Recording a Survey Grade MSL Elevation for USFWS Wetland Projects using VRS Trimble GPS.

Purpose: Mean Sea Level (MSL) surveys are to define and record an elevation tied to a legal agreement or easement. These steps must be followed with proper documentation as it must be repeatable and defendable for any future management or dispute.

Tutorial by:
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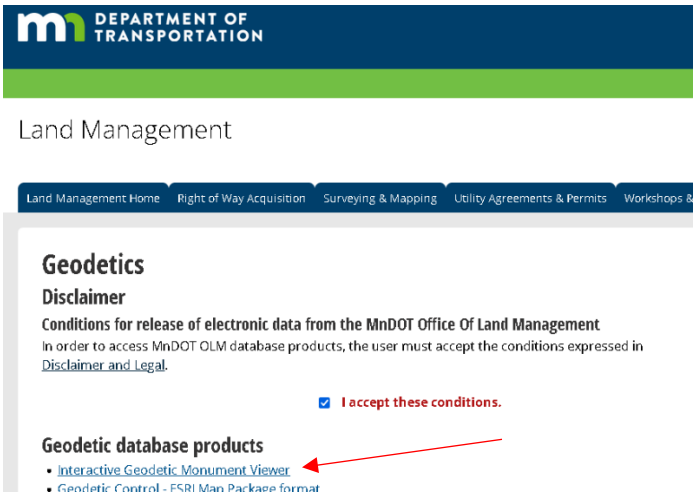
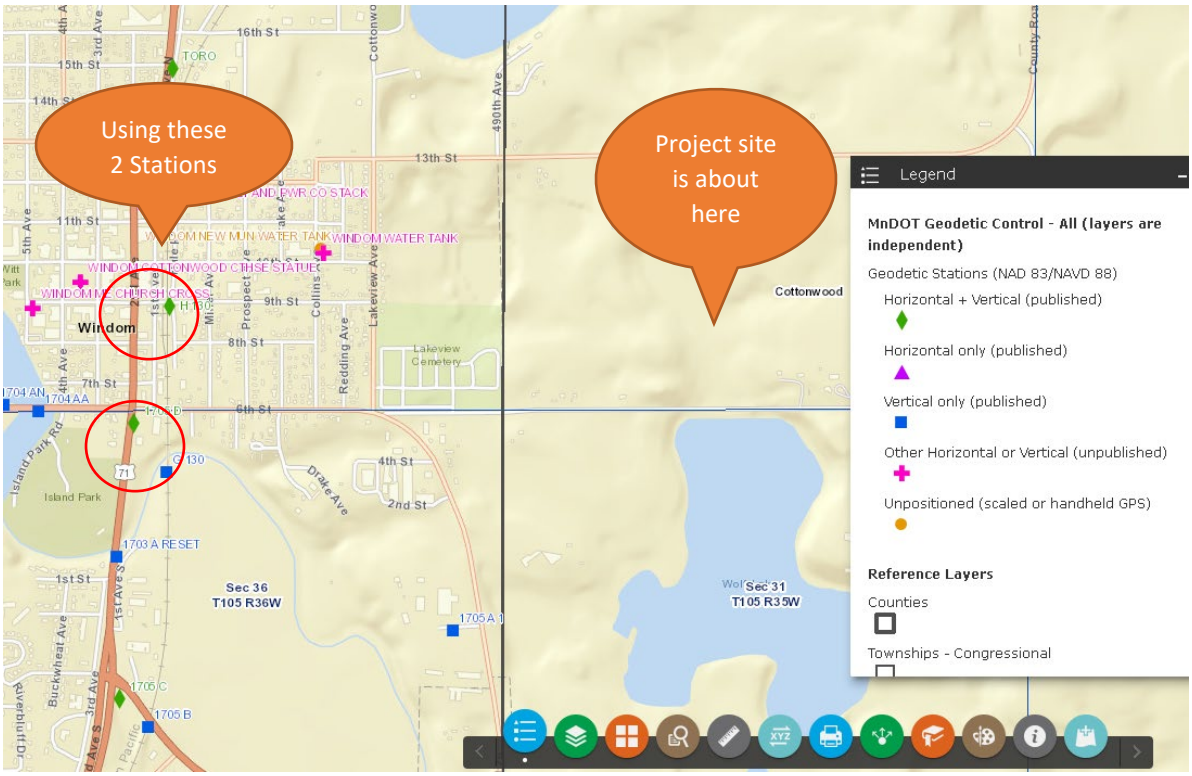
Last Updated 8/8/2023

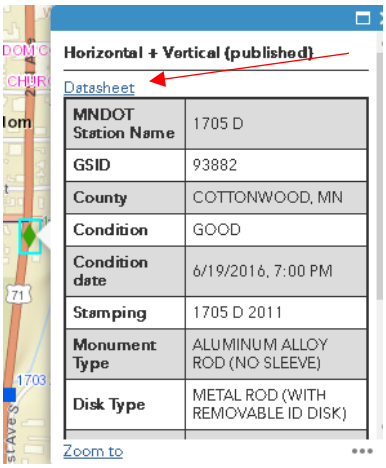
1. **Select Geodetic Monuments:** These are certified control points often placed by DOT or County entities that have recorded positions. These monuments should be compared to your site survey points for accuracy. Calibrations can be done if needed from these standardized locations.
    a. Go to the MNDOT Geodetic website or counterpart if in another state. Web search or : https://www.dot.state.mn.us/surveying/geodetics/index.html
    b. Hit the "I Accept" disclaimer and open the link for Interactive Geodetic Monument Viewer



    c. On the next page hit Launch Viewer
    d. Zoom to near your project site. You want to find Geodetic monuments as close to your site as possible. Preferably withing a few miles. Also, if possible, find 2 sites so you can reference more than one for a better confirmation record. 2nd site would also be helpful if, when you get to the field, you find the monument has been destroyed or altered then you have a backup. Also, one that has clear GPS signal such as not shadowed by trees that can affect signal.
    e. Note the legend. We want only in this case the green diamond which is Horizontal AND Vertical stations



f. Click on a station you want and a popup should appear with station information. At the top is a link for the Datasheet. Click and download the datasheet. Save in the project file. Repeat for a 2nd nearby site if available.



g. What to look for on this Geodetic Record Sheet:
   i. Unique ID number should be top center (See highlighted example for 1705 D).
   ii. Vertical Order should be 2.
   iii. Description is good to read to know where to find it and what you are looking for.
   iv. Leveling-Derived Orthometric Heights (Feet). This is the **most important** for our purpose. Check the Acc (Accuracy) column first and choose the most accurate reading. If otherwise the same then go by the newest in the Year column. Record that Height listed. This example is 1351.113
   v. County Coordinates (Feet). This is the horizontal position of the station. Slightly less important for MSL but still want close. Again choose the more accurate reading first then newest. Record the X and Y. Not using the Lat/Lon.
   vi. Repeat if a second station is used.
   vii. At the end of the report there may be links to site photos if available. Download and view these as they may be helpful in finding the monument and knowing what you are looking for.

h. Print these Geodetic survey sheets for the project and put them in your survey file.

