization points may need to be observed if local accuracies are above tolerances (approximately 0.10 feet horizontally and 0.10 feet vertically).

j. Once the field localization data has been reviewed, office personnel will provide the final localization file for production use. MDOT SHA RTN Observation Log Sheets and survey field book notes shall be filled out **completely and must be legible**. See example in section 9.F.

ii. RTN procedures and guidelines: The procedures and guidelines for the use of Real Time Network (RTN) surveys are the same as Real Time Kinematic (RTK) procedures and guidelines, except that there will not be a base station. All occupations and setups will be done using the rover only. See the RTK procedures and guidelines in section 1.D.

<u>F. Traverse Bookwork:</u> When new control points are set during a survey, the party chief is responsible to record information in the survey field book, so these traverse points and lines can be incorporated into our control network and utilized for future surveys. This information shall include the following details.



i. In the traverse bookwork example above, items "**a**" through "**e**" have been labeled to correspond with the details below.

a. Point name and material used. (Naming conventions for traverse are described in section 1.A.iv.)

b. Northing and easting coordinates (including horizontal datum specified for the project). Coordinates shown in the field book must correspond with the final coordinate list and reflect the final adjusted values. If any earlier values are written in the field book, the final adjusted values shall be shown in red with a strikethrough applied to the replaced values.

c. Elevation (including vertical datum specified for the project). Elevations shown in the field book must correspond with the leveling notes, the final coordinate list and reflect the final adjusted values. If any earlier values are written in the field book, the final adjusted values shall be shown in red with a strikethrough applied to the replaced values.

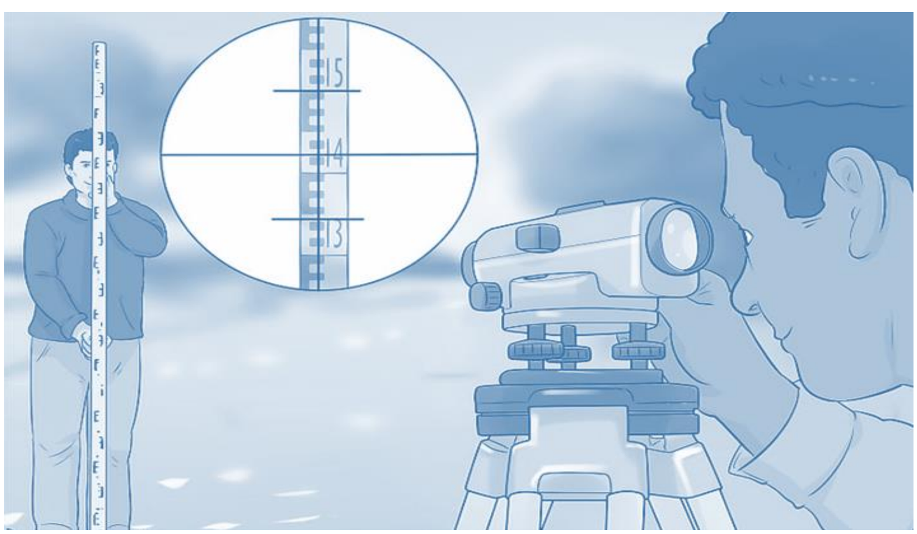
d. Sketch illustrating field-collected measurements for traverse turns including bearings, angles, and distances between points. If these items are adjusted, they shall be shown with a strikethrough applied to the replaced values and the adjusted value shall be written in red. Include reference to book and page numbers (or source information) for any existing control used for a starting point or a tie in or closure.

e. Sketch to illustrate location of traverse point with reference ties to at least three permanent features. These need to include the name of any adjacent roadway and should be done so that the control point can be recovered as easily as possible for any future work in the area. Be descriptive. Include pole numbers, house numbers, cross streets, tree species, etc.

ii. Only place one traverse point per page.

iii. Adjusted coordinate values for fly points may be entered in the field book but must be marked clearly with the words "fly point".

iv. Level runs must be performed to accompany any traverse point or line set. PSD will not accept trigonometric levels from traverse turns as a stand-alone means of establishing elevations for traverse. These level runs shall be documented in the field book and include reference to book and page number (or source information) for starting and tie in points. If a digital level is used, submit an appropriate MDOT SHA approved electronic file. An example of the book work for a level run is on the following page.



70

CE 446821 CECIL CO.

MD-272 BRIDGE # 07036 OVER AMTRAK

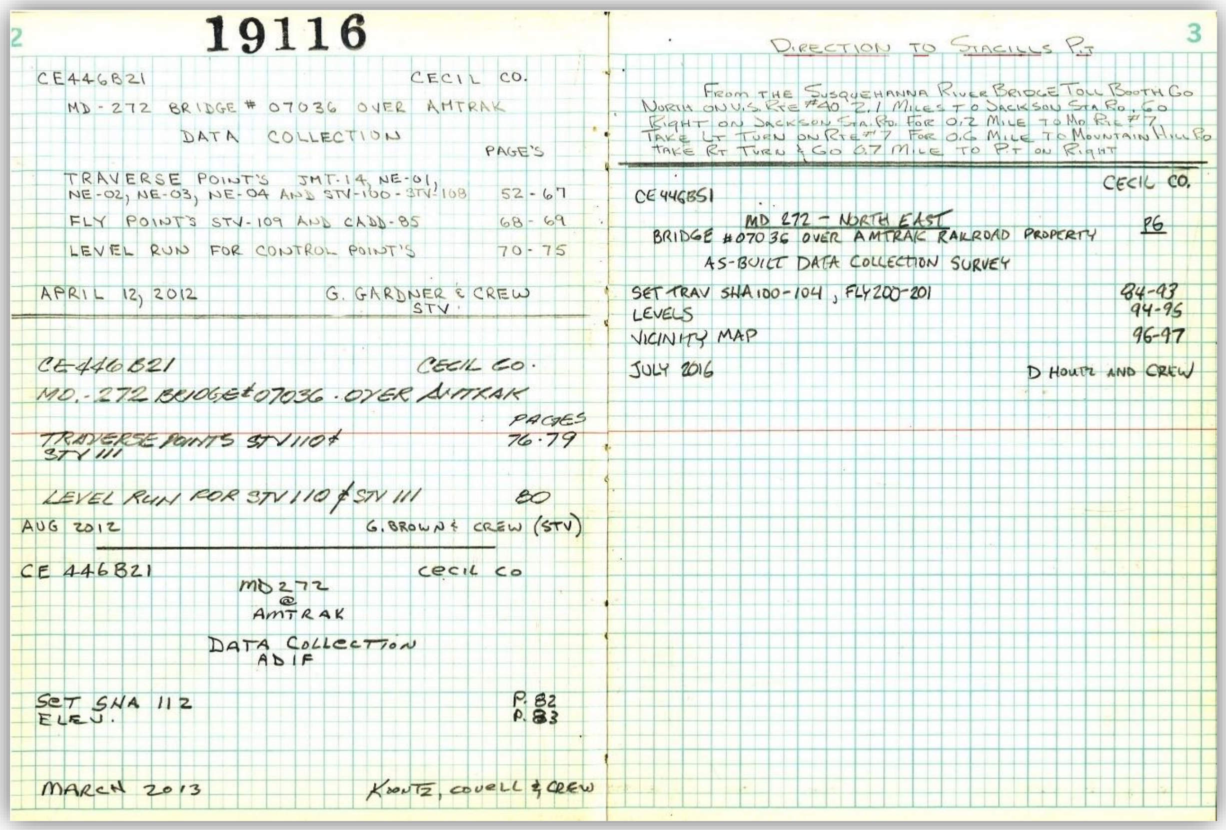
LEVEL RUN FOR NE-01, NE-02, NE-03, NE-04, JMT-14
AND STV-100 TO STV-108

	BM L118 (DISK) NGS DATA SHEET			NAVD 88
	8.71	79.27		70.56
⊼	5.75	82.20	2.82	76.45
	TBM JMT-14 (CECIL CO. DISK) BOOK 25595			
	2.74	81.83	3.11	79.09
	TBM NE-01 (REC) BOOK 25595 PAGE-10			
	0.95	73.42	9.36	72.47
	TBM STV-100 (REC) THIS BOOK PAGE-53			
	5.77	68.86	10.33	63.09
	TBM NE-02 (RR/SPIKE) BOOK 25595 PAGE-11			
	12.03	74.80	6.09	62.77
	BM STV-11 ("+" CUT) BOOK-25171 PAGE-70			
	0.19	71.62	3.37	71.43 VS 71.44 ERR -0.01
	TBM STV-101 (MAG NAIL) THIS BOOK PAGE-56			
	0.58	60.07	12.13	59.49
⊼	2.63	50.32	12.38	47.69
	BM CADD-90 (REC) BOOK 25171 PAGE-72			
	0.11	42.16	8.27	42.05 VS 42.01 ERR +0.04
⊼	0.33	28.46	14.03	28.13
	TBM NE-03 (REC) BOOK-25595 PAGE-12			
	2.66	22.11	9.01	19.45
⊼	4.68	17.15	9.64	12.47
	TBM NE-04 (MAG NAIL) BOOK 25595 PAGE-13			
	6.27	19.36	4.06	13.09

CONTINUE ON PAGE-72

71

v. Index shall indicate party chief, crew, date, project, location (county and route), notable weather, what points were set, intended purpose, date set, and by whom the work was done.



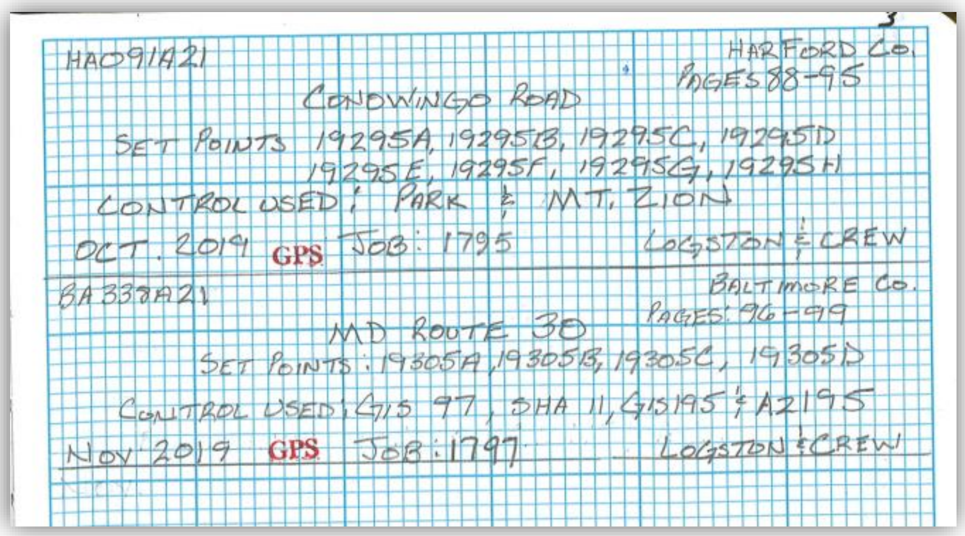
2
19116
CE446B21 CECIL CO.
MD - 272 BRIDGE # 07036 OVER AMTRAK
DATA COLLECTION
PAGE'S
TRAVERSE POINT'S JMT-14, NE-01, NE-02, NE-03, NE-04 AND STV-100 - STV-108 52 - 67
FLY POINT'S STV-109 AND CADD-85 68 - 69
LEVEL RUN FOR CONTROL POINT'S 70 - 75
APRIL 12, 2012 G. GARDNER & CREW STV

CE-446 B21 CECIL CO.
MD.-272 BRIDGE #07036 · OVER AMTRAK
PAGES
TRAVERSE POINTS STV 110 & STV 111 76 · 79
LEVEL RUN FOR STV 110 & STV 111 80
AUG 2012 G. BROWN & CREW (STV)

CE 446B21 CECIL CO
MD 272 @ AMTRAK
DATA COLLECTION ADIF
SET SHA 112 P. 82
ELEV. P. 83
MARCH 2013 KOONTZ, COVELL & CREW

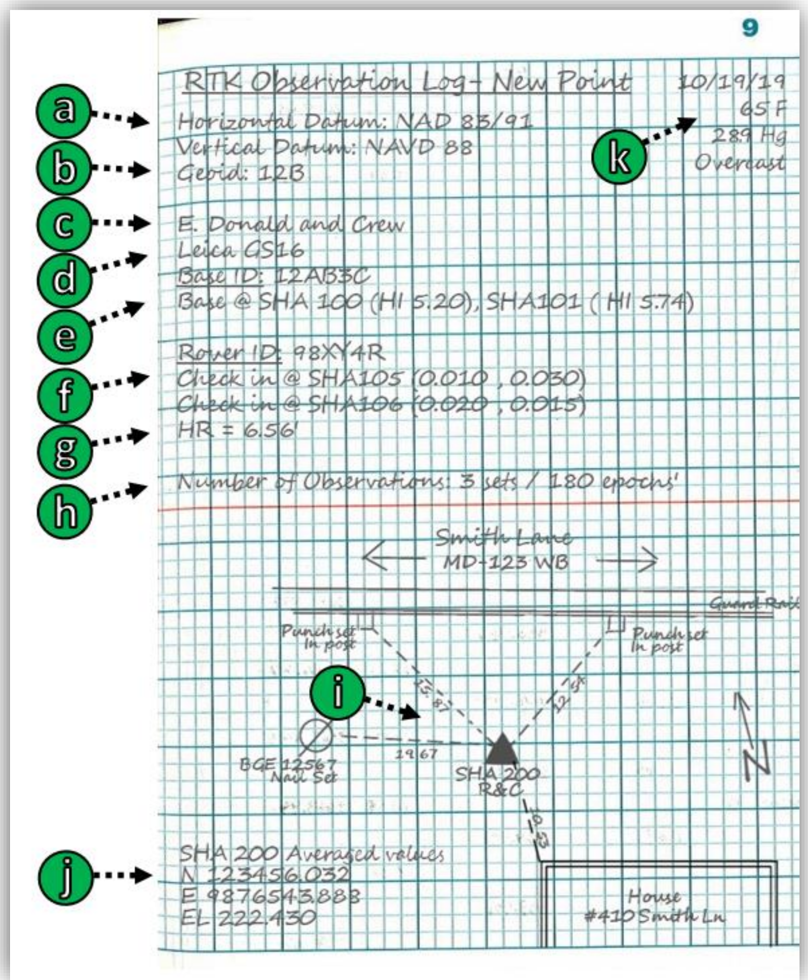
3
DIRECTION TO STACILLS PIT
FROM THE SUSQUEHANNA RIVER BRIDGE TOLL BOOTH GO NORTH ON U.S. RTE #40 2.1 MILES TO JACKSON STA RD. GO RIGHT ON JACKSON STA. RD. FOR 0.2 MILE TO MD RTE #7 TAKE LT TURN ON RTE #7 FOR 0.6 MILE TO MOUNTAIN HILL RD TAKE RT TURN & GO 0.7 MILE TO PIT ON RIGHT
CE446B51 CECIL CO.
MD 272 - NORTH EAST
BRIDGE #07036 OVER AMTRAK RAILROAD PROPERTY P6
AS-BUILT DATA COLLECTION SURVEY
SET TRAV SHA 100-104, FLY 200-201 84-93
LEVELS 94-95
VICINITY MAP 96-97
JULY 2016 D HOUTZ AND CREW

vi. Index notes for GPS work shall include control points set and control points used.



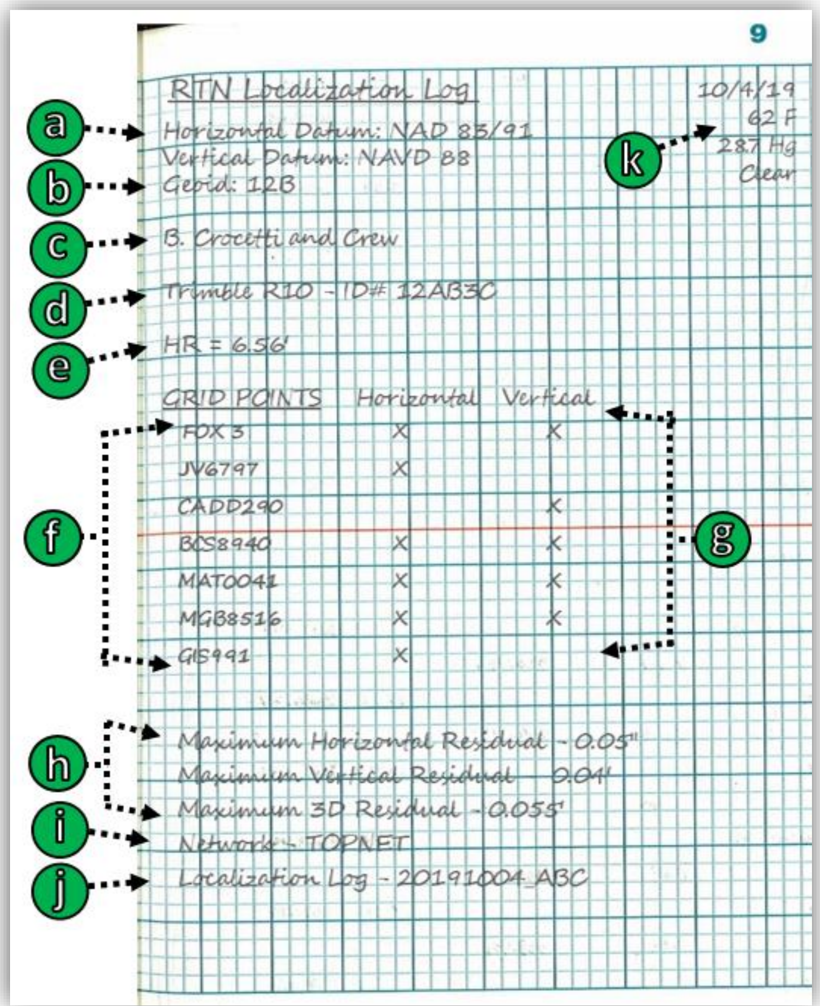
HA091A21 HARFORD CO.
PAGES 88-95
CONOWINGO ROAD
SET POINTS 19295A, 19295B, 19295C, 19295D, 19295E, 19295F, 19295G, 19295H
CONTROL USED: PARK & MT. ZION
OCT. 2019 GPS JOB: 1795 LOGSTON & CREW
BA338A21 BALTIMORE CO.
PAGES: 96-99
MD ROUTE 30
SET POINTS: 19305A, 19305B, 19305C, 19305D
CONTROL USED: GIS 97, SHA 11, GIS195 & A2195
NOV 2019 GPS JOB: 1797 LOGSTON & CREW

vii. For each new RTK traverse point set, bookwork must be performed to document the establishment of the control point. The following details shall be included as shown below in the example. This bookwork must to be done in addition to filling out the RTK Observation Logs as shown in section 9.E.



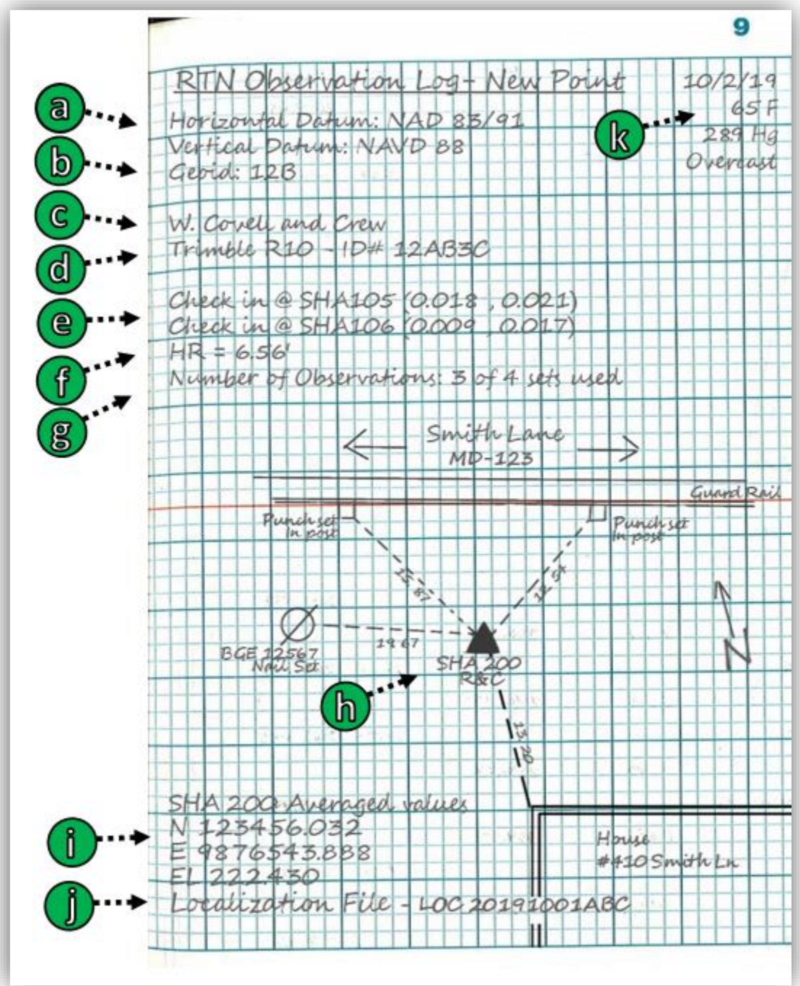
a. Datums
b. Geoid used for observations
c. Party chief
d. Instrument make and model
e. Base information including ID number and base position(s)
f. Rover information including ID number and check shots
g. Height of rod
h. Number of observations
i. Control point sketch including: point name, material, location with reference to roadway or landmarks, a north arrow, and three distance ties
j. Averaged values for new control point. Any adjustment to the averaged value shall be shown in red with a red strikethrough the original coordinate (as shown in section 1.F.i.)
k. Date, weather, and atmospheric conditions

viii. If a localization is performed for RTN surveys, bookwork must be performed to document the localization procedure and all control points set thereafter. The following layout shall be used to document the localization. This must be done in addition to filling out the appropriate RTN Localization Log as shown in [section 9.F](#).



a. Datums
b. Geoid used for observations.
c. Party chief
d. Instrument make and model with ID number
e. Rod height
f. Localization grid points
g. Indication whether a point was held horizontally, vertically, or both ways
h. Maximum residuals
i. Network service used
j. Localization log file name
k. Date, weather, and atmospheric conditions

ix. For each new RTN traverse point set, bookwork must be performed to document the establishment of the control point. The following details shall be included as shown below in the example. This bookwork must to be done in addition to filling out the RTN Observation Logs as shown in section 9.G.



a. Datums
b. Geoid used for observations
c. Party chief
d. Instrument make, model, and ID number
e. Check shot information
f. Height of rod
g. Number of observations
h. Control point sketch including: point name, material, location with reference to roadway or landmarks, a north arrow, and three distance ties
i. Averaged values for new control point. Any adjustment to the averaged value shall be shown in red with a red strikethrough the original coordinate (as shown in section 1.F.i.)
j. Localization filename
k. Weather and atmospheric conditions

<u>G. Deliverables:</u> Specifics for assignments will be included in every request. All accuracy standards set forth in the first section of this manual will apply to all traverse turned in. General deliverables for traverse are as follows.

i. RW5 file for all traverse turns. This file shall be separate from any data collection or associated work that is turned in. Traverse files shall be named to indicate county, route number, year, month, and type of work (as described in section 1.A.iv.b.)

ii. Control drawing file including the following: SHA or consultant firm, contract and task number, FMIS charge number, horizontal and vertical datums, project combined scale factor point (grid to ground), linework for traverse, adjusted angles and distances, references to field books, point descriptions, last date of field work, and any other pertinent info. This file shall be named "mCO", "S" for survey or "A" for aerial, and indicate the route. E.g. mCO-S000_MD123.dgn.

iii. If any edits are made to your control files, they must be done in a duplicate file named to indicate that the file has been edited. The traverse file is expected to be a raw unedited file with field borne information.

iv. Bookwork as described above.

v. Final adjusted coordinates shall be submitted in .CSV and .TXT format including point name, northing, easting, elevation and description.

vi. NGS Data Sheets, control cards or existing field notes for control points used in the control survey.

vii. If any adjustments are performed to your traverse, a least squares adjustment report must be provided with the final deliverable. Acceptable reports shall indicate an adjustment that passes a two-sigma (95% confidence) Chi Square Test and the relative and positional semi-major error ellipses.

viii. GNSS observation files, proprietary and RINEX format for Static GPS.

ix. Ephemeris file used for processing raw data for Static GPS.

x. Observation logs for each setup for GNSS. Logs will be provided by MDOT SHA Area Engineer at the time of assignment.

xi. Traverse setup sheets for each setup of conventional traverse establishment. (See example in section 9.D.i.)

xii. Electronic files are typically turned in on a cd or flash drive. It may be acceptable to email or submit files through ProjectWise or an FTP site with advance approval.