Geodetic Data Sheet (Feet)
GSID Station # 93882

1705 D

08/08/2023
Sheet Help

Mn/DOT Name: 1705 D
NGS Name: 1705 D
County: COTTONWOOD, MN (Sheet 1)

NGS ACRN: DO7186 Get Map
NGS Quad / Sta Num : 43095112/
USGS Quad: WINDOM

1/4	Sec	Twp	Rng	Reference Latitude	Reference Longitude	Vert Order	Horz Order
NW	36	105 N	36 W	435143.02	950653.62	2	C

Year Set	Last Recovery	Condition	Geodetic Usability	Photos	Bridge Num	F/P/R	Magnetic Properties
2011	2016	GOOD	Horz=YES Vert=YES	YES		RECESSED 2 IN.	BAR MAG IN DRILL HOLE

Monument Type	Disk Type	Mon. Agency
ALUMINUM ALLOY ROD (NO SLEEVE) (DEPTH 22 FT)	METAL ROD (WITH REMOVABLE ID DISK)	MNDT

Description: (2011) **Stamping:** 1705 D 2011

IN WINDOM, AT THE JUNCTION OF TRUNK HIGHWAY 62 AND TRUNK HIGHWAY 60/TRUNK HIGHWAY 71 IN WINDOM, AT TRUNK HIGHWAY 60 MILEPOINT 40.65, 48.7 FEET EAST OF TRUNK HIGHWAY 60/TRUNK HIGHWAY 71, 155.8 FEET SOUTH OF COUNTY ROAD 17 (6TH STREET), 82.8 FEET NORTH OF AN ENTRANCE TO THE RIVER BEND PLAZA, 50.4 FEET WEST OF THE RIVER BEND PLAZA SIGN, 1.8 FEET WEST OF A WITNESS POST.

Leveling-Derived Orthometric Heights (Feet)

NAVD88

Orthometric Height			Ellipsoid (NAD83)				Project Info	
Height	Acc	Order (/Class)	Height	Acc	Adj	Determination Method	Year	Reference
1351.113	.016	2/1				VERTICAL ADJUSTMENT	2019	00000938
1351.113	.016	2/1				VERTICAL CONTROL SURVEY	2017	VWDOM
1351.113	.016	2/1				VERTICAL CONTROL SURVEY	2017	VBLOW
1351.113	.016	2/1				VERTICAL ADJUSTMENT	2013	00000792
1351.113	.016	2/1				VERTICAL CONTROL SURVEY	2012	VFULD

Non Leveling-Derived Orthometric and Ellipsoid Heights (Feet)

NAVD88

Orthometric Height			Ellipsoid (NAD83)				Project Info	
Height	Acc	Order (/Class)	Height	Acc	Adj	Determination Method	Year	Reference
1351.087	.262		1261.464	.197	2011	GPS - RTRN	2016	RTRN2016
1351.113			1261.448	.024	2011	HORIZONTAL ADJUSTMENT	2014	GPS2962
1351.113			1261.448	.024	2011	GPS - STATIC	2014	HFULD
1351.113	.131		1261.677	.066	1996	GPS - STATIC	2013	HFULD

Geoid Separations(ft): GEOID18 = -89.645 12B = -89.626 09 = -89.518 03 = -89.436

Lat/Lon and County Coordinates (Feet)

NAD83(2011)

Geodetic Position		Cottonwood County					Project Info	
Latitude	Longitude	X	Y	Acc	Order	Determination Method	Year	Reference
43 51 43.01703	95 06 53.62299	447713.564	105127.841	.131	3	GPS - RTRN	2016	RTRN2016
43 51 43.01687	95 06 53.62226	447713.617	105127.825	.020		ADJUSTMENT	2014	GPS2962
43 51 43.01687	95 06 53.62226	447713.617	105127.825	.020	C	GPS - STATIC	2014	HFULD

NAD83(1996)

Geodetic Position		Cottonwood County					Project Info	
Latitude	Longitude	X	Y	Acc	Order	Determination Method	Year	Reference
43 51 43.01583	95 06 53.62263	447713.590	105127.720	.033	C	GPS - STATIC	2013	HFULD

State Plane and UTM Coordinates (Feet)

NAD83(2011)

Geodetic Data Sheet (Feet)
GSID Station # 93882

1705 D

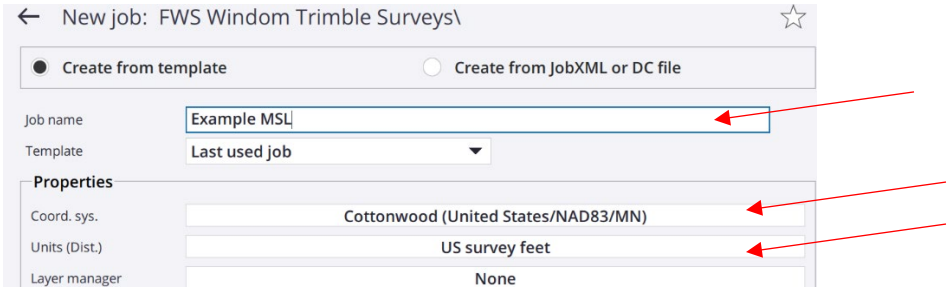
08/08/2023
Sheet Help

Station Photos

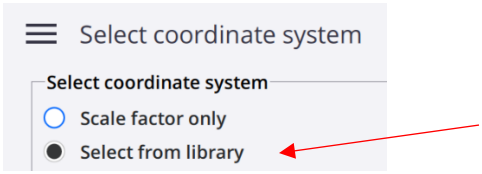
Type	File Name	Dir	Date
Location:	https://www.olmweb.dot.state.mn.us/geod/StationPhotos/cottonwood/1705_D-DO7186-3E-20JUN2016.jpg	E	Jun 20, 2016
Monument:	https://www.olmweb.dot.state.mn.us/geod/StationPhotos/cottonwood/1705_D-DO7186-2-20JUN2016.jpg		Jun 20, 2016
Disk:	https://www.olmweb.dot.state.mn.us/geod/StationPhotos/cottonwood/1705_D-DO7186-1-20JUN2016.jpg		Jun 20, 2016

** All station images can be viewed at: ftp://ftp.olmweb.dot.state.mn.us/geod/StationPhotos **

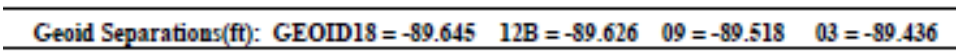
2. **Create a Survey Job**.
   a. On your Trimble Controller open Trimble Access.
   b. On the survey screen hit New
   c. Give the Job a name such as the Name of your project and “MSL”



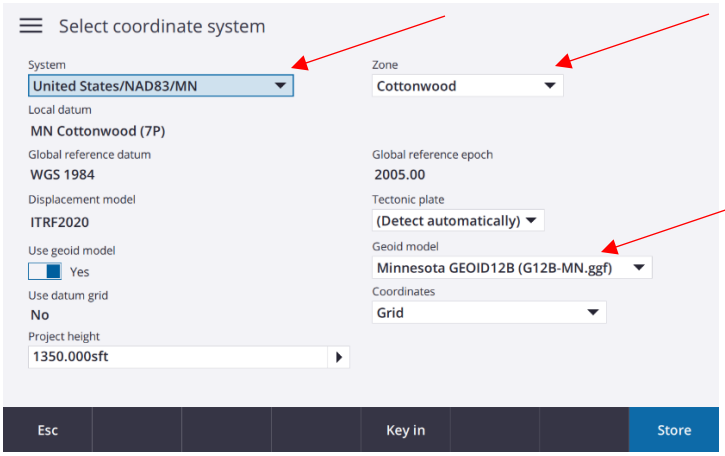
   d. Click the coordinate system box and hit Select from Library and Next



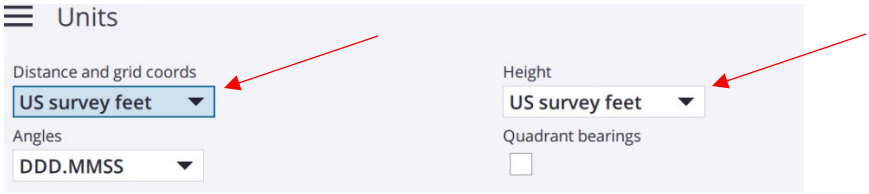
   e. In the system Dropdown menu find United States/NAD83/MN or may be named slightly different depending on your version but should be the MN County system. Once selected you will also have a Zone drop down menu which you select your county.
   f. Under project height enter an approximate elevation for your area within about 500 – 1000ft is fine.
   g. Geoid model. This can be some guess work as ideally you should take your Geoid in the same system as the Station elevations were recorded as each geoid will be slightly different. Note on the Data sheet there is a listing of Geoid separations as in the example below so difference could be calculated and calibrated if needed. There isn’t a listing of what Geoid was used for the record but can make some assumptions on date of the Station. A 2014 record for example couldn’t have used the 2018 Geoid so more than likely using 2012. New geoids usually aren’t loaded until surveyors get a new unit or intentionally do updates so likely will use 2012 geoid up though the early 2020’s. Picking the wrong one could result in error as in this example almost 2 tenths difference between 12B and 03.



   h. Leave Coordinates set as Grid.
   i. Hit store as that is all the settings in the coordinate system screen.



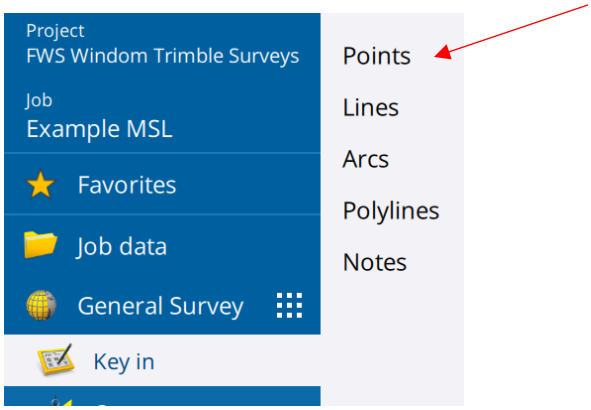
j. Back on the job properties hit Units and make sure both the Distance grid Coordinates and the Height fields are both set to US Survey Feet. Leave other settings as default and hit accept



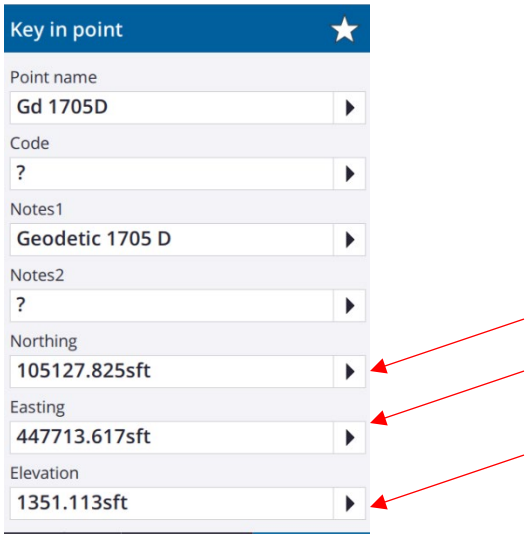
k. These are all the specific job settings so hit accept to save this new job file.