2. Datums and Adjustments

A. Datums: Unless specifically directed to use a different realization, all work for the MDOT SHA Plats and Surveys Division is to be completed using the following guidelines.

For standard assignments, MDOT SHA tasks shall be performed on the North American Datum of 1983, 1991 realization (NAD 83/91) and the North American Vertical Datum of 1988 (NAVD 88). For special projects like large corridor studies, we may allow the use of the North American Datum of 1983, 2011 realization (NAD 83/2011). Datums for the project will be specified at the time of assignment for all tasks.

The geoid used for each task should be determined based on the table below. For most tasks using leveled orthometric heights, the most current geoid should be used. However, for any job on NAD 83/91 that requires elevations to be established by combining an ellipsoid height and geoid height, the Geoid "03" should be used in combination with the appropriate ellipsoid.

	Standard Assignments		Special Projects	
Horizontal Datum	NAD 83/1991		NAD 83/2011	
Vertical Datum	NAVD 88		NAVD 88	
Elevation Derived From	Orthometric Height	Ellipsoid Height + Geoid Height	Orthometric Height	Ellipsoid Height + Geoid Height
Geoid Model	Most Current/As Directed	Geoid 03	Most Current/As Directed	

B. Units of Measurement: All tasks for the MDOT SHA Plats and Surveys Division shall be completed using the US Survey Foot, unless otherwise directed.

C. Adjustments: Least squares adjustment software (StarNet, SurvNet, etc.) shall be used. The project settings, equipment tolerances and files required should follow the guidelines as shown in the following example. All report settings associated with tolerances and standard errors for a survey instrument shall be based upon the actual capabilities of the instrument. These are generally specified by each manufacturer. **However, best practice is for field testing to be performed for each instrument to determine its actual accuracy.**

i. Project settings: The following pages contain screen shots of StarNet Project Options settings tabs that identify information that shall be included in all listing reports. If other adjustment software is used, similar parameters must be set. Any deviation from these settings shall be reported and approved before project delivery.

ii. Equipment tolerances: Tolerance settings within the software shall reflect the accuracy capabilities of the instrument used for the survey to be determined by field testing or be set based on the equipment manufacturer's specifications for horizontal and vertical angle accuracies. The correct standard error values shall be used. Reasonable centering errors shall also be applied in accordance with manufactures specifications.

iii. Files required with project submission: Any RW5 and DAT files, both unedited and edited versions shall be supplied. The listing file and a network plot showing the project shall also be included. If GPS data or leveling data is included with the project, all unedited and edited files must also be included.

iv. Least squares adjustment header information required: The header for the least squares adjustment shall include the following information.

Requestor:

FMIS charge number:

Route:

Termini:

District:

County:

Job reference number if any:

Equipment information: (Include type of instrument and variant.)

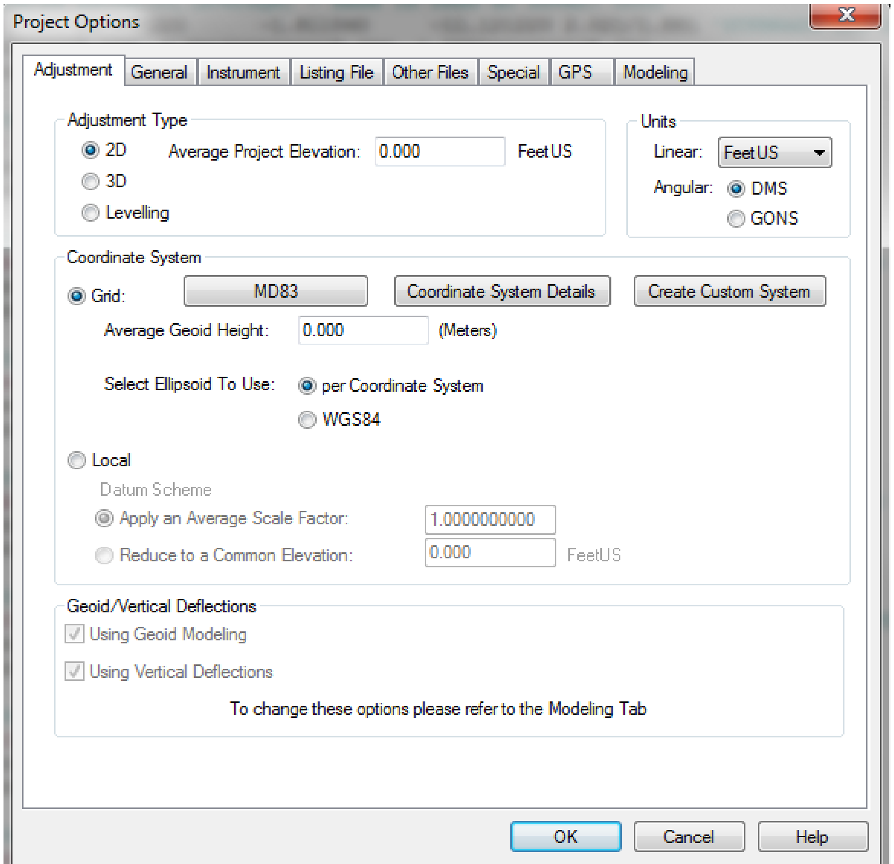
Serial number:

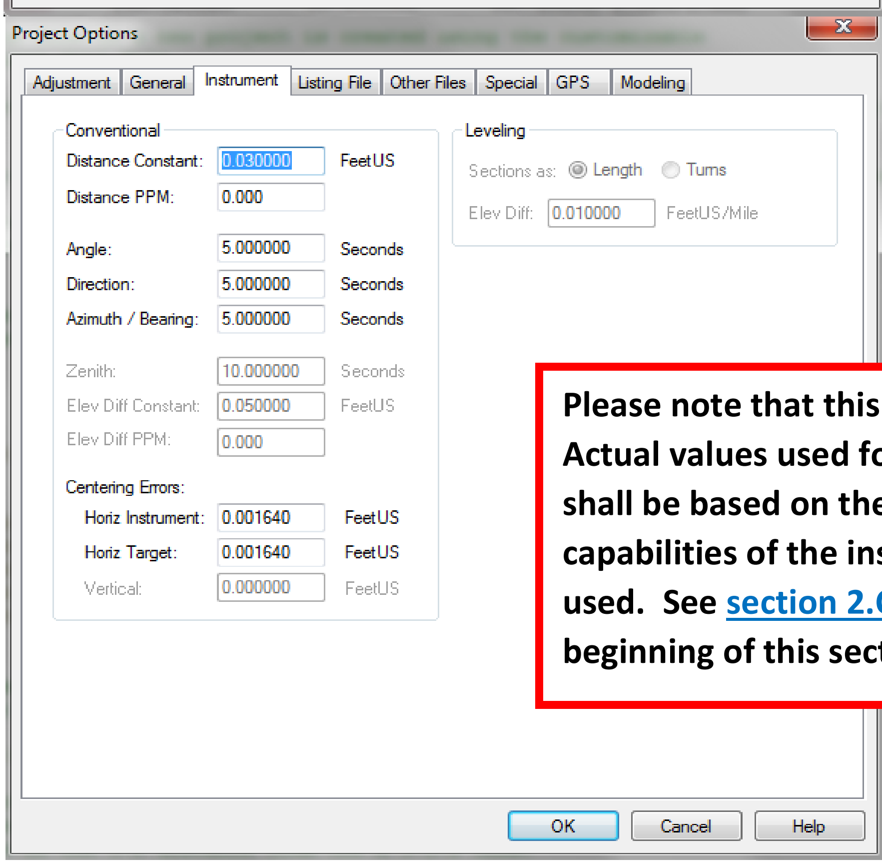
Adjusted by:

Project path:

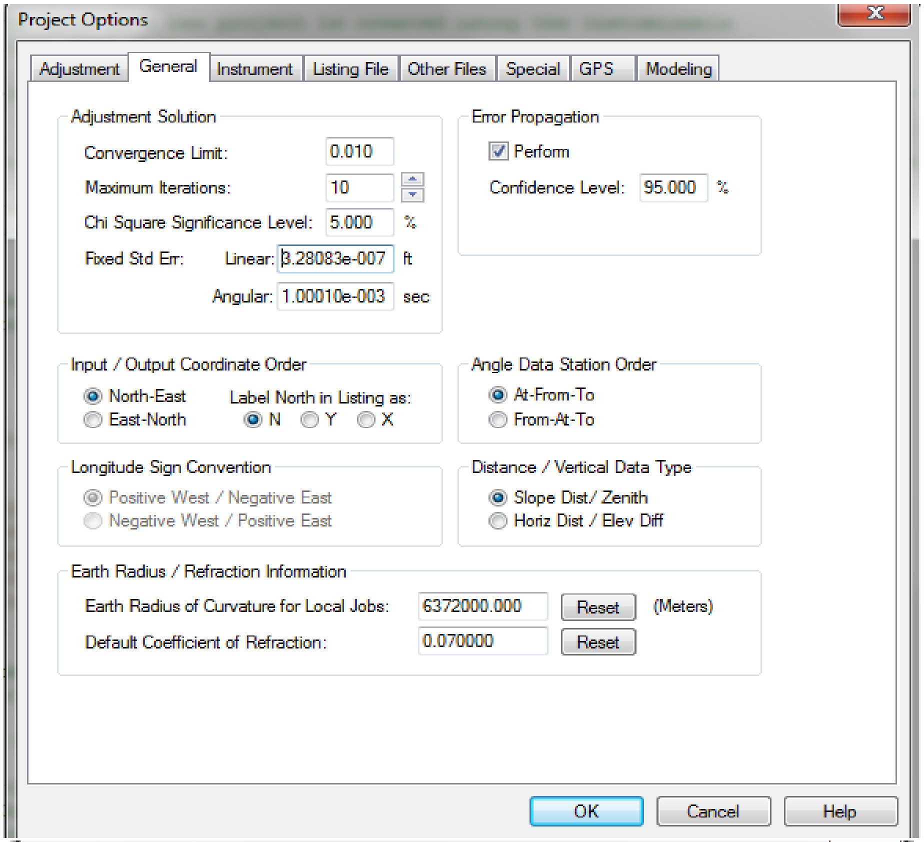
MDOT SHA or consultant:

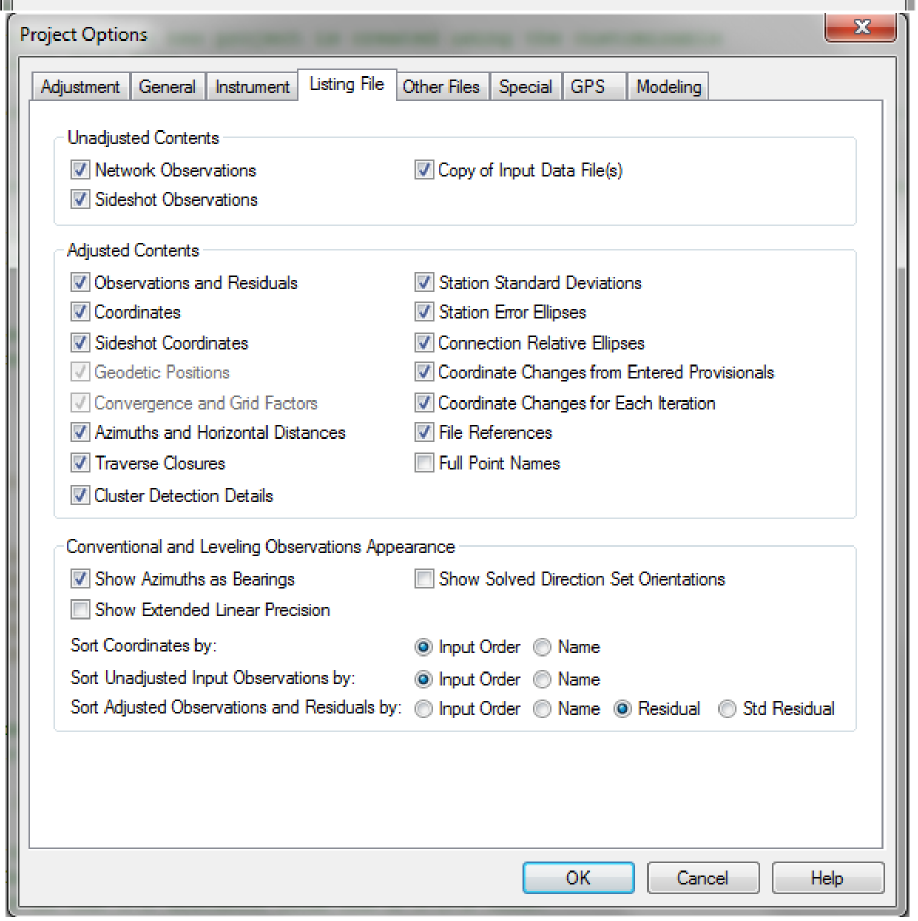
Crew chief:

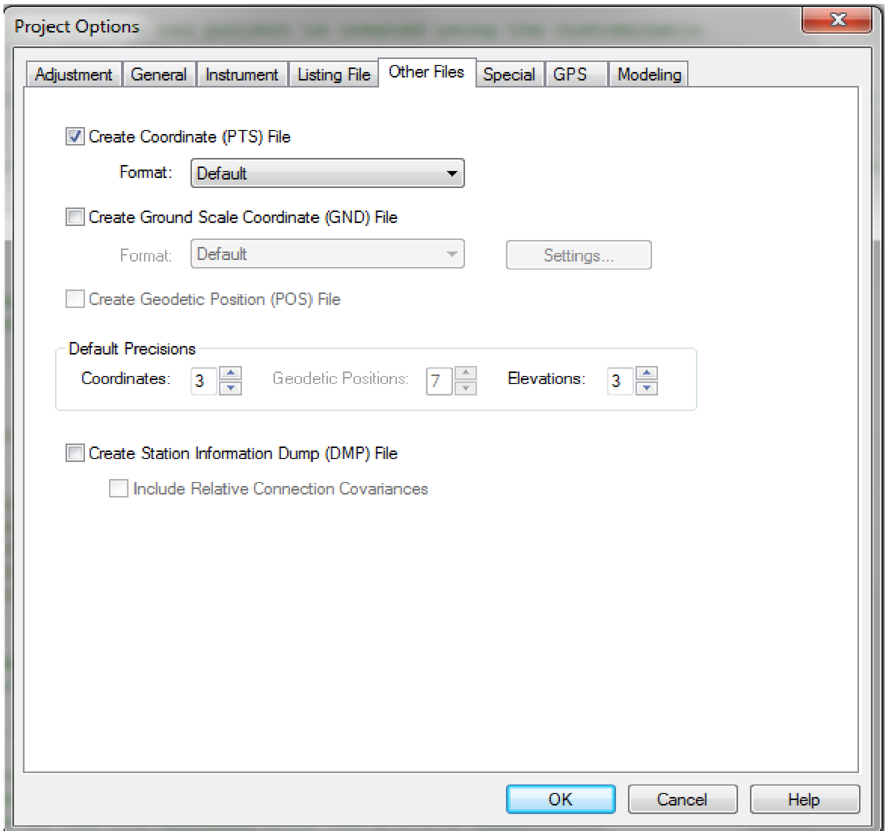


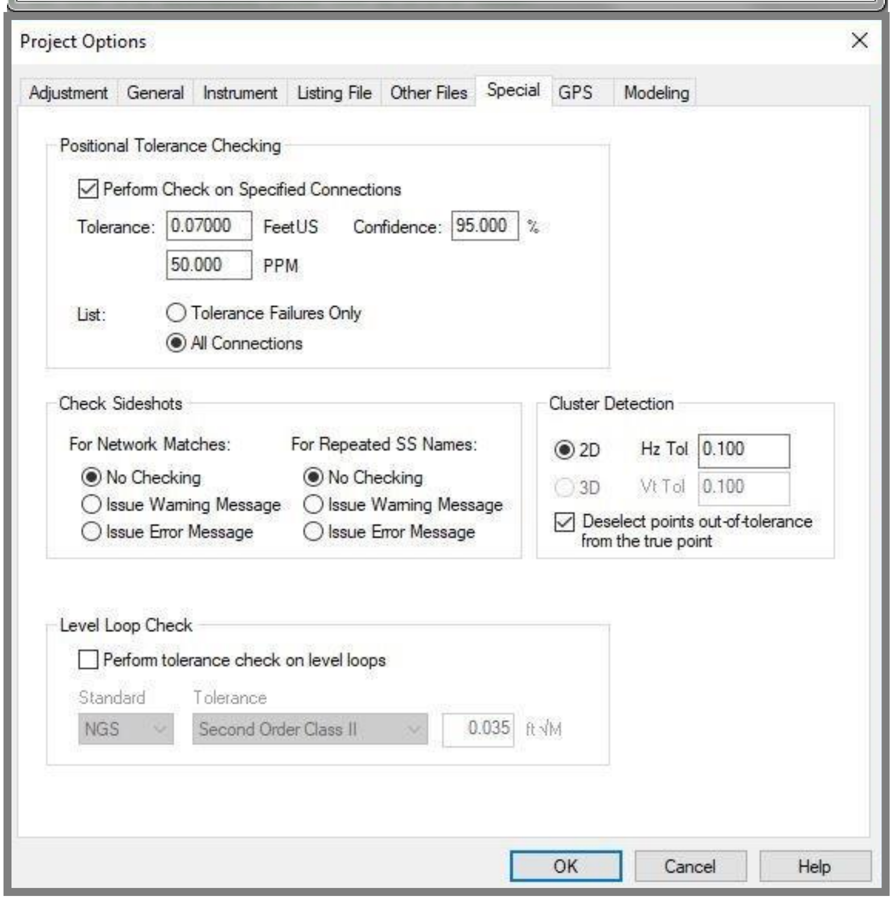


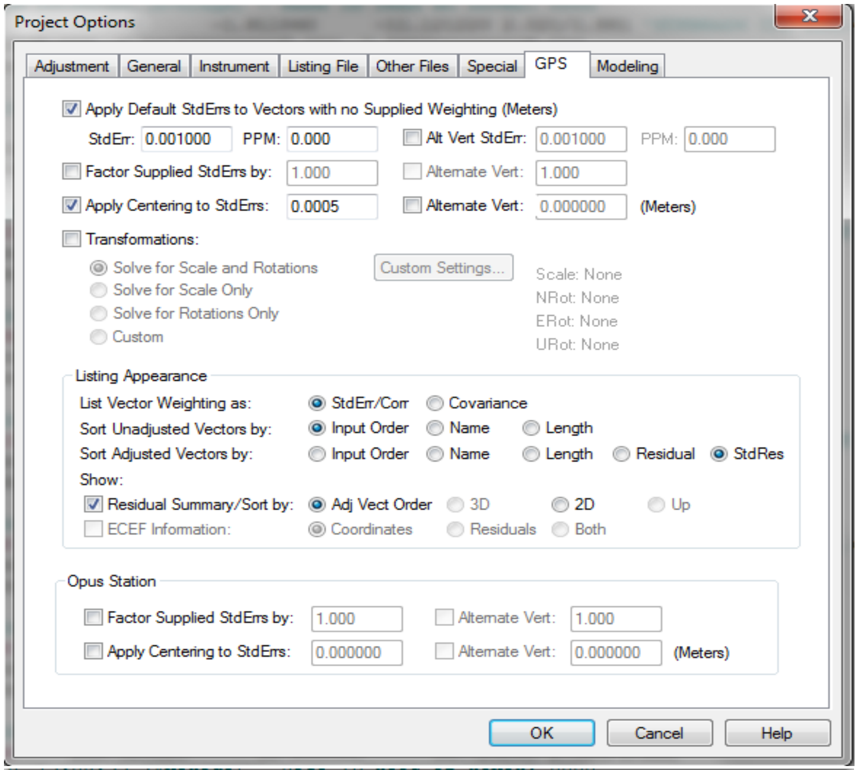
Please note that this is an <u>example</u>. Actual values used for this section shall be based on the accuracy capabilities of the instrument being used. See <u>section 2.C.</u> at the beginning of this section.

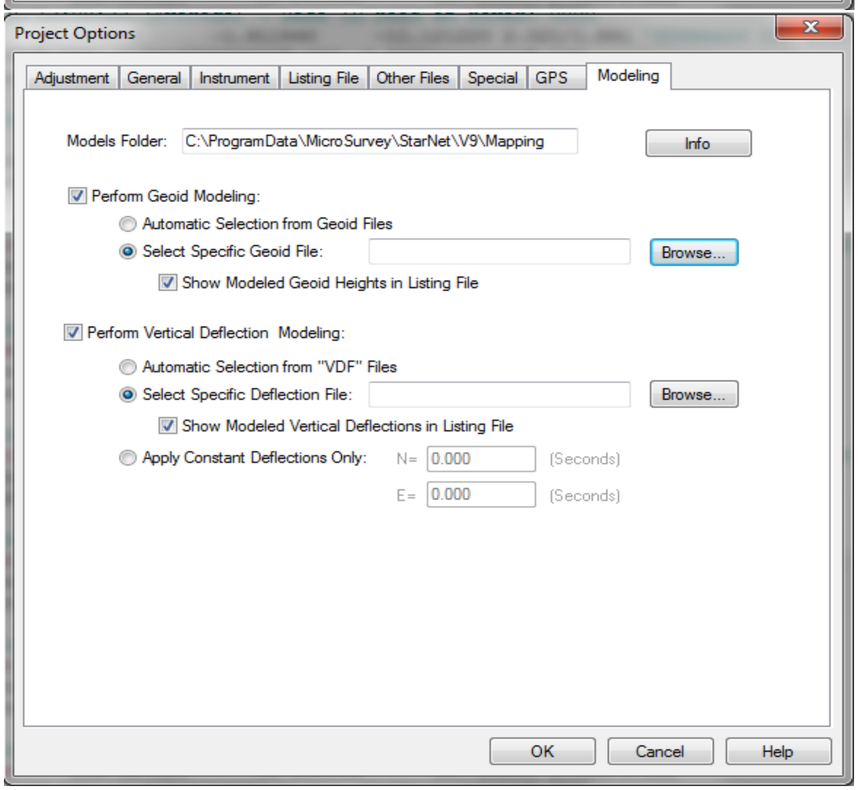

Project Options
Adjustment | General | Instrument | Listing File | Other Files | Special | GPS | Modeling
Adjustment Solution
Convergence Limit: 0.010
Maximum Iterations: 10
Chi Square Significance Level: 5.000 %
Fixed Std Err: Linear: 3.28083e-007 ft
Angular: 1.00010e-003 sec
Error Propagation
Perform
Confidence Level: 95.000 %
Input / Output Coordinate Order
North-East
East-North
Label North in Listing as: N Y X
Angle Data Station Order
At-From-To
From-At-To
Longitude Sign Convention
Positive West / Negative East
Negative West / Positive East
Distance / Vertical Data Type
Slope Dist/ Zenith
Horiz Dist / Elev Diff
Earth Radius / Refraction Information
Earth Radius of Curvature for Local Jobs: 6372000.000 Reset (Meters)
Default Coefficient of Refraction: 0.070000 Reset
OK
Cancel
Help


Project Options
Adjustment | General | Instrument | Listing File | Other Files | Special | GPS | Modeling
Unadjusted Contents
Network Observations
Copy of Input Data File(s)
Sideshot Observations
Adjusted Contents
Observations and Residuals
Station Standard Deviations
Coordinates
Station Error Ellipses
Sideshot Coordinates
Connection Relative Ellipses
Geodetic Positions
Coordinate Changes from Entered Provisionals
Convergence and Grid Factors
Coordinate Changes for Each Iteration
Azimuths and Horizontal Distances
File References
Traverse Closures
Full Point Names
Cluster Detection Details
Conventional and Leveling Observations Appearance
Show Azimuths as Bearings
Show Solved Direction Set Orientations
Show Extended Linear Precision
Sort Coordinates by: Input Order Name
Sort Unadjusted Input Observations by: Input Order Name
Sort Adjusted Observations and Residuals by: Input Order Name Residual Std Residual
OK
Cancel
Help


Project Options
Adjustment
General
Instrument
Listing File
Other Files
Special
GPS
Modeling
Create Coordinate (PTS) File
Format: Default
Create Ground Scale Coordinate (GND) File
Format: Default
Settings...
Create Geodetic Position (POS) File
Default Precisions
Coordinates: 3
Geodetic Positions: 7
Elevations: 3
Create Station Information Dump (DMP) File
Include Relative Connection Covariances
OK
Cancel
Help


Project Options
Adjustment
General
Instrument
Listing File
Other Files
Special
GPS
Modeling
Positional Tolerance Checking
Perform Check on Specified Connections
Tolerance: 0.07000 FeetUS
Confidence: 95.000 %
50.000 PPM
List:
Tolerance Failures Only
All Connections
Check Sideshots
For Network Matches:
No Checking
Issue Warning Message
Issue Error Message
For Repeated SS Names:
No Checking
Issue Warning Message
Issue Error Message
Cluster Detection
2D
Hz Tol 0.100
3D
Vt Tol 0.100
Deselect points out-of-tolerance from the true point
Level Loop Check
Perform tolerance check on level loops
Standard
Tolerance
NGS
Second Order Class II
0.035 ft √M
OK
Cancel
Help

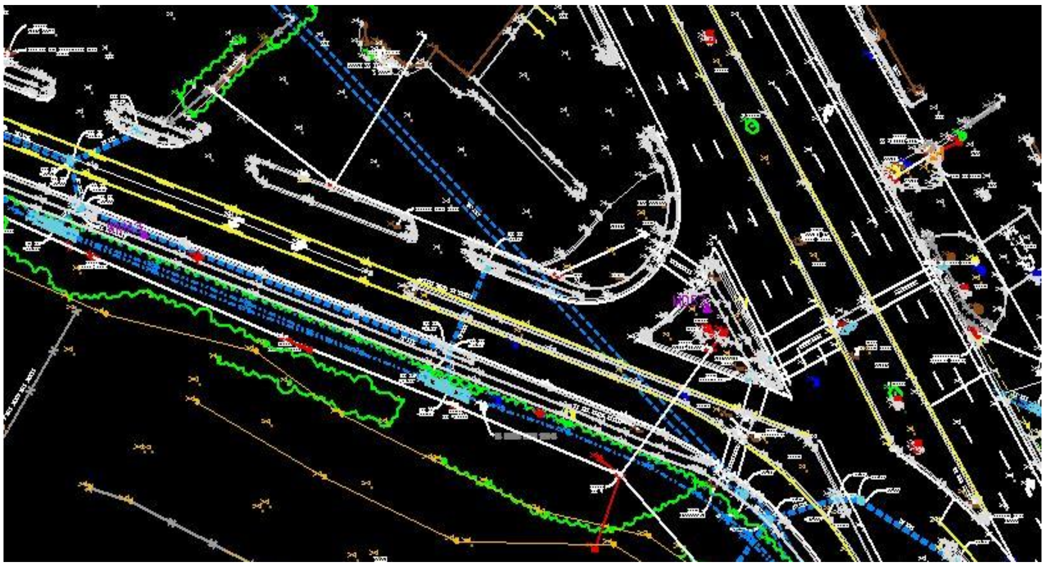




The appropriate geoid and vertical deflection files can be downloaded from the following link: https://www.ngs.noaa.gov/GEOID/

3. Topographic Mapping, Scanning and Photogrammetry Surveys

Topographic maps are made from data collected by field crews. These maps are used to model existing and as-constructed conditions in a specific area. Analysis of this data throughout the area of interest allows MDOT SHA to determine needs for a project or improvement based on field located information. Engineers use these maps as a base for their design to identify obstacles and establish project limits by the current conditions on site. When performing a topoographic mapping task it is important to consider the end user(s) and the purpose for each survey. They can vary greatly in terms volume, content and the amount of details necessary.



A. Materials Provided to Crew:

i. Limits map or file.

ii. Scope letter/survey request letter with details for assignment.

iii. Field book with free pages to document the field survey information.

iv. Information for available control points within or surrounding the work area.

v. Job card.

vi. Assignment and Delivery Checklist including starting data collection shot number and starting traverse number.

vii. PROJECTrack Survey Crew Daily Report template.

viii. Copies of property owner notification letter.

ix. Lane closure permit.

x. Task specific information including as-built plans, wetlands location maps, sketches, and detailed location markups.

xi. Project or property specific requirements including work conditions, concerns or restrictions.

B. Mapping Limits: All topography within the scope requested shall be located and drainage taken out to at least one structure beyond the scope as applicable. Design and terrain requirements may dictate broader coverage. In general, all topography which may in any way affect the design and construction of the highway and the acquisition of the necessary right of way shall be located.

C. Procedures and Guidelines: Topographic features may be located by conventional total station, robotic total station or RTK topo measurements. The use of RTK topo methods requires prior approval (see conditions below). All surveys must meet the accuracy requirements as determined by PSD management.

i. Limit conventional data collection shots to a 300-foot radius from any control point.

ii. All SHA data collection coding shall be consistent with SHA code sheets and SHA attributes shall be used to add descriptions and/or notes as necessary to data collection shots. If a code does not exist for a specific feature being located, locate the feature as a miscellaneous point (MISCPT) or run associated line work as a miscellaneous break line (MISCBL) and use notes to describe the feature.

iii. Each setup shall be recorded on data collection setup sheets including occupy and backsight points, HI measurements, shot numbers, and dates collected.

iv. For each setup, check shots shall be recorded at least at the start and end of the setup. Best practice includes check shots to additional traverse points.

v. On a typical job, shot numbers will start at #1000. Check the supplied job card for each task for any deviation from this practice or special instructions.

vi. To establish consistent contouring, locate continuous features (roadway, curbing, and break lines) with at least one shot for every 50 feet. Additional shots at shorter intervals may be required to properly model certain planimetric features. Make sure that open areas are covered similarly with spot grade shots.

vii. Some data collection being performed for design purposes may require design scale work and require a tighter grid of shots. (e.g. Typically, bridge decks are located with shots every 10 feet.) In general, shot spacing shall match the design scale of the project. These details will be included with information provided at the start of a task.

viii. Data collection coverage is expected to be complete and to produce accurate mapping for the entire request area through the farthest shot on the perimeter of the data collected. If there is a shot in an area, the end user should be able to use the surface produced in that area, assuming it to be complete in detail. Unless specified at the time of assignment, all existing planimetric and topographic features shall be collected.

ix. If data collection is performed using RTK or RTN devices and methods, the following guidelines will apply. **Use of these methods requires advance approval from PSD.**

a. Epochs shall be recorded for 5 seconds per location shot.

b. Tolerances for HRMS (0.025 feet) and VRMS (0.050 feet) shall be set.

c. Tolerance for PDOP (2.0) shall be set.

d. If RTK or RTN methods are used for sizable areas of data collection, or will be merged with conventional data collection, conventional check shots shall be taken to coincide with RTK/RTN shots using the code "CKSHOT" with notes to indicate the feature being shown. These shots will be compared to verify accuracy throughout the RTK/RTN data collection work.

e. Any work turned in that does not meet accuracy standards will have to be redone. PSD Management reserves the right to restrict the use of RTK and RTN at their discretion.

D. Mapping Content: The following decribes the detail that is typically required in a data collection/mapping task. Area Engineers will discuss any project specific requirements with the party chief at the time of assignment.

i. Locate the face or perimeter of all buildings and structures including attributes and/or notes for description, face material, type, use, and if the structure or building has a basement. As per ADA requirements, it may be necessary to locate step elevations, first floor elevations and basement elevations.

ii. Locate all visible utility features such as poles, guy wires, hand boxes, pedestals, manholes, structures, meters, valves, fire hydrants, and utility markers. Include ownership and identification numbers. Some requests may include location of marking for subsurface utility features and overhead wires.

iii. Do not locate overhead wires or paint lines associated with underground utilities unless specifically requested.

iv. Curbing is to be located as bottom of curb (BC) on the flow line at the bottom of the face of curb and top of curb (TC) on the top back side of the curb. The outer edge of the gutter pan does not need to be shot unless specifically requested.

v. Curb templates are acceptable, but may not be used when changes in style, shape, and height of curb exist. All depressions in the curb must be shown.

vi. In lieu of locating any painted lines in a roadway surface, be sure to locate relevant paving joints where present and fill in large open areas in the surface with paving spot grades when necessary.

vii. Locate signalization features including signal poles, pedestrian crossing signal poles, lane lines, and stop bars. As per ADA requirements it may be necessary to locate pedestrian crossing push buttons and truncated dome mats.

viii. In accordance with the memorandum from May 30, 2012, all ADA compliance surveys will require location of:

> **a.** Truncated dome mats (*done as miscellaneous break lines around the edge of matting with a spot grade shot to label "truncated domes" in the center*).
>
> **b.** Pedestrian crossing push buttons (*shot directly at the center of the button with a rod height of zero for 3-dimensional location to ensure accessibility*) as well as the pole they are attached to.
>
> **c.** Step elevation shots (two shots, one on each side of step) must be taken on the first two steps of any run within the limits of these requests.
>
> **d.** Roof drains and/or downspouts and any associated outfalls for them, especially in conjunction with sidewalks and curbing.
>
> **e.** Footers for buildings or porches if they are exposed.
>
> **f.** Thresholds for any doorways which shall be accompanied by a close spot grade shot for determining possible water entries.

ix. Locate all storm drain structures and invert shots for all pipes including enough information to determine direction of flow to or from the furthest structure in the work area.

> **a.** This includes location of structures and inverts for the next upstream and downstream structure outside the request area**.**

b. Feature code attributes shall be used to note descriptions for pipe/structure material and pipe sizes.

c. Pipe sizes shall be indicated by feature code, including a letter at the end of each pipe invert shot starting with “PINVA”, indicating a pipe 12-inches in diameter, and advancing as shown in the MDOT SHA data collection code list.

d. Any pipe that is smaller than 12-inches or of a different size than accounted for in the code sheet shall be coded as “PINV” with a note of the actual diameter.

e. Elliptical pipes will require two measurements and notes to reflect field measured dimensions. The letter used in the shot code (e.g. PINV”B”) shall reflect the largest dimension of the pipe.

f. Direction-only shots for pipes are only to be used as a last resort when a pipe’s connections cannot be determined.

x. It may be necessary for some structures/storm drain systems to be accompanied by sketches in a field book.

xi. Locate curbs, fences, walls, springs, ditches (showing direction of flow), hedges and trees (showing species and trunk diameters). This may include “champion” or “specimen” trees and associated tag numbers as well.

xii. For tasks requiring tree locations (typical requests will ask for location of trees 18” and larger). Trees shall be labeled with diameter at breast height (DBH) and species of tree. Identify tree species to the best of your ability.

xiii. Tasks may require location of champion or specimen trees. Make note of this when doing so and include any tag numbers associated with the trees in question.

xiv. Make note or show attributes to indicate nature of land use, i.e. pasture, cultivated field, woods, etc.

xv. When locating wetlands flagging, put these shots in a separate file from any regular data collection on the same task. Use attributes to note the flag numbers and classification of the wetland delineation.

xvi. When locating a bridge within a task:

a. All shots associated with the bridge deck, span, beams, scuppers and line work within the first and last bridge joints (or within the inner edge of the abutments) will be put in a separate file from the regular data collection.

b. All features attached to the ground (abutments, piers, wing walls, headwalls, and the road surfaces attached shall be kept in the regular data collection file.

c. It may be necessary to accompany locations with sketches and depending on the request multiple views/angles/schemes may be required. These sketches need to include dimensions and elevations for the structures depicted.

d. Typical location will include shots every 10 feet on the bridge deck and adjacent surfaces. Be sure to review the survey request for specific details.

E. Bookwork: When performing data collection surveys there are many reasons to provide accompanying bookwork. The most common reason is for traverse information as described above. Other reasons may include the following:

i. Bridge or structure sketches with appropriate dimensions and elevations as requested.

ii. Profile drawings for overhead wires or bridge clearances.

iii. Reference sketches for complex locations like 3-D models.

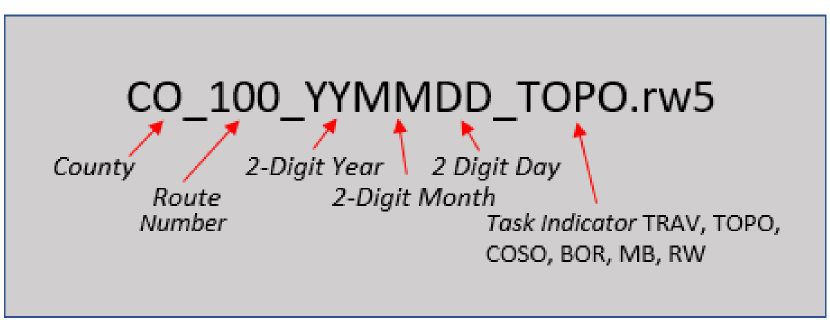
iv. Cross-section or profile sketch for detail information.

F. Deliverables: When a data collection assignment is complete the following materials shall be turned in.

i. Materials:

a. All necessary CADD files.

b. RAW data collection files (unedited version). Field data collection files shall be named to indicate county, route number, year, month, day (when file is started), and type of work (TOPO) as follows.



c. Edited and merged RW5 file.

d. Data collection setup sheets (Example in section 9.D.ii.).

e. Accompanying bookwork in PSD format.

f. Full color book scans in JPG format (Example in section 9.H.).

g. Photos for reference of data collection features.

h. Job card (Example in section 9.B.).

i. Assignment and Delivery Checklist (Example in section 9.C.).

j. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

k. Electronic files may be turned in on a cd or flash drive. It is also acceptable to email files to the task manager. You may also submit files through a ProjectWise deliverables folder or the MDOT FTP site with SHA approval. All physical deliverables are expected to be turned in within one to two business days of an electronic submission of files. **A survey is not considered to be delivered until all materials have been turned in.**

ii. Guidelines:

a. Separate files are required for traverse establishment, wetlands locations, bridge locations, and cross sections.

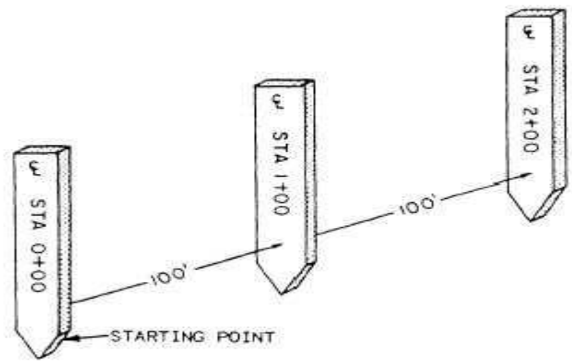
b. All work shall be checked for accuracy and coverage of the request area. All necessary edits to the data collection shall be made by the party chief and/or CADD processor and saved as an edited version.

c. All traverse, levels, and any necessary sketches to accompany data collection shall be completed in the MDOT SHA field book provided. All entries must be added to the index. All entries into the field book in addition to the altered index need to be scanned and submitted with deliverables in JPG format.

d. Any photos to be used as reference for the data collection shall be submitted with the work. Photos should include some reference to their significance and what is being shown. (i.e. attach photos to data collection shots in the RW5 file, name photo to correspond with a shot number, etc.)

4. Construction Stakeout Surveys

A construction stakeout is performed for each major project in the lead up to the start of construction. PSD will oversee the stakeout of the baseline of construction and all necessary spur lines for a project through the limit of work extents. The entire design for a site can be created with reference to these construction baselines, references, and benchmarks. These surveys are the backbone of a roadway construction site.



A. Materials Provided to Crew:

i. Plans for the project, including geometric layout, rights of way, limits of work, and limits of disturbance around work area.

ii. Electronic files associated with the baseline(s) to be staked.

iii. Deflection angles and any necessary curve data.

iv. Field book with free pages to document the field information.

v. Information for available control points within or surrounding work area.

vi. Job card.

vii. Assignment and Delivery Checklist.

viii. PROJECTrack Survey Crew Daily Report template.

ix. Copies of property owner notification letter.

x. Lane closure permit.

B. Guidelines:

i. Baselines of construction will be staked at 50-foot intervals and at all cardinal points, break-in-line points, and intersecting baseline points along the requested baseline(s).

ii. Cardinal, break-in-line, and beginning/end points shall be staked with rebars and caps (non-property corner caps), hubs and tacks, PK or MAG nails, masonry nails, etc.

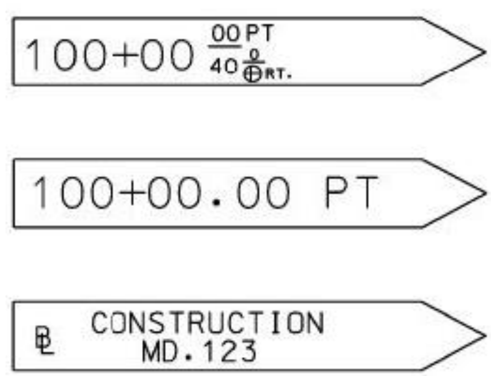
iii. Every effort shall be made to stake baselines direct. It may be necessary to use an offset for safety reasons or convenience of the contractor or a utility company involved in the project.

iv. 50-foot interval points only need a stake or nail. Each point shall be labeled with its baseline station(s) and any offset used.

v. If a baseline is laid out using an offset, the stationing shall be labeled so that stations are legible while facing the points from the centerline.

vi. Where an offset begins or changes, there shall be a stake placed on each line at that station. (e.g. If an offset is changed from centerline to 20 feet left at 100+00, a point should be staked on centerline and the new offset line at that station before moving forward).

vii. Stakes shall be marked with the station on the front of the stake and any offset distance and direction (e.g. 80.00 Left) along with “baseline of construction” on the back of the stake. Make sure to mark stakes to differentiate between multiple baselines on a project (e.g. Baseline “A”).



viii. Cardinal and breakpoints will be referenced to two permanent points set outside of the limits of disturbance where possible.

ix. Set vertical benchmarks outside the limit of disturbance at least every 1,000 feet for use by the contractor. If existing traverse will remain, they may be used for this purpose. Levels shall be performed on all benchmarks as part of the stakeout task.

x. Crews shall check that baseline geometry, stationing, bearings, and coordinates are correct using the geometric layout plans provided. Verify information before performing stakeout.

xi. RAW or RW5 data files from data collector with points stored "as staked" shall be part of your final deliverables.

xii. All work shall be documented in the MDOT SHA field book provided and must include a sketch of the baseline(s) staked. The sketch shall include all relevant baseline information including stations (at 50-foot intervals and including all cardinal points and break points), offsets, bearings, curve data, curve deflections, and materials set (i.e. hub and tack, PK Nail, MAG Nail, nail, stake, etc.). Benchmarks and reference points for the cardinal and break-in-line points shall be set outside the limits of disturbance and sketched in the field book.

xiii. Visual field checks shall be performed to verify that the line has been staked according to plans and procedures in this manual.

xiv. Some properties/parcels along a route may present concerns or conditions for entry that may require the crew to alter their procedure. In this case, the crew shall seek direction from the Area Engineer.