3. Key in Geodetic Stations

a. Once the job file is created go to the menu and Key In, Points



b. Give the point a name such as the Geodetic Station ID. In this example 1705D
c. See notes above of which set of coordinates you choose from the data sheet.
d. Under Northing enter the Y value from the data sheet
e. Under the Easting enter the X value from the data sheet
f. Under Elevation enter the Height value from the data sheet.
g. Hit enter to save the point
h. Repeat if you have a second Geodetic station.



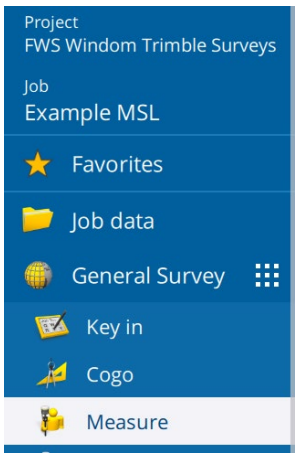
4. Field Notebook

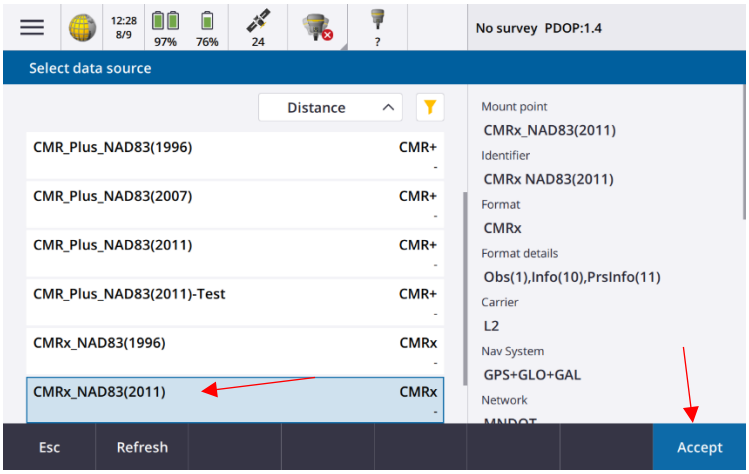
a. Field notes are important documentation for legal surveys. All surveys must be accompanied by field notes. They should be hand written in most cases in a notebook or a log or data sheet.

b. Should include:
    i. Surveyor Name
    ii. Date
    iii. Project Name
    iv. Equipment used (Example Trimble R12i, TSC7, VRS 2011adj
    v. Any relevant site notes such as if the MSL is shot from a benchmark that is not the same as the water structure then note that such as “Flowline outlet elevation for wetland MSL is 2ft lower than Shot #2 reading”.
    vi. Record each shot with the same number on the GPS unit as what is recorded in your notes with description of what it was and what the elevation was.
    vii. Shot 1 would be “Check in with station ###” then the Horizontal and vertical Distance of the shot from the keyed value.
    viii. Shot 2 may be your MSL site or benchmark with elevation
    ix. Shot 3 would be after reinitializing your GPS, measuring the same MSL reference point again.
    x. Shot 4 assuming you are done with MSL on site would be another check in after the survey at preferably a different Station with Horizontal and vertical differences from the keyed value.
    xi. May have more than these 4 shots if a bigger site or more readings needed but at minimum these 4 shots on a basic MSL in your field notes.

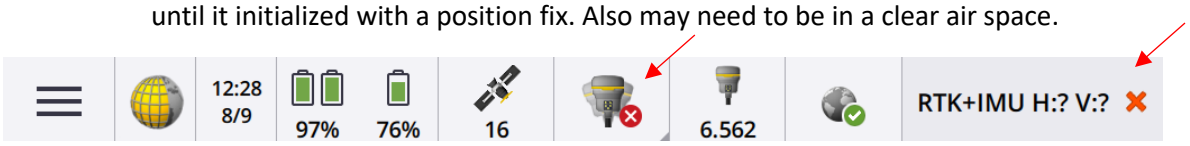
5. Check in with your first GSID Station

a. Head to the field with the first stop being one of the Geodetic stations you recorded.
b. Bring the data sheet and site photo if needed along with your GPS including bipod and survey point foot for the rod, also bring a survey notebook as documentation is required for MSL surveys.
c. If it isn’t already, mount the sharp survey point foot on the survey rod as this will aid in a more accurate placement on the Station monument.
d. To start your Trimble GPS reminder of a few steps. Order is helpful in reducing errors.
    i. Turn on the wifi jetpack 1st or other hotspot so it is available to find when the unit turns on and seeks a connection
    ii. Turn on the GPS receiver R10 or R12 etc so again it is already available when the control turn on.
    iii. Last turn on the Control (TSC7 or TSC5). Make sure it connects to the hotspot or if needed enter your wireless settings and manually connect.
    iv. Open Trimble access and open the project job file you created with the keyed in points or create it now if you didn’t previously using the steps above.
    v. Start the survey on the unit by hitting the measure button. Assuming the GPS was on it should connect through Bluetooth and assuming you had an internet connection it should start logging into the mount point. In the mount point list choose CMRx 2011.

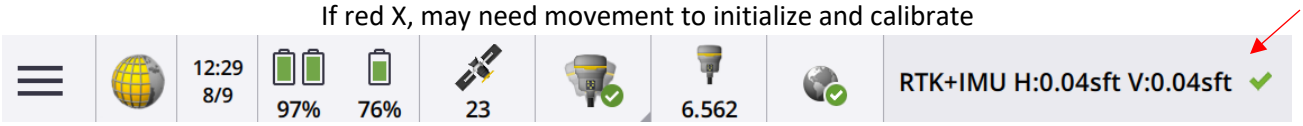




vi. Once logged in the GPS should initialize which will be indicated by the red X changing to a green check box in the top toolbar next to the GPS icon. Some units particularly the R12i need movement to initialize and to calibrate it's IMU so walk around or wobble the unit in a circle until it initialized with a position fix. Also may need to be in a clear air space.