C. Bookwork: Construction stakeouts can take many forms. The associated bookwork is a record of what was staked and it shall provide sufficient information to recover the points staked and/or reestablish the baseline. The bookwork for construction stakeouts must include the following information:

i. Sketch for all points set, including baseline description, stations, and offsets.

ii. Northing and Easting Coordinates for cardinal points and reference points (including MDOT SHA specified datum).

iii. Material set must be labeled for each point set.

iv. Bearings for tangent sections of the baseline.

v. Any descriptors like POB, POT, PC, PCC, PRC, PT, etc.

vi. Curve data for any part of the baseline that is in a curve. This information will be provided to the crew on geometric layout sheets from construction plan sets.

vii. Deflection angles for points staked on a curve.

viii. Sketches for reference points for cardinal/end points, labeled with distances, offsets, and hand pull references.

ix. Depiction of the roadway and intersecting routes surrounding the points staked out.

x. Benchmarks with station, offset, and elevation information. Level runs must be included.

D. Deliverables:

i. Accurate layout of all requested baseline points, associated references, and benchmarks in the field.

ii. Bookwork as described above.

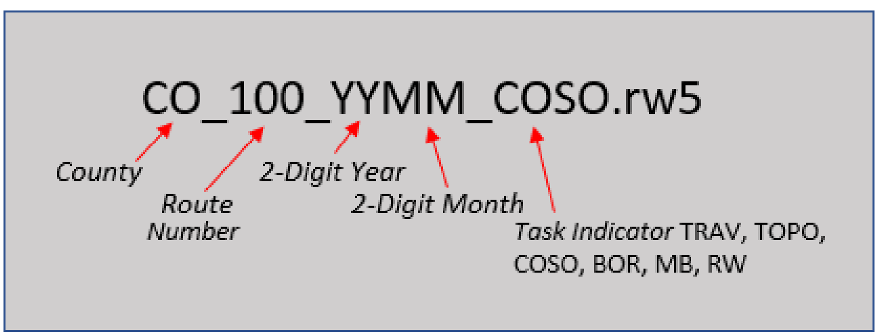
iii. Full color book scans in JPG format (Example in section 9.H.).

iv. Job card (Example in section 9.B.).

v. Assignment and Delivery Checklist (Example in section 9.C.).

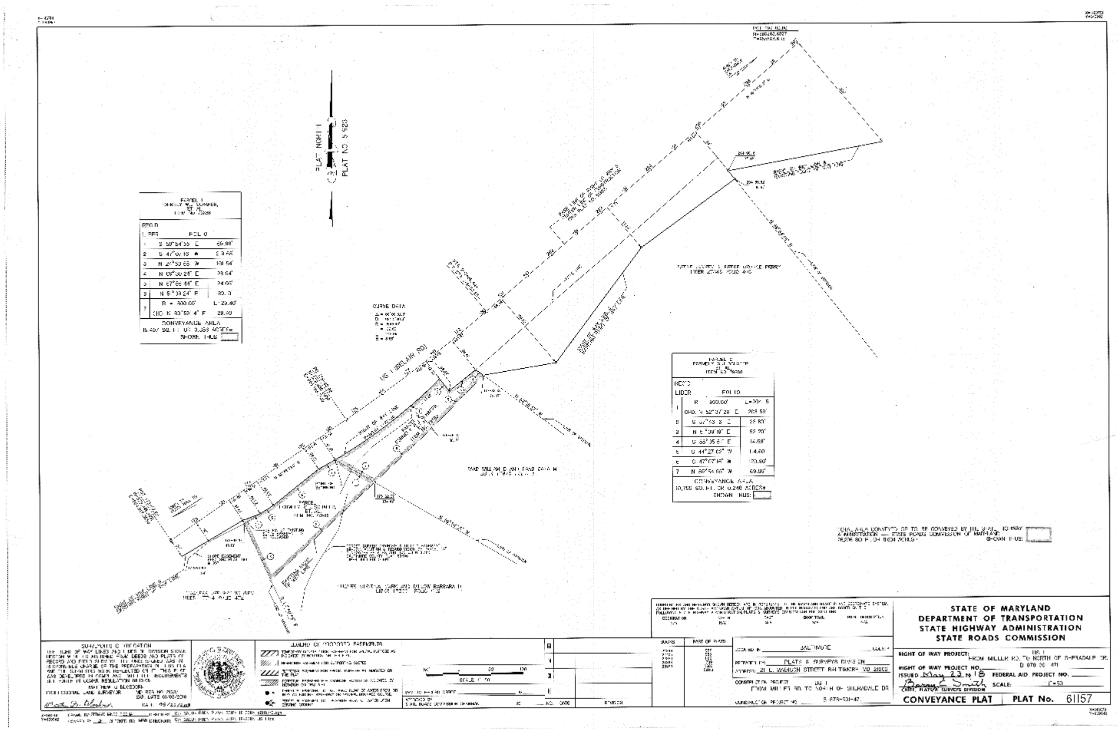
vi. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

vii. Crews may be requested to provide a RW5 and/or TXT file with stored "as-staked" values for points staked in the field. Field stakeout files shall be named to indicate county, route number, year, month, and type of work (COSO) as follows.



5. Right of Way Stakeout Surveys

Right of way stakeouts are performed for appraisals and evaluation for land acquistions or conveyances. Some of these assignments may pertain to a Board of Property Review (BPR Stakeout) hearing. These BPR stakeouts are typically on a strict schedule. When laying out right of way, the crew shall stake each line so that it may be seen continuously through the limits of the request.



A. Materials Provided to Crew:

i. Plat/Worksheet/Markup with requested parcels/item #'s highlighted.

ii. Coordinate values for points to be staked if available. If computations have not been performed, baseline information included on plats (station and offset values) will be used to determine locations for stakes.

iii. Information for available control points within or surrounding the work area.

iv. Job card.

v. Assignment and Delivery Checklist.

vi. PROJECTrack Survey Crew Daily Report template.

vii. Copies of property owner notification letter.

viii. Lane closure permit.

B. Materials To Be Staked:

i. Hub and guard are required on all **existing right-of-way** line breaks. The guard will be taped with orange ribbon and an orange flag.

ii. Hub and guard are required on all **right-of-way** line breaks. The guard will be taped with red ribbon and a red flag.

iii. Hub and guard are required on all **perpetual easement** breaks. The guard will be taped with yellow ribbon and a yellow flag.

iv. Hub and guard are required at all intersections of **lines of division** and existing right-of-way lines, right-of-way lines, and perpetual easement lines. The guard will be taped with blue ribbon and blue flags.

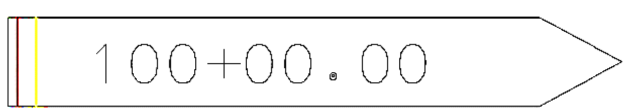
v. Stakes will be set at all **revertible easements** and **temporary easement** breaks. Yellow ribbon and a yellow flag will be used.

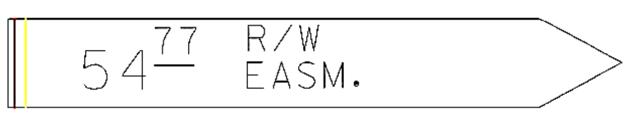
vi. Where hubs are placed, tacks are NOT required.

B. Guidelines:

i. When staking overlapping and/or intersecting easement lines, right of way lines, lines of division, etc., multiple flagging colors shall be used to represent common lines.

ii. Guards will be placed next to hubs with the baseline station written on one side of stake and the offset distance and description of line(s) written on other side. The station will be facing the baseline. Hubs shall be tacked if they are used as a control to set other points.





iii. Stakes set on lines of interest will be placed between points that are over 100 ft. or as necessary to ensure a clear line of sight to other staked points.

iv. When placing hubs and/or stakes at property corners where existing monumentation is found (i.e. rebar and caps, iron pipes, pins, stones, monuments, etc.) only stakes should be placed next to the found monumentation. If SHA Right of Way plats are available, plats will often make reference to whether or not monumentation was “found and held”, in which case a “witness stake” with the appropriate flagging should be placed next to the found monumentation.

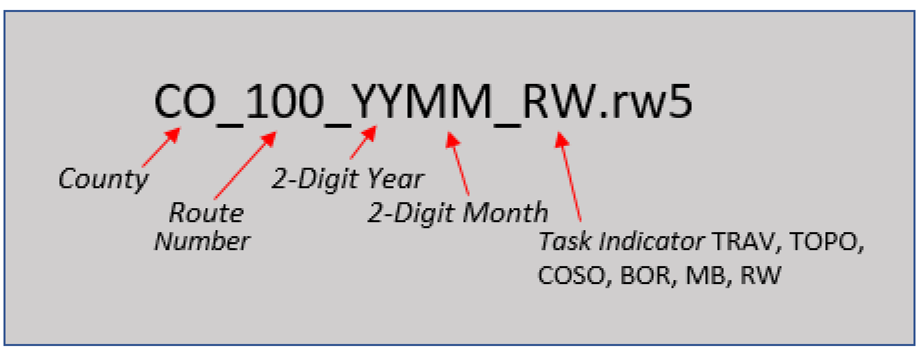
v. Some properties/parcels along a route may present concerns or conditions for entry that may require the crew to alter their procedure. In this case, the crew shall seek direction from the Area Engineer.

vi. Right of way stakeouts are not intended to permanently monument lines of division. Materials used for right of way stakeouts are meant for temporary depiction of lines of interest.

C. Deliverables:

i. No book work is required for right of way stakeouts. Notations shall be marked on the plats provided as to what type of marker is used. (e.g. rebar and cap, PK or MAG nail, masonry nail, hub & stake, and stake.)

ii. RAW or RW5 files from data collector with “as staked” values shall be part of your final deliverables. Field stakeout files shall be named to indicate county, route number, year, month, and type of work (RW) as follows.



iii. For some requests, photos of the completed stakeout may be requested as proof that a stakeout has been performed.

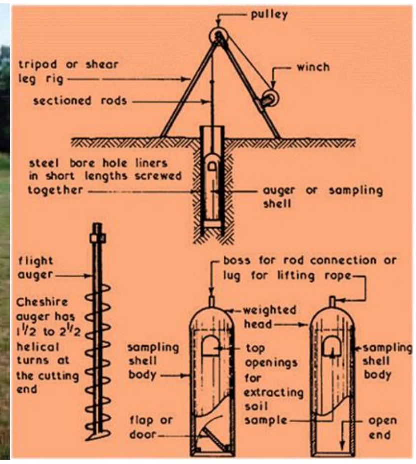
iv. Job card (Example in section 9.B.).

v. Assignment and Delivery Checklist (Example in section 9.C.).

vi. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

6. Boring Stakeout Surveys

Boring stakeouts are performed for the Office of Material Technology's Field Explorations Division. The location of the boring points for investigation are marked on plans, provided to the crew and staked out so that borings may be performed.



Boring points will be classified by their purpose. Typically, the name for a boring point will reflect the end use for the data obtained. This information is helpful in determining the required accuracy for the stakeout.

"P" boring points will be associated with pavement.
"F" boring points will be associated with foundations.
"S" boring points will be associated with soil.
"SWM" boring points will be associated with storm water management.

A. Materials Provided to Crew:

i. Location of boring points and map.

ii. Excel spread sheet or plan sheets with coordinates.

iii. Field book with free pages to document the field information.

iv. Information for available control points within or surrounding work area.

v. Scope letter specifying the requirements.

vi. Job card.

vii. Assignment and Delivery Checklist.

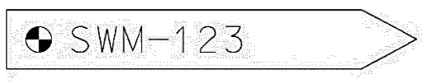
viii. PROJECTrack Survey Crew Daily Report template.

ix. Copies of property owner notification letter.

B. Procedures:

i. Stake the borings as per the provided coordinates. Offset the points if needed.

ii. Boring number/name (e.g. SB-1, SMW-1) and ground elevation at boring shall be written on a witness stake or marked on the ground using spray paint. The elevation should be shown to the nearest tenth of a foot unless the point is associated with a foundation or structure.



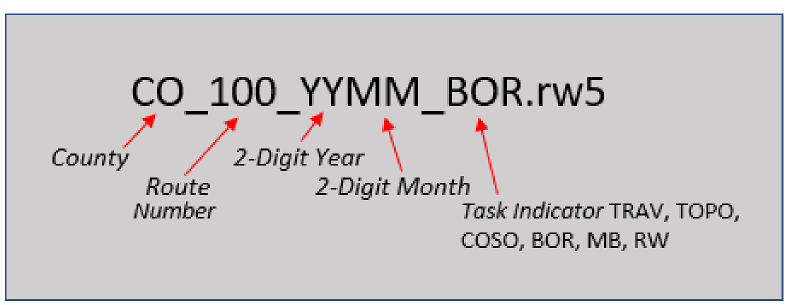
iii. For foundation or structure specific boring stakeouts, elevations must be shown to the hundredth.

iv. If a point is offset due to inaccessible location, write the offset information on the ground or on the stake. Make notes in the field book and/or final spreadsheet explaining why an offset was used.

C. Deliverables

i. Survey field book containing boring point names (i.e., SB-1, SMW-1), coordinates, elevations, and marker description (i.e., nail, stake) as staked in the field. An excel spread sheet may be submitted in lieu of bookwork.

ii. RAW or RW5 data files from data collector with "as staked" values shall be part of your final deliverables. Field stakeout files shall be named to indicate county, route number, year, month, and type of work (BOR) as follows.



iii. Job card (Example in section 9.B.).

iv. Assignment and Delivery Checklist (Example in section 9.C.).

v. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

7. Metes and Bounds Surveys/Baseline Re-establishment

A major part of the process for each roadway project and improvement is the establishment of the baseline of right of way. This process takes a project from lines and profiles on a computer screen and situates it on the earth. To do this, PSD has to verify lines of possession for any land where work is to be performed and fit the project where it belongs. Plat Engineers utilize recorded property information and field survey information to determine boundaries. These boundary lines build together into a base map and the relationships between parcels and corresponding measurements are used to set the baseline of right of way.

When surveying professionals, survey technicians and plat engineers are evaluating recovered boundary evidence, the material and type of evidence should be weighted based on sound legal and surveying principles. In addition to researching the original intent, the following information should also be considered when performing a retracement survey:

1. Lines run in the field (lines established by the original surveyor)
2. Adjoiners
3. Natural Monuments (trees, large stones, streams, etc.)
4. Artificial Monuments (rebars and caps, concrete monuments, pipes, etc.)
5. Courses
6. Distances
7. Area (intended area of property)
8. Coordinates (state plane or other)

When Plat Engineers work to re-establish Right of Way, the materials and recorded information is weighted from greatest to least in the following order:

1. Recovered baseline stations and/or offset references as shown in SHA field books
2. Recovered baseline stations and/or swing tie references along baseline spurs as shown in SHA field books
3. Property corner evidence
4. Key points on bridges and/or structures
5. Topographic survey features used to reference original baseline
6. Roadway surface or construction plan detail

A. Materials Provided to Crew:

i. Mosaic and/or electronic file for search (TXT, RW5, DGN, etc.).

ii. Search coordinates if available.

iii. MDOT SHA plats/subdivision plats/tax maps/worksheets/markups with requested parcels highlighted.

iv. Copy of deeds.

v. Job card.

vi. Assignment and Delivery Checklist.

vii. PROJECTrack Survey Crew Daily Report template.

viii. Copies of property owner notification Letter.

B. Field Procedures and Guidelines:

i. Area Engineers will contact property owners in anticipation of a field survey. Crews may be approached by property owners at the time of the survey. Politely let them know that you are recovering boundary evidence and respectfully refer them to the Area Engineer for the project if they ask for more information. You may also provide them with a copy of the property owner notification letter.

ii. Crews are expected to search for all requested information including baseline stakeout points, references and/or properties highlighted in the survey request.

iii. Area Engineers will provide crews with some form of mosaic, bookwork, plan sheet, markup, search coordinates and/or aerial mapping. The parcels to be searched will be marked clearly. These searches will include:

a. coordinate throws to possible locations based on deed calls or other research.

b. traditional metes and bounds searches with a call to a point of beginning with a group of angles, distances, and/or bearings to search.

c. searching around delineating features such as fence lines, tree lines, tax ditches, etc.

d. searches for road features, bridge information, reference points, swing ties, and other references for points and lines of interest.

iv. Property monumentation should only be used as part of a traverse when absolutely necessary. If monumentation is included, every effort should be made during the traverse adjustment process to preserve the integrity of the location of the monument as it relates to adjoining property corners and the overall parcel.

v. Search at least a 15-foot radius surrounding a call to a corner or a provided search coordinate.

vi. Flag up recovered evidence with blue ribbon denoting a line of division.

vii. Do not use paint to mark stones, concrete monuments or discs as it may obscure important information or markings on their surfaces.

viii. When locating monumentation, baseline references, and other points of interest by conventional methods, crews must turn **a minimum of two sets** of angle and distance observations. Best practice is to locate all evidence with four sets of observations. (A "set" is described in section 1.A.vi.)

ix. If an appropriate monument or property marker will be occupied to locate other metes and bounds evidence, the point must be established using the same procedures for a traverse or fly point as described in section 1.A.vi. This includes turning **a minimum of four sets** of angle and distance observations.

x. One combined average for angle and distance observations shall be shown with the location sketches in the field book. All direct and reverse angle sets must be either documented in the field book or included in an unedited RAW or RW5 file.

xi. Field book notes for evidence location shall include horizontal distances.

xii. Approval must be given by PSD Management to perform Metes and Bounds surveys using RTK equipment. This will require two sets of observations for the recovered monumentation, each set having a different base location. All RTK procedures (from section 1.D.) shall be followed as though control is being established. Each observation will record at least 180 epochs. These points will still need to be sketched in the field book, but these sketches will not include field measurements. See information below for specific RTK Metes and Bounds bookwork format.

xiii. When locating property corners, if a bent pipe or other type of marker is recovered, it shall be located at the bottom of the bend or where it is perpendicular with the ground. If there is no place where the marker is perpendicular with the ground, it should be located where it goes into the ground and/or at the highest point.

xiv. Take pictures of any evidence recovered and make sure that pertinent information on caps, discs or monuments (stamps, engravings, punches, cross cuts, etc.) are clear and legible. Add a visual reference to the point number in the photo and/or name the photo accordingly.

xv. Make notes during field searches to provide all necessary details about recovered boundary evidence. (See section 7.D.i.g.).

xvi. In lieu of or in addition to any boundary monumentation be sure to locate visible delineating features on site that may indicate a line of possession or property rights. This includes woods lines, fence lines, ditches, stone walls, barbed wire in trees, mill races, old roadbeds, and/or any feature that may have the appearance or reputation of a property line. These features can be located using a single angle and a horizontal distance. This measurement may be performed by taking a data collection shot for each point of interest.

xvii. Additional monumentation may be present and/or some evidence found may be in different places or forms than called for. Locate all evidence recovered in or around the work area. This includes locating multiple pieces of evidence at the same location. In the case of multiple items recovered in one area, provide a sketch to illustrate locations.

xviii. Respect the property of landowners. Minimize brush clearing and mark up of recovered evidence on private property. Also, make every effort to leave the ground in the condition you found it if any digging was done to search for evidence.

xix. Document and locate any evidence pointed out by property owners. This is known as parole evidence and may be valuable in boundary determination.

xx. It may be necessary to expand the scope of a metes and bounds survey. If no boundary evidence is recovered, the survey crew may be asked to search adjoining and/or adjacent properties. Contact the project Area Engineer for more information or guidance.

xxi. The Professional Land Surveyor that will use field recovered information to establish rights of way or make boundary determinations should be as involved in the site work as possible.

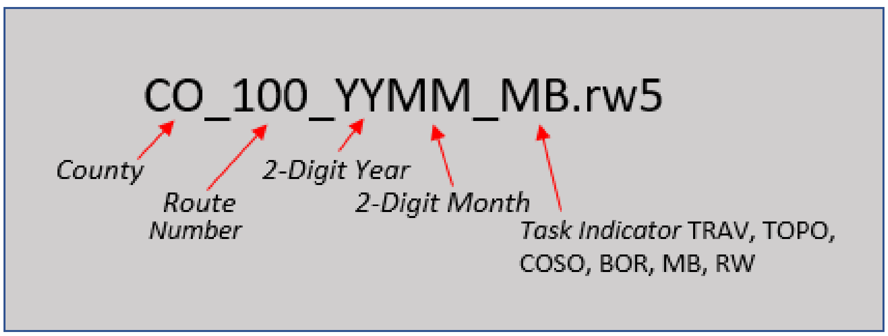
D. Deliverables:

i. Materials:

a. Provided mosaic(s) are to be returned with markings for points found and any traverse set shall be sketched on the mosaic. Mark "N/F" or "not found" on any searched-for corners if no evidence was recovered. If these are not marked, it will be assumed that these corners were not searched.

b. Include any RAW or RW5 files with location information, traverse files, and any associated least squares adjustment reports. All traverse sets are expected to meet or exceed the standard set in the control section of this manual and abide by the COMAR 09.13.06, Minimum Standards of Practice.

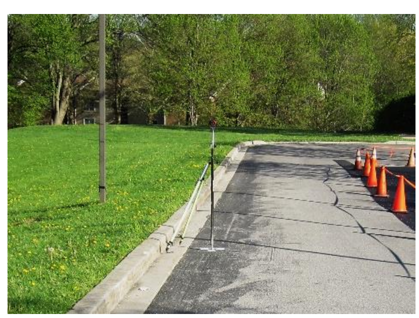
c. Files shall be named to indicate county, route number, year, month, and type of work (MB) as follows.



d. Bookwork with location sketches as described below.

e. Full color book scans in JPG format (Example in section 9.H.).

f. Two photos shall be taken for each point. One photo shall be taken up close to show detail and the other to show context for the surrounding area. Include visual reference indicating the point number associated with the location. Photos may also be named to coincide with point number.



g. Include detailed descriptions of monumentation/boundary evidence in bookwork, location RW5 files, and on marked mosaic or worksheet.

1. Type of point found (rebar and cap, iron pipe (include size), pin, monument (include dimensions, disc diameter, etc.).

2. Include any names, license numbers, or information found on caps, discs, etc.

3. Depth or height above ground.

4. Any condition issues (bent, leaning, broken, in tree roots, etc.).

5. Relevant location info (located at bottom of bend or lean, sketch for multiple locations in one area).

h. Job card (Example in section 9.B.).

i. Assignment and Delivery Checklist (Example in section 9.C.).

j. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

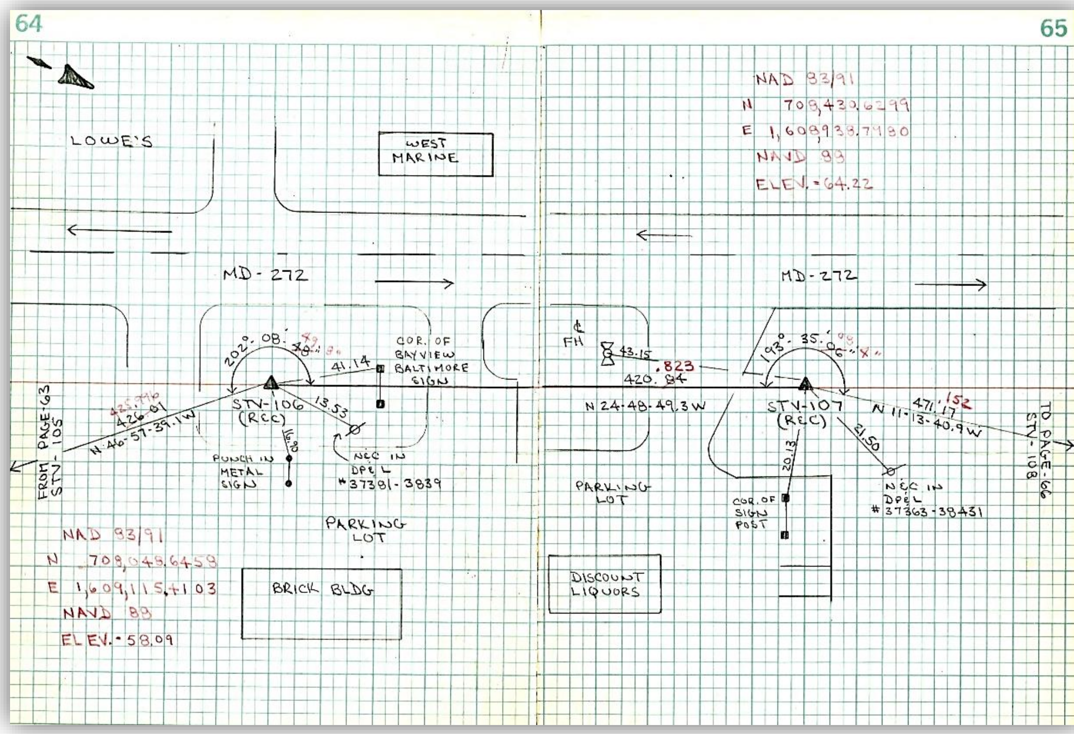
ii. Bookwork: Metes and bounds surveys are integral to any major project or work being done by MDOT SHA where there may be impacts on nearby properties. The metes and bounds surveys performed by the field crews help our team to establish lines of division and baselines of right of way that get the process in motion.

The bookwork for a metes and bounds survey is especially important because the field notes prepared by the survey crew document their efforts to search for and recover field evidence to establish lines of possession. This information may be used as evidence in legal proceedings and it will likely be used by another surveyor in the future, to establish either the same lines of possession or adjoining lines. For these reasons the integrity and clarity of the record is vital.

The information that must be included in the bookwork for a metes and bounds survey is as follows:

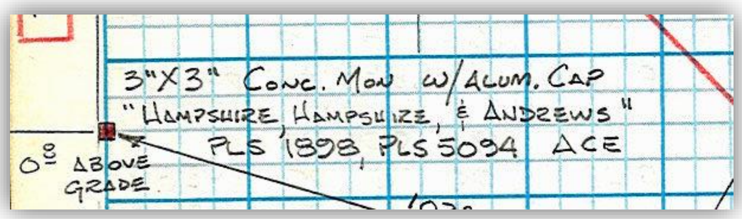
a. All information for any traverse lines or loops set for metes and bounds will follow the same format described above in the control section. Metes and bounds specific traverse do not necessarily require elevations.

b. Traverse reference sketches for recovery including pulls to three permanent features if available. Be sure to include detail for any materials used for reference (nail and cap, x-cut) and what it is set in/on (20" maple tree, curb at nose down, etc.).

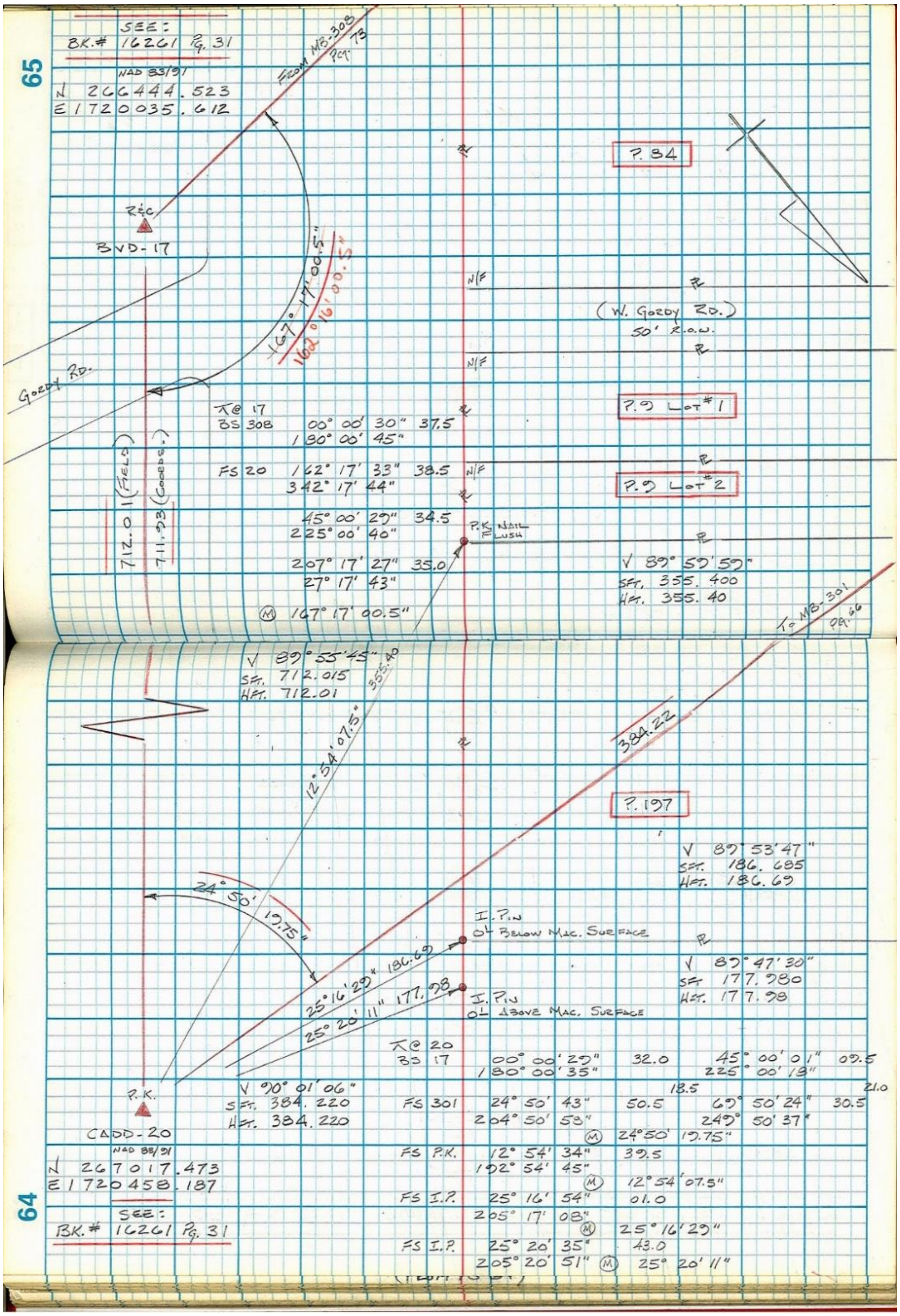


c. Evidence location points (described below) sketched in relation to traverse and adjacent/adjoining property lines.

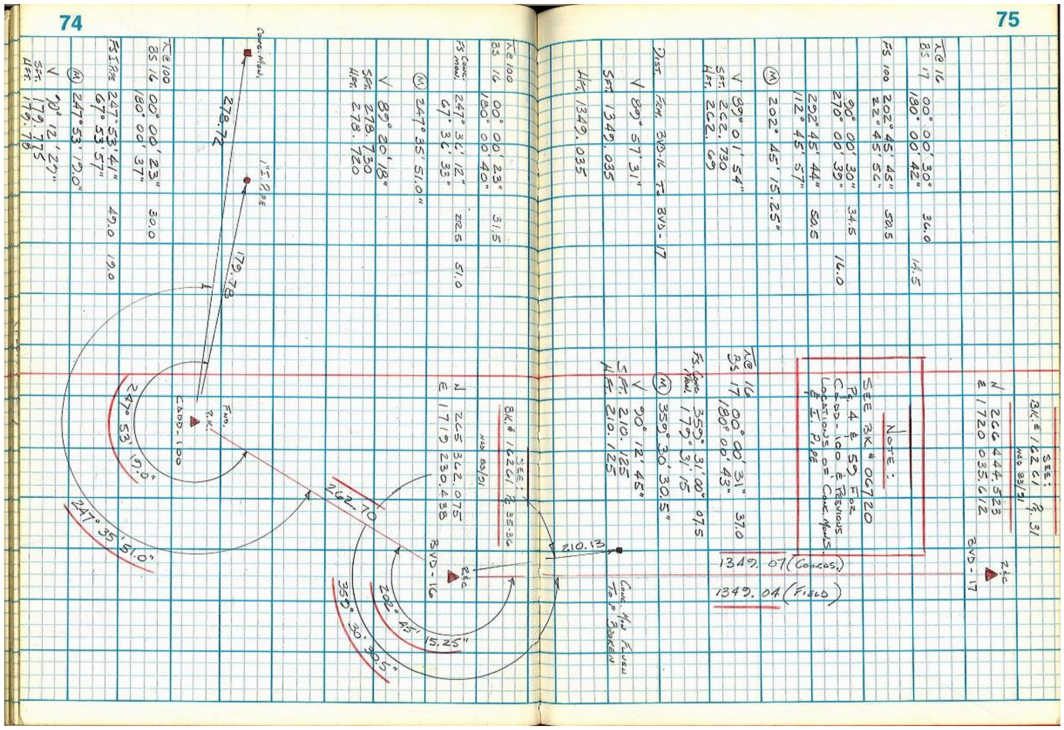
d. Detailed description of recovered evidence as described in the materials section above.



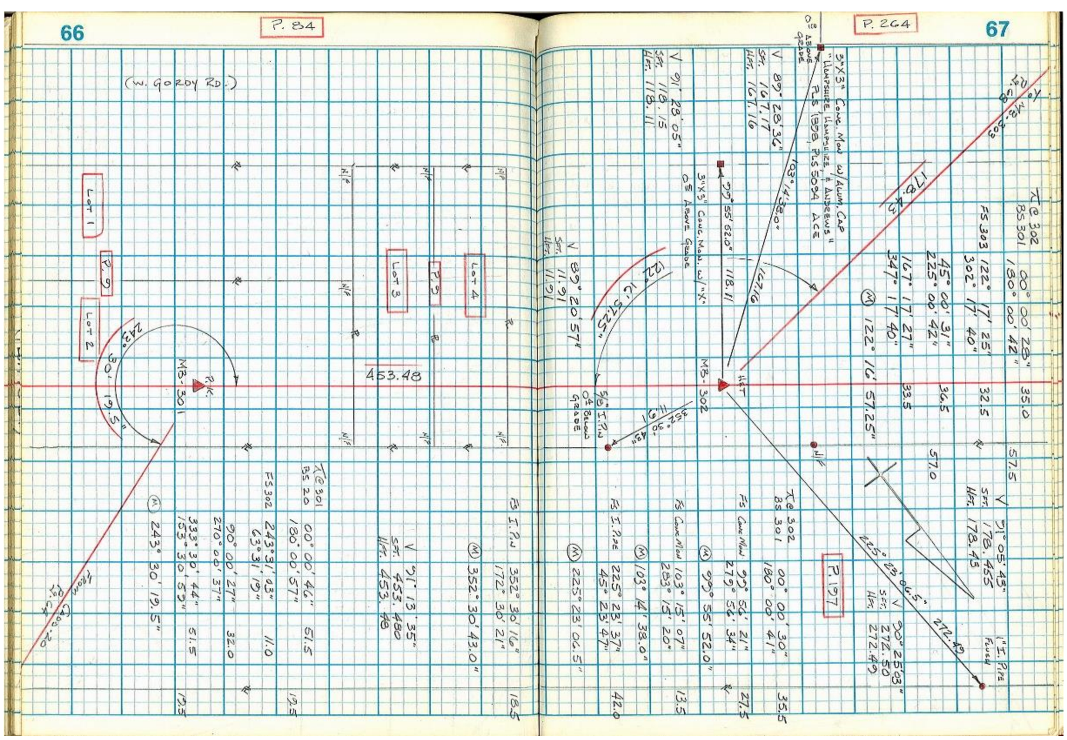
e. Location sketch including combined averages for all angle and distance observations for each piece of field recovered evidence. All angle sets turned must be included in the deliverables for a metes and bounds task. These angle and distance measurements may be shown in the bookwork, or included in an unedited RAW or RW5 file. (In the example below, the angle sets have been included in the field notes.) If necessary, angle sets may be shown on a separate page with page references to field note sketches.



f. Location drawing shall show the traverse lines in relation to the location of evidence. Mean angles and horizontal distances must be included in these sketches.



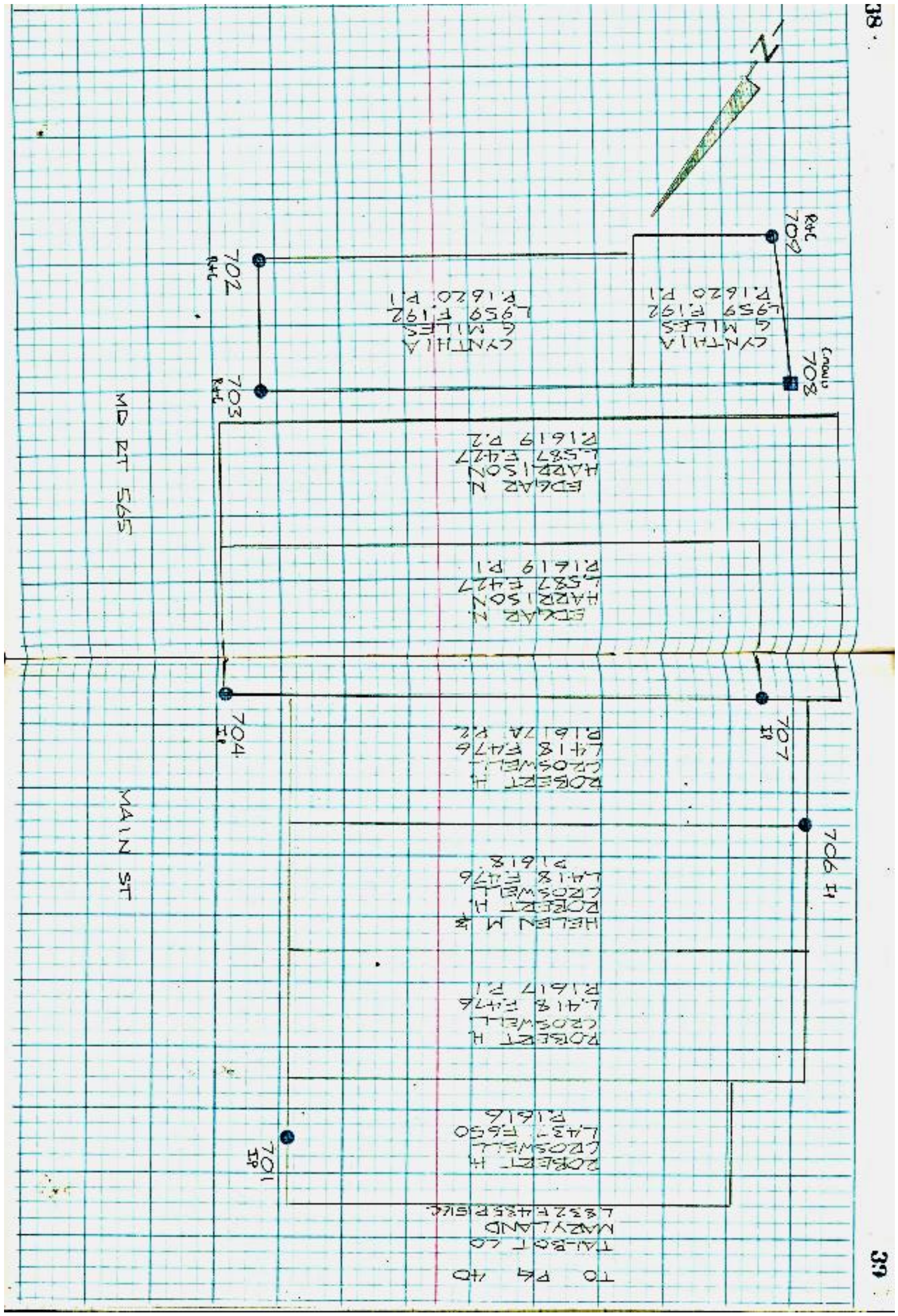
g. Location drawing shall depict property lines as much as possible and include basic parcel information (parcel number, ownership, and any other property identifier available).



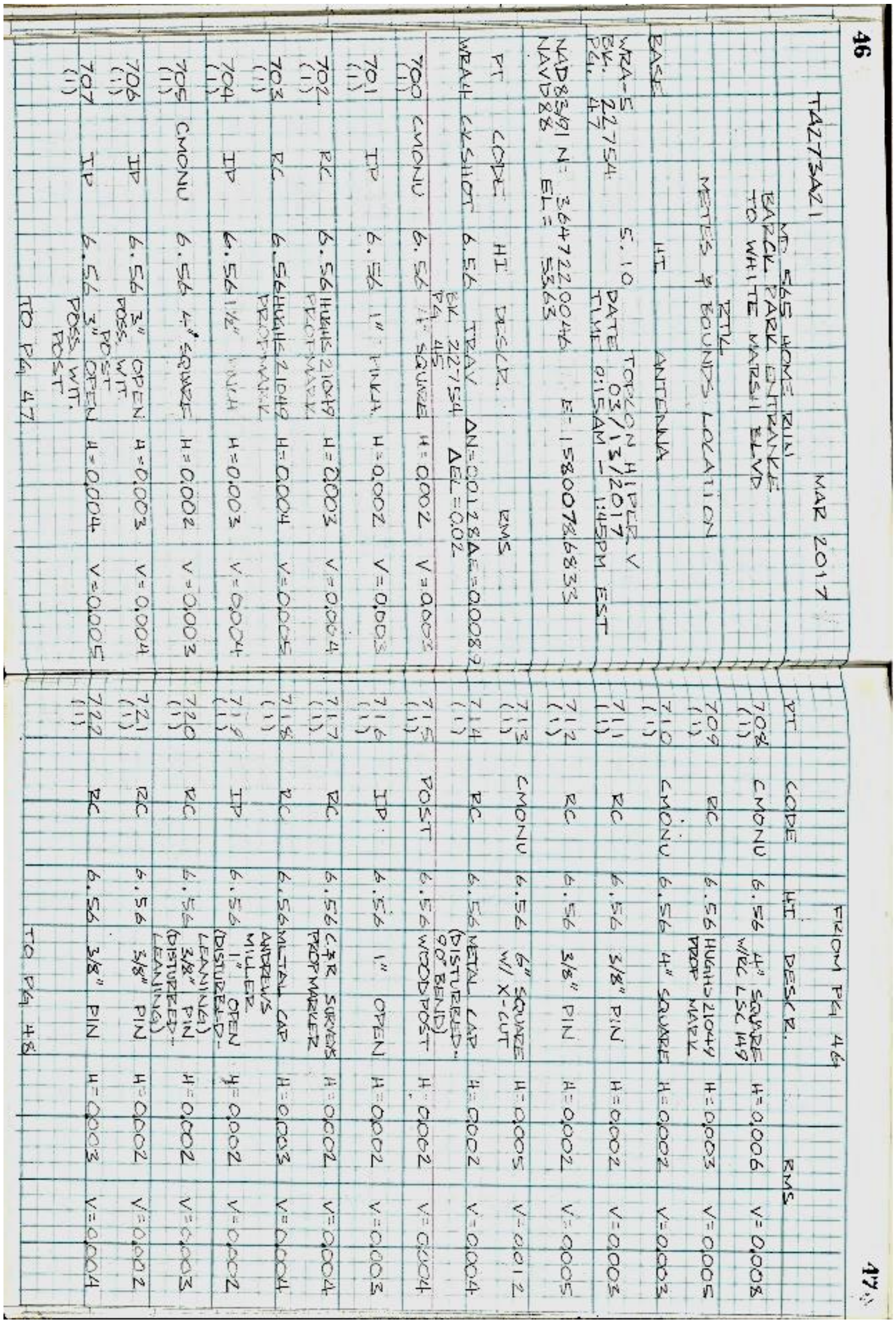
iii. Surveyor's Report: For Metes and Bounds assignments, as well as workmap and plat development tasks, a signed and sealed Surveyor's Report is required to accompany all other deliverables mentioned in this section. This report will contain a sequence of field operations, a summary of all findings and when appropriate, it will allow the surveyor of record to document the process to determine boundaries and/or right of way lines, as surveyed.

iv. RTK Metes and Bounds Bookwork: Metes and Bounds surveys may be performed using RTK equipment, but **only with prior approval from PSD Management**. The recordings need to be thorough, accurate and documented in detail. The bookwork for these surveys must include metes and bounds location sketches, all setup and observation data, and adjustment information (see examples on the following pages).

a. Metes and Bounds location sketches depicting parcels and located evidence. Mark points clearly with descriptions and point names.



b. All setup and observation data including: point names for base stations, held coordinates, source of control information, heights of base and rover, datum, time and date, equipment information (make and model), store point names, descriptions, PDOP, HRMS, and VRMS values, and a page number reference for the location sketch associated with each point.