If red X, may need movement to initialize and calibrate



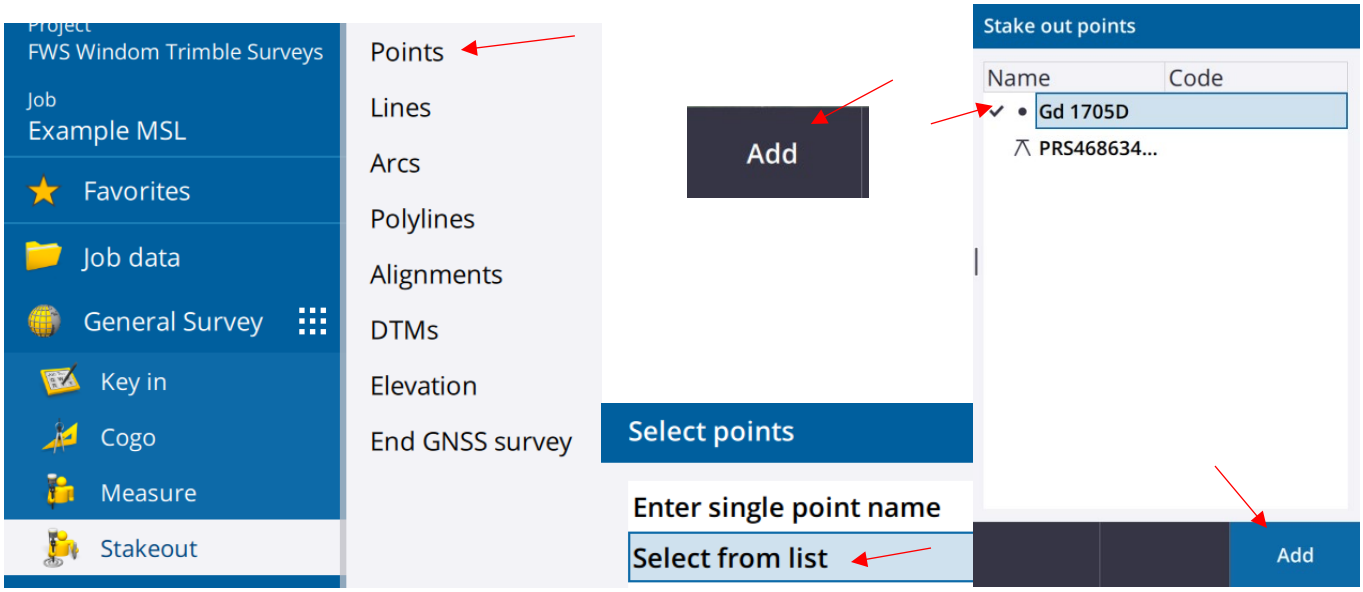
vii. Confirm your GPS heigh is set correct which should be 2 meters or 6.562 feet for a standard survey rod

e. The Geodetic Marker will most often have a sign post near it that is labeled as such and may have an indication of the station direction and distance relative to the sign. Refer to the photo available in the data sheet if needed. Monuments may be enclosed in a covered box or may be a surface pin or disk. Sometimes may be covered with dirt or vegetation so might need to lightly dig. Caution not to damage them. They often will have an x or dimple in the center which is where you would place the point of your survey rod and record your elevation from. If not, use the center of the top.

f. Stakeout point. You may visually find the station which is fine or can use the stakeout feature to navigate to it. Even if you find it visually the stakeout feature is good to easily check how close you are and determine if something is wrong.

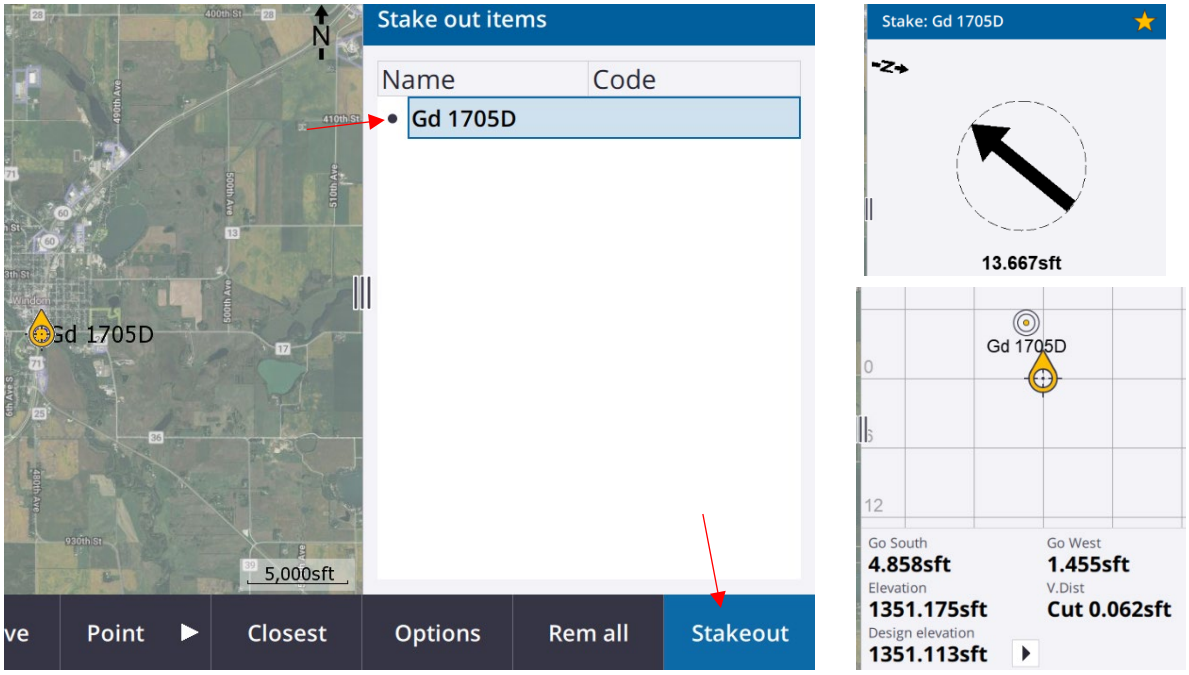
i. On the settings menu go to Stakeout and Stakeout Points option

ii. If your keyed in station point is not in the list then hit Add from the bottom menu and From List.



iii. Select and hit a check box next to your keyed points and hit Add.

iv. Then select that point in the stake out list and hit Stakeout.