46

TAZ73AZ1 MAR 2017

MD 565 HOME RUN
BARCK PARK ENTRANCE
TO WHITE MARSH BLVD

RTK
METES & BOUNDS LOCATION

BASE HT. ANTENNA
WRA-5 5.10 TOPCON HIPER V
BK. 22754 DATE 03/13/2017
PG. 47 TIME 9:15AM – 1:45PM EST

NAD83/91 N= 364722.0046 E= 1580078.6833
NAVD88 EL= 53.63

PT	CODE	HI	DESCR.	RMS	
WRA4	CKSHOT	6.56	TRAV BK. 22754 PG. 45	ΔN=0.0128 ΔE=0.0089	ΔEL=0.02
700 (1)	CMONU	6.56	4" SQUARE	H=0.002	V=0.003
701 (1)	IP	6.56	1" PINCH	H=0.002	V=0.003
702 (1)	RC	6.56	HUGHS 21049 PROP MARK	H=0.003	V=0.004
703 (1)	RC	6.56	HUGHS 21049 PROP MARK	H=0.004	V=0.005
704 (1)	IP	6.56	1½" PINCH	H=0.003	V=0.004
705 (1)	CMONU	6.56	4" SQUARE	H=0.002	V=0.003
706 (1)	IP	6.56	3" OPEN POSS. WIT. POST	H=0.003	V=0.004
707 (1)	IP	6.56	3" OPEN POSS. WIT. POST	H=0.004	V=0.005

TO PG 47

47

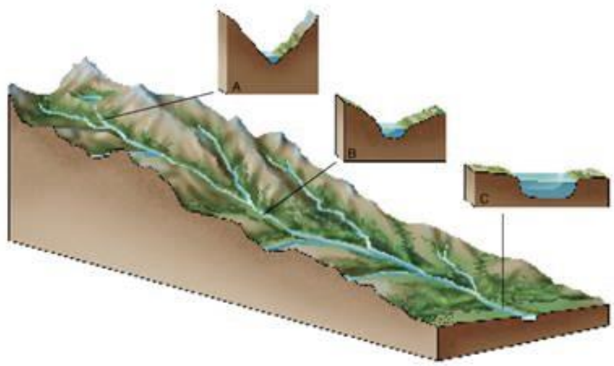
FROM PG 46

PT	CODE	HI	DESCR.	RMS	
708 (1)	CMONU	6.56	4" SQUARE W/RC LSC 149	H=0.006	V=0.008
709 (1)	RC	6.56	HUGHS 21049 PROP MARK	H=0.003	V=0.005
710 (1)	CMONU	6.56	4" SQUARE	H=0.002	V=0.003
711 (1)	RC	6.56	3/8" PIN	H=0.002	V=0.003
712 (1)	RC	6.56	3/8" PIN	H=0.002	V=0.005
713 (1)	CMONU	6.56	6" SQUARE W/ X-CUT	H=0.005	V=0.012
714 (1)	RC	6.56	METAL CAP (DISTURBED-90° BEND)	H=0.002	V=0.004
715 (1)	POST	6.56	WOOD POST	H=0.002	V=0.004
716 (1)	IP	6.56	1" OPEN	H=0.002	V=0.003
717 (1)	RC	6.56	C&R SURVEYS PROP MARKER	H=0.002	V=0.004
718 (1)	RC	6.56	METAL CAP ANDREWS MILLER	H=0.003	V=0.004
719 (1)	IP	6.56	1" OPEN (DISTURBED-LEANING)	H=0.002	V=0.002
720 (1)	RC	6.56	3/8" PIN (DISTURBED-LEANING)	H=0.002	V=0.003
721 (1)	RC	6.56	3/8" PIN	H=0.002	V=0.002
722 (1)	RC	6.56	3/8" PIN	H=0.003	V=0.004

TO PG 48

8. Cross-Section Surveys

Cross-sections are performed in areas where active waterways meet structures and bridges that require remediation or replacement. A baseline is computed for the requested area and perpendicular cross-sections (by way of topographic mapping shots) are collected by field crews. This data is used to provide profiles for designers to analyze the waterway and interpret the needs of the project.



A. Materials Provided to Crew:

i. Plan sheet including layout of all cross-section alignments.

ii. Northing and easting values at the end points and breakpoints of cross-section lines.

iii. Field book with free pages to document the field information.

iv. Information for available control points within or surrounding work area.

v. Scope letter specifying the requirements.

vi. Job card.

vii. Assignment and Delivery Checklist.

viii. PROJECTrack Survey Crew Daily Report template.

ix. Copies of property owner notification letter.

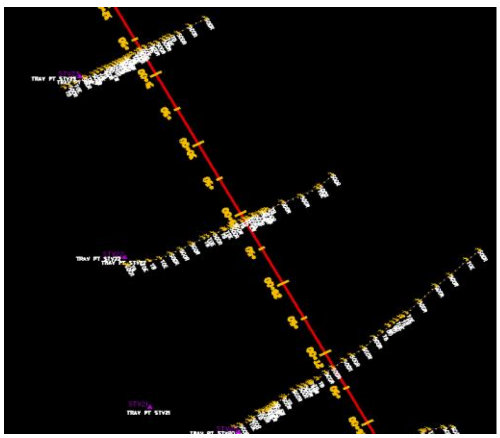
B. Guidelines:

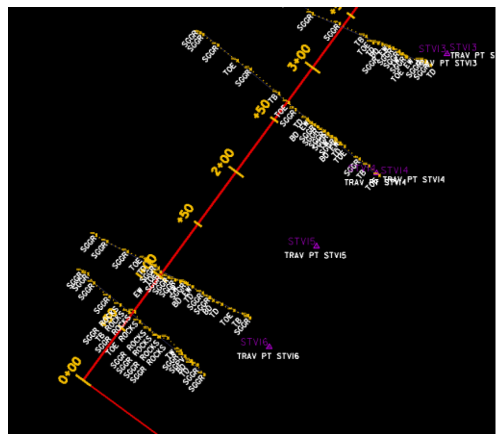
i. All cross-section alignments shall be established by data collection field measurements and all shots used for cross-section alignments shall have been taken for the cross-section survey. These alignments may not be cut from an existing surface or established by extrapolation from data collection prepared for another purpose.

ii. Data collection for cross-section alignments shall be collected starting upstream and working each section (often perpendicular to the flow of the stream or traffic) through to completion and advancing in a downstream direction. These sections shall be shot from left to right based on a perspective facing downstream.

iii. The cross-section baseline shall start at 0+00 at the farthest upstream section and advance positively in station from upstream to downstream. (e.g. A section located 500 feet downstream from the 0+00 station would be at station 5+00.)

iv. The baseline shall be created so that it intersects each of the cross-section alignments. Ideally, the baseline should be made up off a series of tangents where each break connects to an actual cross-section point.



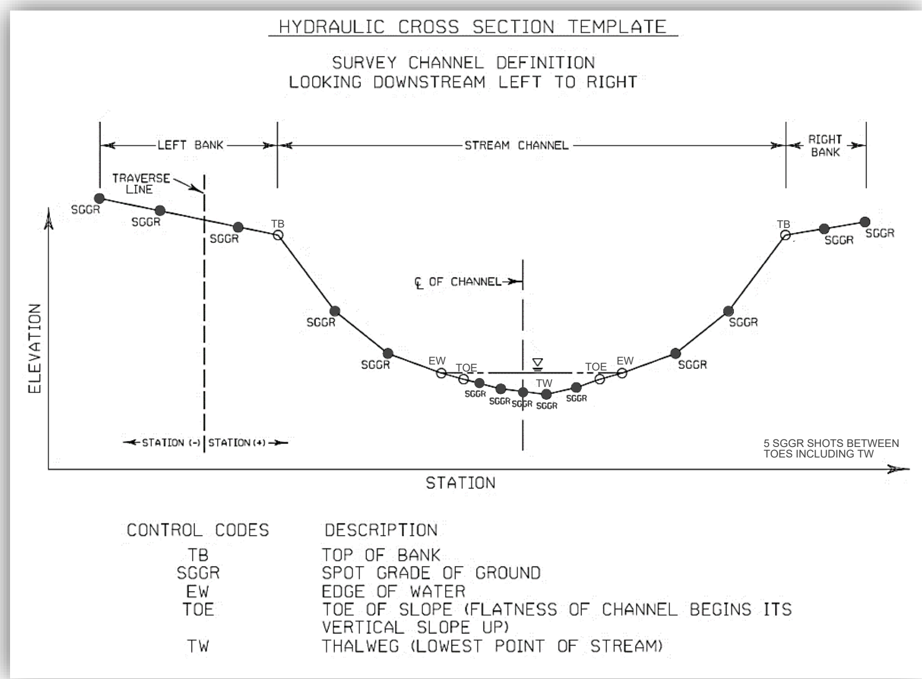


v. Cross-sections shall include enough points to define changes in the area of interest. This includes shots to show details for slopes, channel thalwegs, toes of slope, tops of banks, and edges of water.

vi. Cross-section alignments are expected to be collected in a straight line as much as possible.

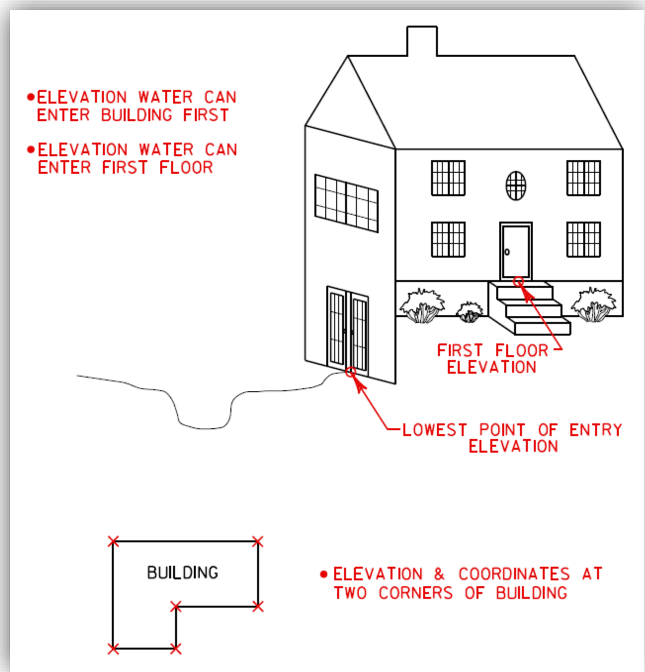
vii. Shots along a cross-section shall be spaced according to the scale of the request. Typical scale for these requests is 20 Scale. That would require shots to be no more than 20 feet apart. Within the stream channel or point of interest, points may need to be much closer together to show detail.

viii. There needs to be a **minimum of 5 spot grade shots to detail the bottom of the channel** between the toes of slope including a shot on the lowest point or thalweg**.** These shots will be in addition to the shots for tops of banks, toes of slope, and edges of water. All shots must be located using SHA feature code PGL (profile grade line) with an attribute to describe the feature present (toe of slope (TOE), bottom of ditch (BD), spot grade (SGGR), etc.) and the section number. Proper judgement should be used to determine if more shots are needed to accurately define the stream channel. See the example on the following page.



ix. Some cross-section requests will require profiles to be collected in the same manner for the road surface over a structure or bridge.

x. First floor and/or lowest point of entry elevations for flood prone buildings may be requested. When necessary, these buildings will be identified in the survey request. See the reference below pertaining to building location.



xi. Traverse run solely for cross-section data collection can be run without normal traverse closure with prior approval. Traverse closure and corresponding levels are to be performed whenever possible.

xii. RTK (on MDOT SHA designated datum) may also be used to establish control as a means of directly performing cross-section data collection or for closing out/ tying in open cross-section traverse.

xiii. Judgement must be exercised when clearing line for cross-sections. Preserve shrubs, plants and trees in or adjacent to lawn areas as much as possible.

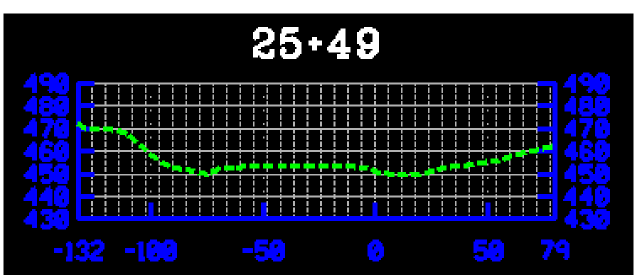
C. Deliverables:

i. Data collection (MicroStation/Power InRoads DGN) files with lines run as profile grade lines (PGL's) and shots including attributes/notes to identify shots by feature and section number including detail described in section 8.B.

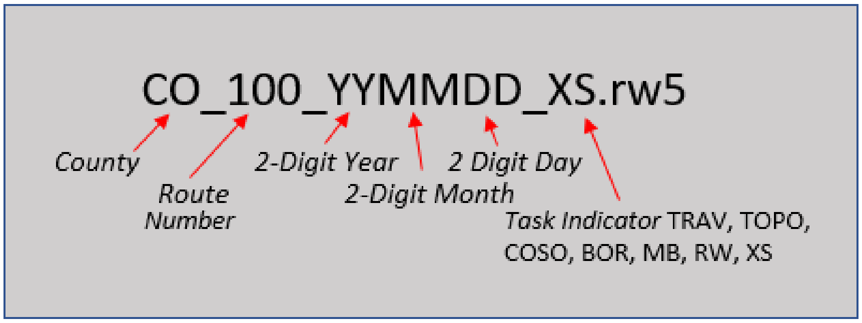
ii. The cross-section baseline needs to be shown in the DGN file, stationed starting at 0+00 at the farthest upstream section and advancing positively in station from upstream to downstream with said baseline intersecting at least one collected shot from each alignment.

iii. Data collection files shall include a profile view of each cross-section line depicting a perspective facing downstream as the data was collected from left to right. These profiles shall be labeled with the station, cross-section number, and alignment specific stationing.

iv. Each cross-section alignment and the subsequent profile will have a 0+00 station where it intersects the baseline. All shots to the left of the baseline will be stationed negative, decreasing as they move away from 0+00. All shots to the right of the baseline will be stationed positive, increasing as they move away from 0+00. This left and right orientation is based on a downstream facing perspective. Alignment stationing shall be based upon the distance along to alignment from the 0+00 station.



v. RAW data collection files (unedited version). Field data collection files shall be named to indicate county, route number, year, month, day (when file is started), and type of work (XS) as follows.



vi. Edited and merged RW5 file.

vii. Data collection setup sheets (Example in section 9.D.ii.).

viii. Cross-section alignment file (ALG) for cross-section baseline.

ix. Station/Offset/Elevation file (SOE) for cross-section lines.

x. Photos taken of upstream and downstream views at the thalweg of each cross-section line. Label each photo with section number and perspective (e.g. Section 12/Upstream View).

xi. Structure sketches including upstream and downstream views for all structures pertaining to the request. Include dimensions for structures and elevations for low chord, parapet wall, and deck surface. Sketches must include all requested information. Review survey request for specifics.

xii. Job card (Example in section 9.B.).

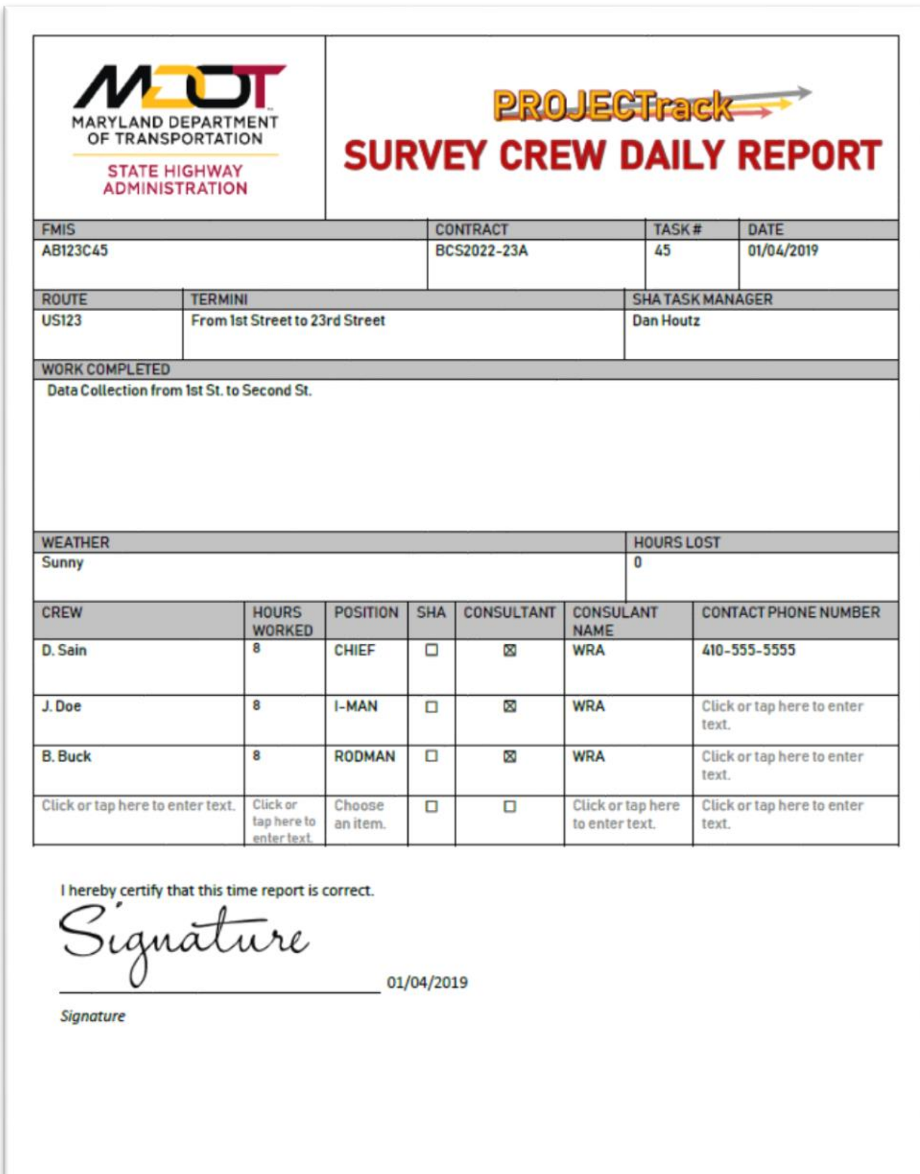
xiii. Assignment and Delivery Checklist (Example in section 9.C.).

xiv. PROJECTrack Survey Crew Daily Reports (Example in section 9.A.).

9. Task Documentation and Work Logs

For all surveying tasks there are forms that need to be submitted along with the deliverable to document the work that was completed. These forms are important because they keep records about what was done, how much it cost, what information was used, and provide justification for costs associated with hours and direct costs charged to a project.

A. Projectrack Survey Crew Daily Reports: These reports are electronic logs to be completed every workday for each survey crew on a task. As shown in the example, these reports include important information that reflect a clear record of what was done each day, who worked on a task, and other background information like weather conditions or hours lost which may affect the production time on any workday.



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

PROJECTrack
SURVEY CREW DAILY REPORT

FMIS	CONTRACT	TASK #	DATE
AB123C45	BCS2022-23A	45	01/04/2019

ROUTE	TERMINI	SHA TASK MANAGER
US123	From 1st Street to 23rd Street	Dan Houtz

WORK COMPLETED
Data Collection from 1st St. to Second St.

WEATHER	HOURS LOST
Sunny	0

CREW	HOURS WORKED	POSITION	SHA	CONSULTANT	CONSULANT NAME	CONTACT PHONE NUMBER
D. Sain	8	CHIEF	☐	☒	WRA	410-555-5555
J. Doe	8	I-MAN	☐	☒	WRA	Click or tap here to enter text.
B. Buck	8	RODMAN	☐	☒	WRA	Click or tap here to enter text.
Click or tap here to enter text.	Click or tap here to enter text.	Choose an item.	☐	☐	Click or tap here to enter text.	Click or tap here to enter text.

I hereby certify that this time report is correct.

Signature 01/04/2019

Signature

i. Information – The following information shall be completed to fill in the information for each daily report.

- **a.** Date worked
- **b.** Party chief name
- **c.** Party chief contact number
- **d.** Crew member names
- **e.** Crew member title and employer(s)
- **f.** MDOT SHA task manager
- **g.** Assignment FMIS charge number
- **h.** Assignment description, route and location
- **i.** Work completed
- **j.** Weather conditions
- **k.** Certification
- **l.** Date prepared

ii. Guidelines

- **a.** Projectrack reports shall be prepared daily and submitted at least weekly (expected on Fridays) or at the completion of a task, whichever is earliest.

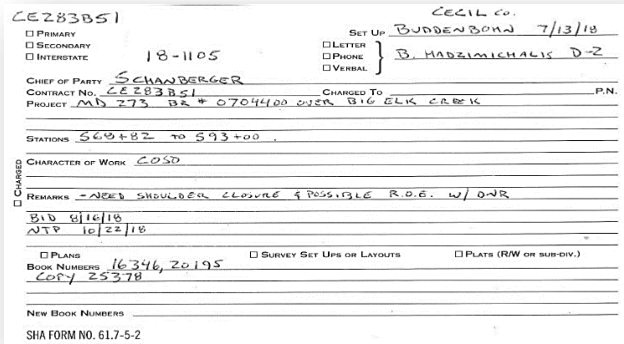
- **b.** Reports must be submitted via email to PSDprojectrack@mdot.maryland.gov.

- **c.** Email subject must indicate MDOT SHA Task Manager, FMIS charge number, and dates in the form of month and week number. (Example: **Buddenbohn_BA006A21_May-Week1**)

- **d.** Reports shall be submitted in PDF format

- **e.** Report files shall be named to indicate SHA or consultant initials, party chief last name, route, and date formatted as MM-DD-YY.
  (SHA example: **SHA_Loskot_MD543_08-03-19**)
  (Consultant example: **STV_Peoples_MD97_05-02-19**)

B. Job Cards: These are large index cards with information about the assignment. The front side is filled out by the Area Engineer or MDOT SHA Task Manager. The information on the front of the job card provides an assignment synopsis and may call out important details to help the crew perform the task to completion. There will also be a description of field methods expected to be used for the subject task.



CE283B51 CECIL CO.

☐ Primary
☐ Secondary
☐ Interstate 18-1105

Set Up BUDDENBOHN 7/13/18
☐ Letter / ☐ Phone / ☐ Verbal B. HADZIMICHALIS D-2

Chief of Party SCHANBERGER
Contract No. CE283B51 Charged To ______ P.N.
Project MD 273 BR # 0704400 OVER BIG ELK CREEK

Stations 568+82 TO 593+00

Character of Work COSD

☐ Charged

Remarks - NEED SHOULDER CLOSURE & POSSIBLE R.O.E. W/ OWR

BID 8/16/18
NTP 10/22/18

☐ Plans ☐ Survey Set Ups or Layouts ☐ Plats (R/W or sub-div.)

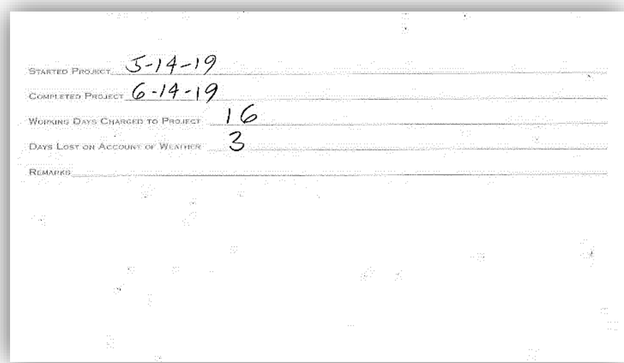
Book Numbers 16346, 20195
COPY 25378

New Book Numbers

SHA FORM NO. 61.7-5-2

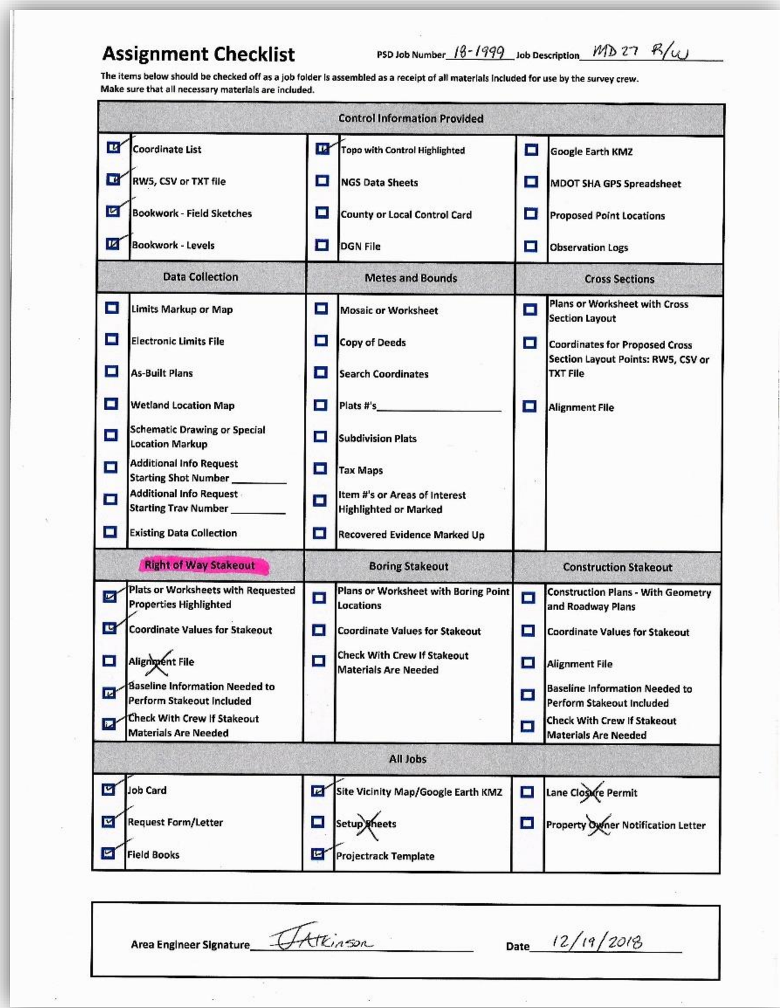
On the back side of the card, as shown below, the party chief needs to fill out the following information.

i. Starting date
ii. Ending date
iii. Working days charged to project
iv. Days lost to weather



Started Project 5-14-19
Completed Project 6-14-19
Working Days Charged to Project 16
Days Lost on Account of Weather 3
Remarks

C. Assignment and Delivery Checklists: These checklists are references to make sure that all necessary information is sent out to the survey crew to perform the task, and in turn, that all necessary materials are turned into the office. There are a lot of pieces to the package associated with each task, so it is important to make sure all necessary information is provided to the crew up front and that all requested information and deliverables are sent into the office so that we can deliver the job promptly.



Assignment Checklist PSD Job Number 18-1999 Job Description MD 27 R/W

The items below should be checked off as a job folder is assembled as a receipt of all materials included for use by the survey crew.
Make sure that all necessary materials are included.

Control Information Provided		
☑ Coordinate List	☑ Topo with Control Highlighted	☐ Google Earth KMZ
☑ RW5, CSV or TXT file	☐ NGS Data Sheets	☐ MDOT SHA GPS Spreadsheet
☑ Bookwork - Field Sketches	☐ County or Local Control Card	☐ Proposed Point Locations
☑ Bookwork - Levels	☐ DGN File	☐ Observation Logs

Data Collection	Metes and Bounds	Cross Sections
☐ Limits Markup or Map	☐ Mosaic or Worksheet	☐ Plans or Worksheet with Cross Section Layout
☐ Electronic Limits File	☐ Copy of Deeds	☐ Coordinates for Proposed Cross Section Layout Points: RW5, CSV or TXT File
☐ As-Built Plans	☐ Search Coordinates	
☐ Wetland Location Map	☐ Plats #'s________	☐ Alignment File
☐ Schematic Drawing or Special Location Markup	☐ Subdivision Plats	
☐ Additional Info Request Starting Shot Number ______	☐ Tax Maps	
☐ Additional Info Request Starting Trav Number ______	☐ Item #'s or Areas of Interest Highlighted or Marked	
☐ Existing Data Collection	☐ Recovered Evidence Marked Up	

Right of Way Stakeout	Boring Stakeout	Construction Stakeout
☑ Plats or Worksheets with Requested Properties Highlighted	☐ Plans or Worksheet with Boring Point Locations	☐ Construction Plans - With Geometry and Roadway Plans
☑ Coordinate Values for Stakeout	☐ Coordinate Values for Stakeout	☐ Coordinate Values for Stakeout
☐ ~~Alignment~~ File	☐ Check With Crew If Stakeout Materials Are Needed	☐ Alignment File
☑ Baseline Information Needed to Perform Stakeout Included		☐ Baseline Information Needed to Perform Stakeout Included
☑ Check With Crew If Stakeout Materials Are Needed		☐ Check With Crew If Stakeout Materials Are Needed

All Jobs		
☑ Job Card	☑ Site Vicinity Map/Google Earth KMZ	☐ Lane ~~Closure~~ Permit
☑ Request Form/Letter	☐ ~~Setup Sheets~~	☐ Property ~~Owner~~ Notification Letter
☑ Field Books	☑ Projectrack Template	

Area Engineer Signature J Atkinson Date 12/19/2018

The "Assignment Checklist" is to be filled out by the Area Engineer or Task Manager. This provides a reminder of all necessary information for the job and also works as a reference for the Party Chief to have a list of what information is included in the job folder.

If you are assigned a task and you are missing any information that you need to perform the survey, reach out to your Area Engineer/Task Manager as soon as possible. Some materials included on the checklist may pertain to electronic files that are sent by email or FTP site.

In the example above, Area Engineer John Atkinson is assigning a right of way stakeout to a survey crew.

He has checked off that he's included control by coordinate list, an RW5 file, field books or copies, and a topo mark up with control. He has included a plat or worksheet, stakeout coordinates, a job card, request letter, field books, and a vicinity map. He has also verfied that the crew has a current Projectrack Report template and that he has checked whether or not the crew needs any materials to complete the stakeout request. For this request, setup sheets, property notification letters, and lane closure permits were not needed. For that reason, those items were not included and crossed out on the checklist.

Best practice is to cross out or make a note for why something is not checked off. Otherwise it may be assumed that the item was left out by mistake.

Delivery Checklist

The items below should be checked off as materials for assignment are finalized or submitted electronically to the Area Engineer. Make sure that all necessary materials are complete and submitted.

Control Information For Any New Control Set		
☑ Work Done Using Existing Control	☐ Bookwork - Levels	☐ NGS Data Sheets Returned
☐ Edited and Unedited RW5 Traverse Files	☐ Electronic Level File	☐ MDOT SHA GPS Spreadsheet Returned
☐ Bookwork - Field Sketches	☐ Observation Logs	☐ County or Local Control Card Returned

Data Collection	Metes and Bounds	Cross Sections
☐ Topo Reviewed for Coverage and Correctness	☐ All Requested Item #'s or Areas of Interest Searched	☐ Plans or Worksheet with Cross Section Layout Returned
☐ Edited and Unedited Data Collection RW5 files	☐ All Exhibits Returned	☐ Edited and Unedited Cross Section Data Collection RW5 files
☐ As-Built Plans Returned	☐ Mosaic/Worksheet Marked With Traverse and Evidence Found	☐ Cross Section Photos
☐ Wetland Location Map Returned	☐ Evidence Not Found Marked N/F	☐ Baseline or Alignment File
☐ Schematic Drawing or Special Location Markup Returned	☐ Edited and Unedited RW5 Metes and Bounds Location Files	☐ Data Collection DGN File
☐ Reference Photos	☐ Evidence Photographs	
☐ Data Collection DGN File	☐ Bookwork Including: Evidence Descriptions, Parcel Info, Angle Sets or RTK Field Notes, Depiction of Locations and Properties	

Right of Way Stakeout	Boring Stakeout	Construction Stakeout
☑ All Requested Item #'s or Areas of Interest Staked	☐ All Requested Boring Points Staked	☐ Baseline Stakeout Completed Including Setting References
☑ As-Staked RW5 File	☐ As-Staked RW5 File	☐ Benchmarks Set and Levels Run
☑ Plats or Worksheets Returned	☐ Bookwork or Excel Spreadsheet With Table Including Information for Point Names, Coordinates and Materials Set, and Any Offsets Used	☐ As-Staked RW5 File
☑ Plats/Worksheets Marked with Materials Set		☐ Bookwork Completed Including: Stations and Offsets, Coordinates for Cardinal and Reference Points, Materials Set, Curve Data, Deflection Angles, Reference Points and Info, Depiction of Baseline in Roadway, and Benchmarks

All Jobs		
☑ Job Card Filled Out	☐ Setup Sheets Filled Out	☑ Projectrack Reports Submitted
☑ Request Form/Letter Returned	☐ Control Referenced	☑ Electronic Files Submitted By Email
☐ Bookwork Complete and New Work Has Been Indexed	☐ Traverse Closure/Levels Checked	☐ Electronic Files Included on CD or Flash Drive

Party Chief Signature G Gosman Date 1/9/2019

The "Delivery Checklist"is to be filled out by the Party Chief. This sheet is to verify that all necessary materials are being turned into the office with the job folder.

Some information, like as-staked RW5 files or data collection files, may be submitted electronically as it may be quicker and more convenient. Those items should be checked off the list and the Area Engineer or Task Manager will know to look for them in an email or electronic submission if they are not included on a disc in the project folder.

These checklists need to be filled out completely and submitted with the final package when the job folder is returned to the office.

In the example, Party Chief George Gosman is turning in his assignment for a right of way stakeout.

He has submitted an as-staked RW5 file (checked off as submitted by email) and marked the worksheets given to him with the materials set. He has also checked off that he has staked all requested properties and submitted Projectrack Reports for each day worked. He has indicated at the top section that all work was performed using existing control, so there are no check marks for new control work at the bottom.

<u>D. Setup sheets:</u> Setup sheets are used to document all measurements, conditions, and important information associated with position establishment and location. These logs can be used to verify information in raw data files, identify trends, or eliminate errors in field collected information.

i. Setup sheets for traverse establishment: These sheets allow the crew to keep a log of each traverse setup, containing important measurements and notes to use when checks are needed during processing of field data. The sketch area at the bottom can be useful for distance ties when establishing a new control point.

In the example given below, the survey crew is documenting work on two different days where they establish a traverse point and a fly point. All information is included for height of instrument (HI) measurements and all backsight check error information is listed.

TRAVERSE DATA / SETUP SHEET

PROJECT/FILE NAME: BA_30_1909_TRAV # OF SETS: 4 DATE: 9/9/19

INSTR. MAKE ID #: LEICA TS-13-12A8C3 PRISM CONSTANT: 0 mm OPERATOR: Harrison

TEMPERATURE: 75 °F PRESSURE: 30.14 Hg WEATHER: Sunny

OCCUPIED POINT #: SHA 101 HI: 5.12

BACKSIGHT POINT #: SHA 100 HT: 4.99

FORESIGHT POINT #: SHA 102 HT: 5.25

HORIZONTAL DISTANCE ERROR: 0.012 VERTICAL ANGLE ERROR: 0°00′04″

NOTES: SET SHA 102, REBAR AND CAP ∡ sets recorded in peg book

****

PROJECT/FILE NAME: BA_30_1909_TRAV # OF SETS: 4 DATE: 9/10/19

INSTR. MAKE ID #: LEICA TS-13-12A8C3 PRISM CONSTANT: 0mm OPERATOR: Harrison

TEMPERATURE: 68° F PRESSURE: 29.92 Hg WEATHER: Partly cloudy

OCCUPIED POINT #: SHA102 HI: 5.20

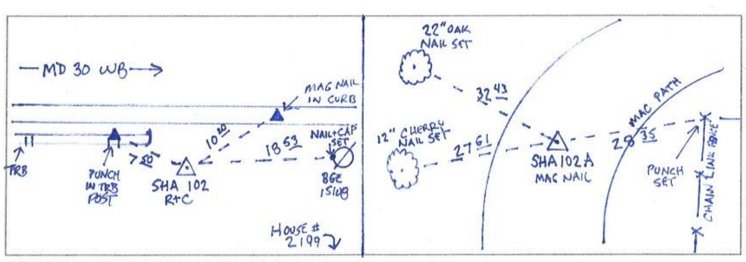
BACKSIGHT POINT #: SHA 101 HT: 5.33

FORESIGHT POINT #: SHA102A (FLY) HT: 4.87

HORIZONTAL DISTANCE ERROR: 0.007 VERTICAL ANGLE ERROR: 0°00′06″

NOTES: SET SHA102A (FLY), MAG NAIL ∡ SETS recorded in peg book

SKETCH AREA



ii. Setup sheets for data collection: These sheets allow the crew to keep a log of data collection setups, containing important measurements and notes to use when checks are needed during processing of field data. The sketch area at the bottom can be useful for sketches or code/shot edit notes for data collection.

In the example given below, the survey crew is documenting two data collection setups. At one setup they are locating ADA features near an intersection and locating storm water management features at the other. They have used the sketch area to make structure sketches for the data collected in the second setup.

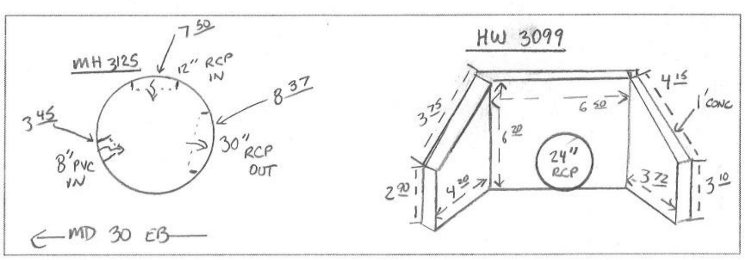
TRAVERSE DATA / SETUP SHEET

PROJECT/FILE NAME: BA_30_190911_TOPO # OF SETS: N/A DATE: 9/11/19
INSTR. MAKE ID #: LEICA TS-13 - 12ABC3 PRISM CONSTANT: 0 MM OPERATOR: REDMOND
TEMPERATURE: 65 °F PRESSURE: 29.6 Hg WEATHER: CLEAR
OCCUPIED POINT #: SHA 102 HI: 5.33
BACKSIGHT POINT #: SHA 101 HT: 5.02
FORESIGHT POINT #: D/C HT: 6.00 ROD
HORIZONTAL DISTANCE ERROR: 0.031 VERTICAL ANGLE ERROR: 0°00'05"
NOTES: Shots 2100 - 2792
Located ADA features at intersection

****

PROJECT/FILE NAME: BA_30_190912_TOPO # OF SETS: N/A DATE: 9/12/19
INSTR. MAKE ID #: Leica TS13 - 12ABC3 PRISM CONSTANT: 0 mm OPERATOR: REDMOND
TEMPERATURE: 68°F PRESSURE: 29.9 Hg WEATHER: SUNNY
OCCUPIED POINT #: SHA102A (FL4) HI: 5.32
BACKSIGHT POINT #: SHA 102 HT: 5.19
FORESIGHT POINT #: D/C HT: 6.00 ROD
HORIZONTAL DISTANCE ERROR: 0.024 VERTICAL ANGLE ERROR: 0°00'02"
NOTES: Shots 2793-3153
Located SWM area and access road features.

SKETCH AREA



E. RTK Observation Logs: These logs are used to document each instance where Real Time Kinematic (RTK) methods are used to establish a control point. Each log shall include job information about the project such as location, FMIS charge number, site conditions, the crew operating the equipment, and the device(s) used. These logs also include information for control points, base position establishment, check shots and residuals, detailed record for all observation sets taken, and averaged values for the new point set. These logs need to be filled out in addition to the bookwork as described in section 1.F.vii.

MDSHA RTK Survey Observation Log (Base / Rover)

Project Name:	Cherrywood Lane Topo	FMIS:	AA456A21			Page:	1 of 1
County:	Anne Arundel	Route:	MD5	Street:		Date:	12/31/2019
Project Description:	Set control for topographic survey						
Firm:	ABC Surveys, Inc.	Horizontal Datum:	NAD83/91	Geoid:	12B	SHA Field Book / Page:	12345/12
Crew:	Jones & Crew	Vertical Datum:	NAVD88				

Start Time:	End Time	Point ID	Northing	Easting	Elevation	Description	HR (m)	Temp.	Humidity	Pressure	Base No.
8:30 AM	2:15 PM	MAT9	487506.564	1338611.208	85.975	Rebar w/orange cap fd	2.000	78	60	29.8	1
8:15 AM	3:10 PM	MAT10	489606.890	1349123.456	120.450	Rebar w/orange cap fd	2.000	78	60	29.8	2

Point ID	Northing	Easting	Elevation	Description	Hz. RMS	V RMS	Observation Time	No. EPOCH Recorded	Set / Check	ΔN	ΔE	ΔZ	RINEX File Name	Base Point No.
SHA100	487500.000	1350000.000	100.000	Rebar w/Red Trav Cap	1.2	1.1	8:55 AM	180	Set					1
CADD14	487250.000	1350200.000	125.000	Rebar w/Red Trav Cap	1.1	1.2	9:30 AM	180	Check	0.02	0.03	0.02		1
SHA101	487750.000	1350750.000	95.000	Stamped Brass Disk	1.0	1.1	9:45 AM	180	Set					1
SHA102	488000.000	1351000.000	80.000	Rebar w/Red Trav Cap	1.2	1.2	10:00 AM	180	Set					1
CADD15	488250.000	1351200.000	85.000	Rebar w/Red Trav Cap	1.1	1.2	10:15 AM	180	Check	0.03	0.02	0.03		1
SHA100	487500.020	1350000.030	100.030	Rebar w/Red Trav Cap	1.2	1.1	10:18 AM	180	Set					2
CADD14	487250.040	1350200.025	125.020	Rebar w/Red Trav Cap	1.1	1.2	10:25 AM	180	Check	0.04	0.03	0.02		2
SHA101	487750.020	1350750.030	95.020	Stamped Brass Disk	1.0	1.1	10:30 AM	180	Set					2
SHA102	488000.040	1351000.030	80.020	Rebar w/Red Trav Cap	1.2	1.2	10:35 AM	180	Set					2
CADD15	488250.030	1351200.040	85.030	Rebar w/Red Trav Cap	1.1	1.2	10:45 AM	180	Check	0.02	0.01	0.03		2
SHA101	487749.990	1350750.010	95.010	Rebar w/Red Trav Cap	1.1	1.3	11:45AM	180	Set					1
SHA102	487999.980	1350999.970	79.990	Rebar w/Red Trav Cap	1.1	1.2	1:15 PM	180	Set					1

Observation Points

SHA101	487750.003	1350750.013	95.010				
SHA102	488000.007	1351000.000	80.003				
				CADD15	488250.015	1351200.020	85.015

20191209

Comments	
File Name:	

ver

F. RTN Localization Logs: These logs are used to document a localization or site calibration. These logs need to include job information about the project such as location, FMIS charge number, site conditions, the crew operating the equipment, and the device(s) used. These logs will also include observation information for control points, whether a point was held horizontally/vertically or both, horizontal and vertical residuals, and file names associated with the end resulting data. These logs need to be filled out in addition to the bookwork as described in section 1.F.viii.