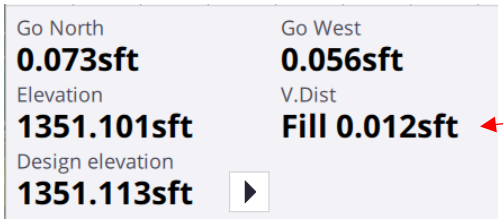


v. Depending on your units version you may have variations but should have a numerical distance North/South or East/West of the point, May have a visual Arrow which in the R12i is relative to the power button panel on the GPS head facing you. May also have a map with a target. In the readout there is also a Horizontal and a vertical distance readout.

vi. Place the point of the survey rod on the divot or x of the monument. Use a bipod and balance the rod vertical using the level bubble as close as possible. Consider removing the controller from the rod to avoid bumping it. Allow the GPS to settle for a minute and should see the precisions get lower.

vii. Observe the Stakeout difference in horizontal and vertical measures. Horizontal is slightly less important but should be within about 2 tenths of a foot or 0.20ft. Vertical tolerance should be within a 500th of a foot or 0.05ft. Some situations if the project does not call for real high

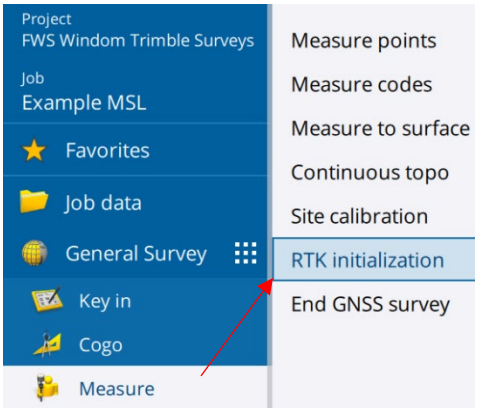
accuracy needs then a looser tolerance may be allowed such as 0.1 for vertical such as no risk of damage if water levels are significantly off. Note this in your field notes.

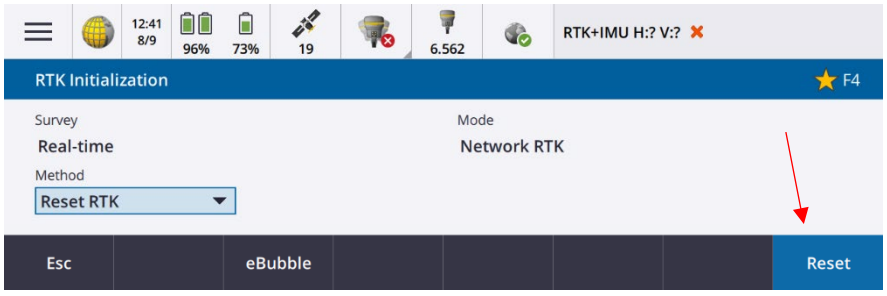


viii. If it is within these tolerance's, then continue with the survey

ix. If not then first check your equipment that the survey rod is fully extended and in locked position. Top and bottom mounts are fully screwed in. Rod is level and on the correct spot on the monument without dirt or other obstruction under it, antenna height is set correct.

1. Next if still off check the data sheet and compare to the keyed in value that there wasn't a mistype.
2. Compare to one of the other entries if there is a difference in several listed for other years.
3. Consider if a different Geoid may have been used such as 2018 vs 2012. Can stop the survey and change geoids in job properties and restart if needed.
4. Reset the RTK survey. This drops it's current position fix and gets a new fix.
    a. Menu hit Measure and RKT survey then hit Reset. May need to move the GPS around to reinitialize.





5. Inspect the monument and compare to photos from the data sheet if you can. Any evidence of tampering or damage?
6. If none of these items fix the problem then note in your field notes and take the best shot you can but may need to follow up with another location for verification.

g. Take a TOPO shot.

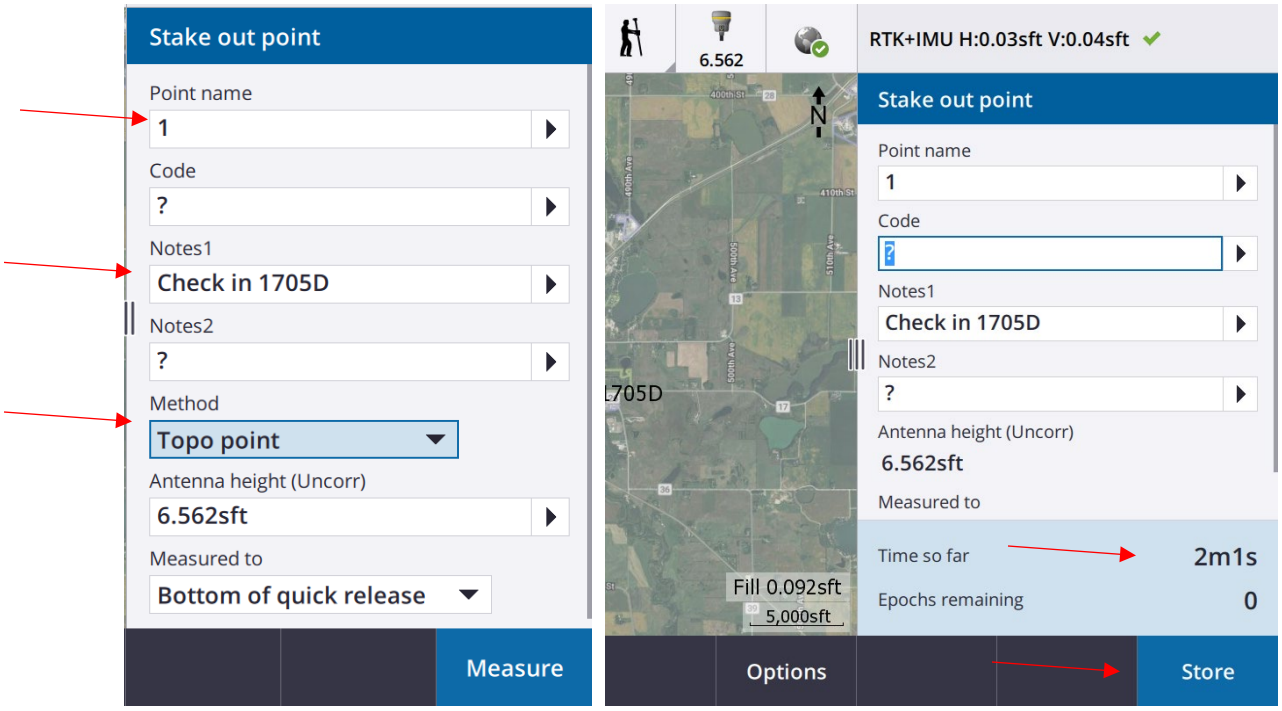
i. On the measure points screen give the point a name such 1.

ii. In the notes or description good to label it such as "Check in at Station number…"

iii. Choose shot type as "Topo" which means it will average multiple readings over time.