MDOT SHA RTN Localization Log

Project FMIS:		AW073A11			Page:	1 of	
Project Name:		P3 - IS495 / IS270			Date:	10/04/2019	
Project Description:							
County:		Montgomery	Route:	IS495	Street:		
Datum:		Horizontal		Vertical	PSD Field Book / Page		12345/45
		NAD83/91		NAVD88	GEOID		
Firm:		Plats & Surveys Division					
Crew:		Loskot & Crew		Network:	TopNET		
Weather:		Temperature		Humidity		Pressure	
		78	°F	14	%	29.8	inHg
Receiver:		Manufacturer		Serial Number		Height Rod (m)	
		Leica		1234567		2.000	
Calibration Points		Northing		Easting		Elevation	
FXCO3		**474855.6930**		**1240873.4660**		**241.656**	
Horizontal	X	NAD83/91	Datum	Residual	0.057		
Vertical	X	NAVD88	Datum	Residual	-0.040		
JV6797		**471864.7780**		**1247760.0110**		**280.134**	
Horizontal	X	NAD83/91	Datum	Residual	0.062		
Vertical	X	NAVD88	Datum	Residual	-0.020		
GPS79		**467794.5530**		**1263466.0330**		**284.097**	
Horizontal		NAD83/91	Datum	Residual	0.025		
Vertical	X	NAVD88	Datum	Residual	0.020		
V1744		**465477.7640**		**1250674.6170**		**324.005**	
Horizontal	X	NAD83/91	Datum	Residual	0.074		
Vertical	X	NAVD88	Datum	Residual	0.010		
20305		**496657.8540**		**1282300.5550**		**308.280**	
Horizontal	X	NAD83/91	Datum	Residual	0.074		
Vertical	X	NAVD88	Datum	Residual	0.040		
20320		**491751.3720**		**1254066.8320**		**365.170**	
Horizontal	X	NAD83/91	Datum	Residual	0.048		
Vertical		NAVD88	Datum	Residual	0.071		
20341		**504726.9050**		**1262694.0050**		**414.150**	
Horizontal		NAD83/91	Datum	Residual	0.045		
Vertical	X	NAVD88	Datum	Residual	0.120		
Horizontal			Datum	Residual			
Vertical			Datum	Residual			
Comments:				Maximum Horizontal Residual			**0.0500**
				Maximum Vertical Residual			**0.0400**
Localization Description:		IS-495 - Phase 1		Maximum 3D Residual			**0.0550**
RTN Localization File Name:		20190918_ABC					

ver 20191018

<u>G. RTN Observation Logs:</u> These logs are used to document each instance where Real Time Network (RTN) methods are used to establish a control point. Just like the RTN Localization Log, these require job information about the project such as location, FMIS charge number, site conditions, the crew operating the equipment, and the device(s) used. These logs also include information for control points, check shots and residuals, detailed record for all three observation sets taken, and averaged values for the new point. There should also be reference to the localization and associated files. These logs need to be filled out in addition to the bookwork as described in section 1.F.ix.

MDOT SHA RTN Observation Log - New Point

Project FMIS:		MO456A21			Page:	1 of 1	
Project Name:		P3 - IS495 / IS270			Date:	10/05/2019	
Project Description:							
County:		Montgomery	Route:	IS495	Street:		
Datum:		Horizontal		Vertical	GEOID		
		NAD83/91		NAVD88			
Firm:		ABC Surveys, Inc.					
Crew:		Smith & Crew		Network:	TopNET		
Weather:		Temperature		Humidity		Pressure	
		78	°F	14	%	29.8	inHg
Receiver:		Manufacturer		Serial Number		Height Rod (m)	
		Trimble R10		123456		2.000	
26194A		Northing		Easting		Elevation	
Observation No. 1 CK		400000.0000		1300000.0000		500.00	
Date	Time:	400000.0800		1300000.0500		500.02	
10/05/2019	8:43 AM	0.0800	ΔN	0.0500	ΔE	0.02	ΔZ
Receiver Data			PDOP		H-RMS		V-RMS
26194B		Northing		Easting		Elevation	
Observation No. 2 CK		450000.0000		1350000.0000		600.00	
Date	Time:	450000.0300		1350000.0500		600.03	
10/05/2019	9:30 AM	0.0300	ΔN	0.0500	ΔE	0.03	ΔZ
Receiver Data			PDOP		H-RMS		V-RMS
19645A		Material Set		5/8" REBAR WITH RED TRAV CAP			
Observation No. 1		Northing		Easting		Elevation	
Date	Time:	425000.0000		1325000.0000		100.00	
10/05/2019	11:15 AM	-0.0200	ΔN	-0.0400	ΔE	-0.0033	ΔZ
Receiver Data			PDOP		H-RMS		V-RMS
Observation No. 2		Northing		Easting		Elevation	
Date	Time:	425000.0500		1325000.0400		100.03	
10/06/2019	9:20 AM	0.0300	ΔN	0.0000	ΔE	0.0267	ΔZ
Receiver Data			PDOP		H-RMS		V-RMS
Observation No. 3		Northing		Easting		Elevation	
Date	Time:	425000.0100		1325000.0800		99.98	
10/06/2019	12:30 PM	-0.0100	ΔN	0.0400	ΔE	-0.0233	ΔZ
Receiver Data			PDOP		H-RMS		V-RMS
Average Values		Northing		Easting		Elevation	
		425000.0200		1325000.0400		100.00	
Comments:							
Localization Description:							
RTN Localization File Name:		20190918_ABC					

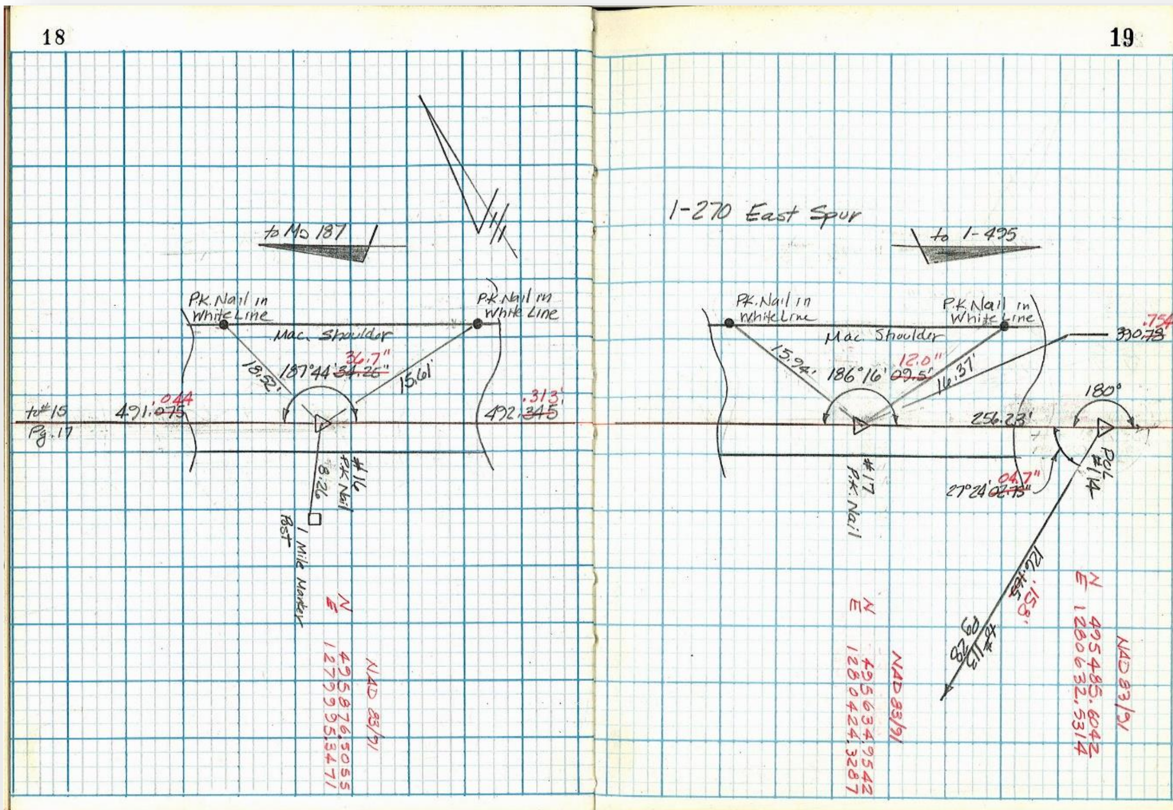
Check Sots

New Points

20191018

ver

<u>H. Survey Field Book Scans:</u> Part of the deliverable for a task will include a full color scan for each new page of survey field book notes. These scans are kept on a shared static data drive that can be accessed by MDOT SHA personnel. PSD has been working to create scans for all current field book data and it is important to have all new information scanned before it is cataloged into the PSD field book room.



a. All scans shall be in JPG format.
b. All scans shall be in full color.
c. All scans shall be created at a resolution of at least 300 x 300 pixels per inch (PPI) and all images must be clear. If a scan is not clear it will need to be recreated.
d. All scans shall be cropped to the outer extents of the right and left pages as shown above.
e. Index pages must be scanned if new entries are present in the field book.
f. All field book scan file names shall be formatted as follows:
Book Number _ Right Page - Left Page.
e.g. The file name for the field book scan above is “**20464_18-19.jpg**”

10. Safety

The Plats and Surveys Division defers to MDOT SHA's overall safety guidelines provided by the Office of Traffic and Safety (OOTS) to include applicable guideline manuals and enacted laws. These guidelines apply to all MDOT SHA personnel and consultant workers performing work on MDOT SHA projects.

For a current and comprehensive list of **MDOT SHA's Safety Policies** visit our website at www.roads.maryland.gov. Select "**Safety**" from the tabs at the top. Then select "**Work Zone Safety and Mobility**" from the menu on the left or click here.

Safety reference manuals and documents for compliance are as follows:

If you are working with an online version of this manual the references below are linked to this list. If viewing a printed version, visit www.roads.maryland.gov and search for the references by the names below. Please note that these guidelines are meant to be followed in addition to any Occupational Safety and Health Administration (OSHA) or Maryland Occupational Safety and Health (MOSH) guidelines that may also apply.

Maryland Manual of Uniform Traffic Control Devices **(MdMUTCD) 2011 Edition**

MDOT SHA High Visibility Safety Apparel Policy **(2019)**

Personal Protective Equipment Program **(PPE) 2008 Edition**

SHA Workplace Safety Manual **2015 Edition**

SHA Workplace Safety Guidelines **2007 Edition**

Temporary Traffic Control Device Quality Standards and Field Practices 2008 Edition

Work Zone Lane Closure Analysis Guidelines 2006 Edition

Below is a list of guidelines and expectations for all workers as it pertains to their role in maintaining a safe roadway and work environment.

A. Responsibilities:

i. Everyone using Maryland roadways needs to practice lawful, safe, and courteous conduct. In performing field surveying tasks, personnel are expected to be aware of certain individual responsibilities including, but not limited to:

a. Knowledge of safety rules and regulations. All safety and traffic laws must be obeyed when operating vehicles and equipment.

b. The need to be well rested and to use good judgment.

c. Focus when working in or around traffic. Traffic can be a hazard to workers around the road, but also be aware that the presence of workers around the roadway can be a distraction to drivers.

d. Understanding emergency procedures and responsibilities regarding accidents or injuries.

e. Wear appropriate clothing and safety gear as defined in the references above.

f. Reporting any unsafe conditions or situations to a supervisor immediately. If it doesn't feel safe, don't do it.

g. Adherence to all guidelines and policies discussed in this section.

ii. Training and equipment shall be provided as needed to ensure that the staff understand their responsibilities and have a comprehensive understanding of all safety issues. They need to approach all working conditions with due caution and work as safely as possible. This includes:

a. Keeping vehicles in good working condition.

b. Performing regular and preventive maintenance of vehicles and equipment.

c. Tracking an inventory to replace worn or obsolete equipment.

d. Trainings and/or certifications necessary for any specialized operations such as **First Aid, CPR, Railroad Safety, Confined Space, and Flagger Training.**

1. Railroads have specific requirements for work on their property. Crew members must be trained and certified by the specific rail company to work on these sites. Rights of entry are needed to perform tasks within the railroad right of way.

2. Crew members shall not enter confined spaces (storm drains, sewers, or vaults) without the necessary training and equipment.

e. Traffic control, including maintenance of traffic utilization and coordination.

f. Pre-operational safety plan development and review.

g. Situational awareness.

h. Management will inform employees of changes, additions and/or revisions to policies, guidelines and procedures and arrange for necessary training.

B. Traffic: Employee travel throughout the State of Maryland must be conducted with an emphasis on safety, mobility and convenience. Every employee that performs duties on roadways and project sites must make a commitment to safety while playing an important role in the success of the work effort and products.

i. Traffic Control & Public Safety:

a. Traffic safety shall be planned to ensure that operations are as safe as practical for the situation. Keep safety of workers and road users in mind.

b. Work efforts shall limit interference with traffic as much as possible. Survey operations should strive to:

1. Avoid abrupt changes of traffic pattern.

2. Provide protection for workers, the work vehicle and the traveling public.

3. Perform work in a safe manner and complete work as quickly as possible.

4. Accommodate pedestrians and cyclists.

c. Use appropriate traffic control devices to provide clear and positive guidance to roadway users through the work zone.

<u>C. Traffic Control Devices:</u> Traffic control devices help ensure highway safety by providing for the orderly movement of traffic. These devices alert road users and provide guidance and warning that may be necessary for users to get through the work zone safely. To be effective, traffic control devices must be in accordance with the current MdMUTCD and meet these basic requirements:

i. Fulfill a need to direct and/or warn road users of a work zone.

ii. Command attention and respect of drivers.

iii. Convey a clear and simple meaning.

iv. Allow adequate time for proper response by roadway users.

v. Respect the classification of traffic control that is required for the speed and type of roadway. **Traffic attenuators are required for any roadway with a speed limit of 55 MPH or greater or when circumstances or conditions warrant use.** This cannot be substituted with extra signage or cones.

vi. Signs and cones are the most typical materials used for traffic control when working in a mobile operation. (Current to 2011 MdMUTCD).

a. All mobile survey signs positioned by Survey Crews are to be **36" x 36" size with "SURVEY CREW AHEAD"** or other appropriate message. All signage shall be constructed of reflective material in accordance with the Maryland Manual for Uniform Traffic Control Devices (MdMUTCD).

b. Cones shall be predominantly orange and shall be made of a material that can be struck without causing damage to the impacting vehicle.

c. Along State owned, operated and maintained roadways, cones shall have a minimum height of 28 inches, be retro-reflectorized, and shall not be equipped with lights or lighting devices.

d. Retro-reflectorized cones that are 28 to 36 inches in height shall be provided by a 6-inch wide white band located 3 to 4 inches from the top of the cone and an additional 4-inch wide white band located approximately 2 inches below the 6-inch band.

vii. All personnel must wear reflective vests (in accordance with the high visibility apparel policy) in good condition when working along any roadway.

viii. The location and placement of signs are based on the roadway type, and conditions at the time work is being performed. The specifications on spacing and placement are detailed in the MdMUTCD Manual.

<u>D. Vehicles and Equipment:</u>

i. Each operator is responsible for the safe operation of their vehicle and must adhere to and obey all applicable traffic laws and regulations.

ii. *All SHA personnel must abide by the general rules for drivers of state owned vehicles and equipment. MDOT SHA's Driver Rules can be found online at the link or by searching for the MDOT Intranet for "SHA Driver Rules".*

"Drivers are required to read the Policies and Procedures for Drivers of State Vehicles and sign a Bi-Annual Driver Rules Acknowledgement Statement. The signed statement must be obtained by the fleet manager. Only drivers who have signed the statement may operate state vehicles."

iii. Vehicle operators must have a valid driver's license required for the class of vehicle being driven.

iv. All individuals driving, riding in, or operating a vehicle must wear seat belts.

v. All vehicles that are working or parked on the roadway should be clearly marked with MDOT logo or consultant firm sticker. They must be of a color that is easily visible to the driving public and be equipped with rotating and/or flashing beacons to include 360 degree visibility.

vi. Conventional survey trucks/vans must be capable of carrying adequate signs and cones needed to control non-lane closure operations.

vii. As a daily routine, the Party Chief should perform a visual inspection of the work vehicle to make sure that it is in proper working condition.

viii. It is the responsibility of **all** crew members to routinely check tools and other gear and inform the Party Chief of any issues with their condition.

ix. All MDOT SHA survey trucks shall be equipped with approved fire extinguishers and first aid kits which must be kept readily available for emergency situations.

<u>E. Lane Closures:</u> There are several instances where lane closures are necessary for surveying tasks. This will require the acquisition of a lane closure permit. This must be done for work on all state roads and includes working in a shoulder. Area Engineers or consultant management will apply to the appropriate district for a permit and it will be supplied to the survey crew at the time of assignment.

The party chief will be responsible to call Statewide Operations Center (SOC) at the start of each workday to activate this permit and at the end of each day to deactivate the permit. The phone number for the SOC is listed on the bottom of the approved lane closure permit. These permits do not fulfill a need for a traffic attenuator. Permits will be required for use in conjunction with such traffic control, but not in place of it.

F. Roadway Restrictions: In general, site work on state roads is restricted to the hours of 9am to 3pm Monday-Thursday and 9am-1pm on Fridays. Be aware of more stringent guidelines on interstates and seasonally traveled routes. Contact SOC if there is any concern about work hours on your site.

Work on major state roads and interstates will be restricted on major travel-heavy holidays. These restrictions typically extend through a workday or two before and after the holiday or holiday weekend.

G. On-Site Risks: There are many risks associated with the varied environments where survey tasks take place. It is important for crews to be aware of hazards and be as prepared as possible. The Plats and Surveys Division is not an authority on information pertaining to these hazards but there are many references online (as well as those listed at the beginning on this safety section) that can give relevant, accurate and important information to help crews stay safe. Hazards to be aware of include:

i. Weather related risks – hypothermia, frostbite, heat stroke, heat exhaustion, sun burn, skin cancer, drowning risk from flooding, lightning strikes, dangers from snow drifts, unsafe roadway conditions during storm events, etc.

ii. Traffic related risks – distracted drivers, accidents, projectiles (vehicle parts, debris), vehicle fires, slick surfaces, erratic driving during traffic detours, etc.

iii. Nature related risks – poison ivy/oak/sumac, ticks, chiggers, spiders, animal attacks and/or bites, tree felling danger, falling rocks, drowning risk in waterways, slips and falls, etc.

iv. Man-made risks – railroads, underground utilities, fences (regular and electric), unstable structures/manholes, confined spaces, toxic gases, use of equipment, and hand tools, etc.

11. Works Cited

1. National Geodetic Survey
Communications and Outreach Branch, NOAA, N/NGS12
National Geodetic Survey, SSMC3 #9340
1315 East-West Highway
Silver Spring MD 20910
NGS
http://www.ngs.noaa.gov/

2. California Department of Transportation
Office of Land Surveys
1727 30th Street Sacramento CA 95816
Caltrans
http://www.dot.ca.gov/landsurveys/index.html

3. New Jersey Department of Transportation Survey Manual, 2016
P.O. Box 600
Trenton NJ 08625
NJDOT
https://www.state.nj.us/transportation/eng/documents/survey/

4. Construction Surveying and Layout, Third Edition, 2003
Wesley G. Crawford
Creative Construction Publishing, Inc.
2720 South River Road
West Lafayette IN 47906
Creative Construction
http://www.creativeconstruction.com

5. Survey Field Procedures Manual, 2001
Maryland Department of Transportation, Office of Highway Development
Plats and Surveys Division
211 East Madison Street
Baltimore MD 21202

6. Delaware Department of Transportation, DelDOT Survey Guidebook
800 Bay Road
Dover DE 19901
DelDOT
https://deldot.gov/Business/drc/pdfs/projectmanagement/deldot_survey_guidebook_drc_full.pdf

7. Code of Maryland Regulations: Title 09 Department of Labor, Subtitle 13 Board for Professional Land Surveyors, Chapter 06 Minimum Standards of Practice
Maryland Department of Labor
500 North Calvert Street
Baltimore MD 21202
http://www.dsd.state.md.us/COMAR/ComarHome.html

Written By

Brian Crocetti, Area Engineer MDOT SHA PSD
Erik Donald, Area Engineer MDOT SHA PSD
Dan Houtz, Senior Area Engineer MDOT SHA PSD
John Jackson, Area Engineer MDOT SHA PSD
Jeremy Jollie, Senior Area Engineer MDOT SHA PSD
Stefan Kunz, Area Engineer MDOT SHA PSD
Douglas Okyere, Area Engineer MDOT SHA PSD

Edited By

Michael Blahut, Project Manager, MDOT SHA OOS
Matthew Bloedorn, Prof. L.S., Assistant Division Chief, MDOT SHA PSD
Steve Buddenbohn, Area Engineer Manager, MDOT SHA PSD
Jeremy Burns, Prof. L.S., Chief of SUE, The Wilson T. Ballard Company
Kevin Carberry, CADD Processor, MDOT SHA PSD
Bill Carroll, Prop. L.S., Senior Area Engineer, MDOT SHA PSD
Eric Cooper, Prof. L.S., Chief of Surveys, Wallace Montgomery and Associates
Paul Ewell, Prof. L.S., Chief of Surveys, AECOM Technical Services
Mark Harrison, Senior Surveyor, Wallace Montgomery and Associates
McKendre Jay, Digital Assets Manager, Chesapeake Environmental Management
Steve Loskot, Survey Party Chief, MDOT SHA PSD
John Redmond, Senior Surveyor, Wallace Montgomery and Associates
Dan Sain, Prof. L.S., Assistant Division Chief, MDOT SHA PSD
Barry Smith, Prof. L.S., P.E., Division Chief, MDOT SHA PSD
Pattianne Smith, Prof. L.S., Team Leader - Plats, MDOT SHA PSD
Matt Tilmes, Prof L.S., Assistant Division Chief, MDOT SHA PSD

Production, Layout and Artwork By

Dan Houtz, Senior Area Engineer MDOT SHA PSD

Maryland Department of Transportation
State Highway Administration
Office of Highway Development
Plats and Surveys Division
211 East Madison Street, M-101
Baltimore, MD 21202