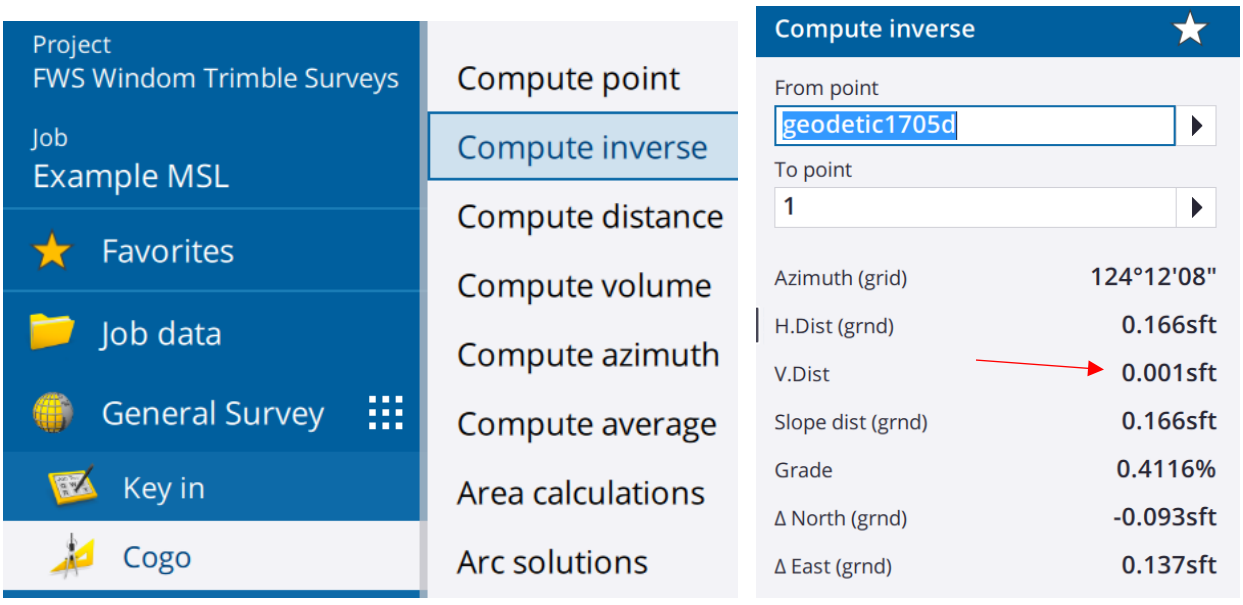
1. Make sure your unit is setup that topo point either runs for at least 2 minutes or does not automatically stop reading until manually stopped. This is in the Settings under Survey styles and Topo Point.

iv. Hit measure and you should see the time counting up. Let it run for at least 2 minutes before hitting Store.



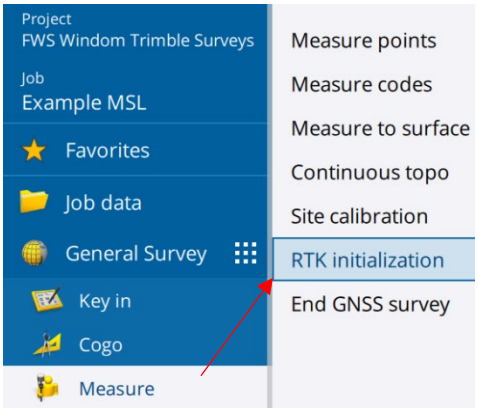
h. When you hit store it will show a confirmation that compares your shot against the keyed value for that point which you would look at the V.Dist Fill for the Elevation, then hit Store. This could also be done using a compute inverse function which is described more below.

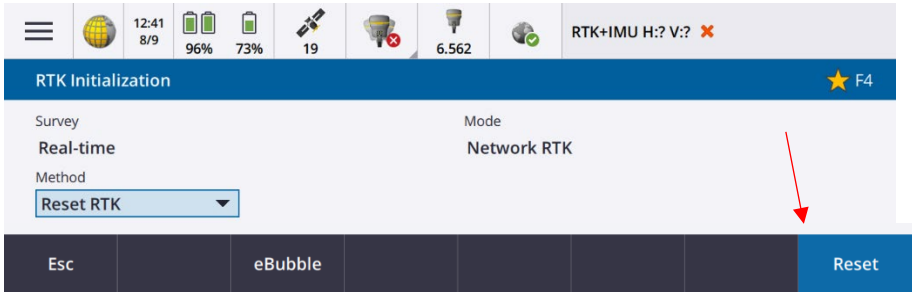
i. Menu go to Cogo then Compute inverse
ii. "From point", choose the keyed in point for that station
iii. "To point", choose the topo shot you just took.
iv. Look at the H.Dist value for horizontal which should be at least <0.20 and the V.Dist that should be <0.05 for most applications. If it is not within tolerance again look at troubleshooting list above. Correct if possible. Take another shot if needed. Record in field notes and move to site survey.



i. Good to take a photo of the Station monument along with your survey equipment used on it for documentation. While you are there.

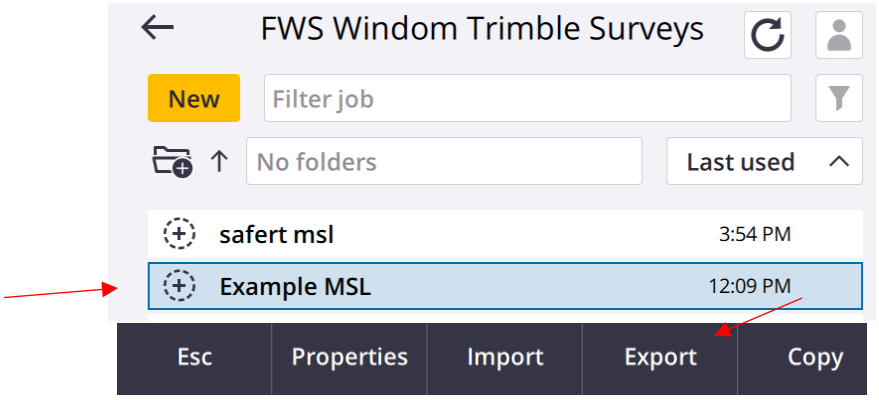
6. **Project site shots**
    a. Go to your project site. If wetland is in place with a solid sill structure then use that structure as the flowline/runout elevation if that is your specified legal wetland MSL limit you want to define. If this is preconstruction and no structure exists you may shoot a benchmark on site that the construction elevations will be referenced from. Then specify in the notes what the desired MSL will be relative to the benchmark shot such as MSL will be 2.0ft below the benchmark in Shot #2. If a non hard sill surface without exact flowline such as a grass or rock spillway then shoot what you believe is the approximate runout elevation or level at which measurable outflow would begin such as midway through the rock surface.
    b. Follow same procedure as in the Check in shot for taking a topo point of your desired elevation point.
        i. Rod point on MSL spot, Use bipod and level it.
        ii. Label as Point 2 (if this was indeed your 2nd shot of the survey after the 1st check-in) and give description, select topo point and start the shot and leave it running untouched for at least 2 minutes before storing.
    c. We need to reset the GPS and do another shot of the same point. Reset RTK which is to lose signal and regain it again. (Menu hit Measure and RKT survey then hit Reset. May need to move the GPS around to reinitialize)

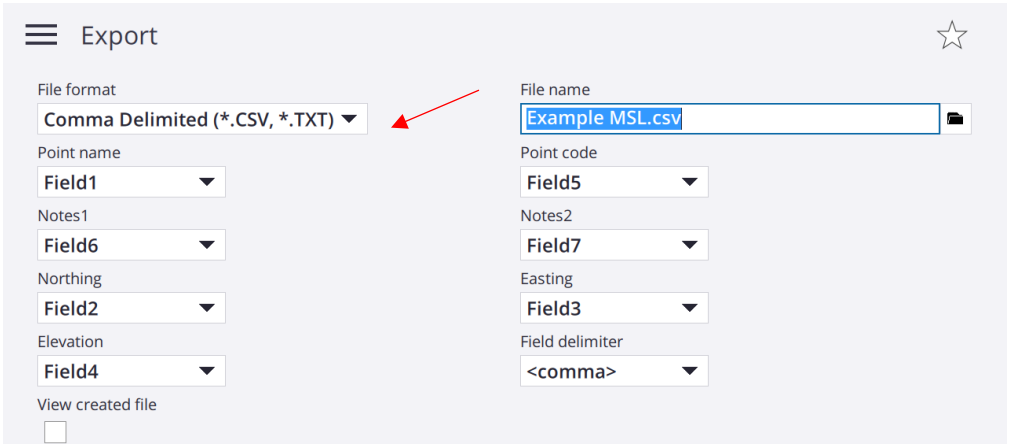


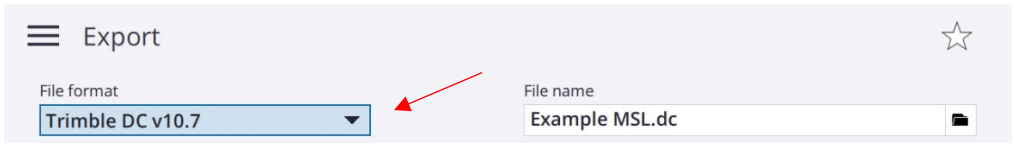


    d. After reset, repeat the topo point of your MSL shot. Label as shot 3 and description of "On site check of benchmark" or something similar.
    e. Not required but good practice to compare your 2 site shots. Can easily do by calculating the inverse. See 5h above. Vertical is what is important and the 2 shots should be close as long as shot on the same exact point.
    f. Take field notes of all shots and any other site reference you deem important to the MSL survey.
    g. Take a photo of your survey of whatever your location point is. Document what it is that is being used to measure the MSL such as a benchmark, structure, weir etc.
7. **Check in post survey**.
    a. This is checking in at another Geodetic station after your MSL survey is complete. Ideally this is a 2nd location. If not available or problems with the 2nd station you could check back in at the first station again.
    b. Repeat from step 5 above at the 2nd station. Reference the data sheet for that station and the 2nd keyed in values.
    c. Take the 2min topo shot. Do the Inverse calculation to compare against the keyed value.
    d. Record it as possibly shot 4 in the field notes as "Check in to Station ID…" "HDist and V.Dist" record numbers. Particularly V should be < 0.05.
    e. Good to take another photo of the station survey in progress.

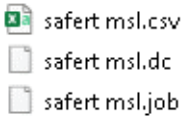
8. **Export GPS files and photos & notes & send to land surveyor**
    a. Go to the Jobs menu in Trimble Access.
    b. Select your Job name and hit Export
    c. In file format dropdown hit Comma Delimited csv. Rest can be default and hit Accept and it should export
    d. Repeat and hit Export again. Choose in the File format dropdown choose Trimble DC v10.7 and hit accept to export.







    e. Close Trimble access.
    f. Go to file explorer and navigate to the Trimble Project folder. This should be C:\ProgramData\Trimble\Trimble Data\Projects\ProjectFolder\
    g. Select 3 files. All 3 should have your project name in them but 3 different extensions .csv, .dc, and .job. Copy these 3 files to a flash drive or other method of transferring to the surveyor project folder.



    h. Also copy any photos you took of the survey to the project file
    i. Once your field notes are complete take a photo of the page or scan it and save it with the project file.

j. Compile all these files and photos and send to your designated land surveyor for certification.
k. Complete package includes**:**
    i. **Survey Field Notes**
    ii. **.csv file**
    iii. **.dc file,**
    iv. **.job file**
    v. **Any site or survey photos**
    vi. **Copies of the Geodetic Data Sheet for any stations used**.