Insurance Advisory Tips for Members

Managing Insurance Risk for Topographic Earthwork Survey Assignments

Part 1 - The Original Ground Survey

By Douglas S. McGill

Mr. Douglas McGill is currently self employed (McGill Development Services Limited) and takes a special interest in earthworks science. His firm offers development management services, contract dispute resolution and approval process expertise to a variety of clients in the Greater Toronto Area. This is the first of a series of articles to outline how the civil engineering earthworks process works and how survey data we collect fits into that process. This first article looks at ensuring the quality of the "original ground survey" or "existing ground topo". The next article in the series will look at how this information is utilized by the engineer to establish his site design and earthworks strategy. Overall, earthworks related work is an area of work fraught with service issues and insurance claims so having a basic understanding of sources/causes of errors from all parties involved in the process can help you to manage your liability.

Working as a project manager for greenfield subdivision developers over the past 15 years, I headed a team of people who produced civil engineering drawings for about 24,000 lots over that period. Each project involved a grading and earthworks operation that in total moved several million cubic meters of topsoil and fill material. This experience has involved working with topographic surveys from many sources to complete these works. My civil engineering experience along with an educational background in Geodetic Sciences (studying at Ryerson with Mr. Mucklestone) led to an invitation to write this article.

A common assignment for surveyors is to collect topographic field survey data for development sites. Elevation information collected from the existing ground surface typically becomes the basis for completing a site earthworks calculation by the civil engineer. When problems arise with earthworks volumes, costs can escalate rapidly. The usual practice of the engineer is to try and "balance" the site. This means that the future grading design less imported material (granular for roads, etc.) plus the onsite displacement of basement excavation material and reuse of stockpiled topsoil will be such that fill material is neither exported nor imported to the site. When this strategy goes wrong the costs soar. For example, if due to a benchmark problem a site was evaluated as being 0.05 m lower than reality this will generate an additional 10,000 m^3 of cut material on a 20 ha site. The cost of dealing with that extra material is then dependent on how it is moved (trucks or scraper) and how far it has to go. Costs to haul clean fill away can vary from a few dollars a cubic meter up to as much as12 to 13 dollars a cubic meter. This could equate to an additional cost of $120,000 for the 20 ha site with the 0.05 m error. These costs are significant and typically result in an investigation to determine the party responsible for the additional costs. As the survey fees are typically small in proportion to the additional construction costs incurred, to be in this situation can be very detrimental to your practice to say the least. This particular article will hopefully provide a few suggestions to help you avoid this situation. The next article will give you some insight to "engineering" sources of error.

Douglas McGill started his career in surveying but ended up in Civil Engineering. He still retains the surveyor's eye however and likes to squint through an optical glass when he can.

Define The Assignment:

Instructions for a site topographical survey may be sparse and cryptic. If this is the case, then your quote should provide specifications as to what your work does and does not cover. Problems do not arise just from earthworks but from utility services (overhead and underground), drainage (in and out of the property), existing vegetation and other items that may be "assumed" by your client to be included. Most engineering firms will provide you with an RFP but if the assignment does not include one, it is important to keep your own internal checklist. This checklist should be provided to your client with a quote as it defines your scope of work and liability.

Topographic Data Collection:

The elevation points you collect will be used by the engineer for the purpose of building a Digital Terrain Model (DTM) of the existing ground surface and comparing it to an "engineering design" surface to confirm (subject to various adjustments, collectively called pre-grades or balance line values) that the cut/fill activity on the site is balanced. Therefore collecting data in a manner that allows that ground surface to be correctly modeled for this volume comparison is the goal of the assignment. Typically, today this means measurements taken with a GPS device affixed to a pole. Measurements taken in this manner are referenced back to a control point or benchmark but the measurements are otherwise independent and with the GPS technology the "accuracy" of any one shot should be very good. A good DTM surface could be built using survey elevations from a site that was saturated with measurements. However, this effort costs money and will make you less cost competitive with pricing and a lot of redundant data will have been collected in the process. The goal is to tailor the density of collection to an understanding of how that data will be processed into a DTM. Essentially your field staff needs some insight into how a DTM will be created by the computer and how it "sees" and interprets collected points into a surface. Flat fields require fewer points to simulate the topography correctly versus a rolling hills site that would require correspondingly more surveyed elevations to define the variation in conditions correctly.

Two common systemic factors that can influence the accuracy of data collection are locally uneven topography and seasonal conditions issues. The best example of uneven topography is a freshly ploughed field. Measurements taken within a short distance of each other can vary by ± 0.1 m. Dropping the pole consistently on the top of the ridge or the invert of the furrow will lead to a systemic error. In this condition the pole should be placed randomly without intent so as to obtain an "average surface" and the density of point collection increased. Winter in Canada is another factor. Many surveys are completed with some level of snow cover and the pole is placed without a direct visual of the ground surface contact. Therefore, the pole may be stopped by layers of ice before ground contact without operator knowledge. This of course means that the trend is for the measured (vs. actual) ground surface to be high. Topographic surveys completed under these kinds of conditions should be qualified to identify the limitation <u>directly on the drawing</u>. A few digital pictures placed in the job file would also be wise.

The correct data still does not ensure a good product. The correct use/interpretation of field data to build contours/surfaces is essential. As the receiver of survey work, I have seen circumstances where the base of a stockpile is shot and the contours drawn through the stockpile location (or building, vegetation, etc.) without acknowledging the existence of the pile. I have also experienced various other quirky outcomes that primarily arise from a lack of communication. What was obvious in the field does not appear on the end product.

With communication between the field lead and the office processor (if they are not the same) and training you can build an efficient dynamic for ensuring this does not happen. In my own case practically all calculations were completed by one selected team member who became very proficient in handling and understanding the work. With experience a good operator will see unusual contour conditions and anomalies and ask the questions to confirm or correct these conditions.

Benchmarks/Control Points:

The most serious errors that can and do occur in topographic surveys are systemic errors. In almost all cases any one data point in a field being out by 0.10 m is a matter of no real consequence but that same error in a control point or benchmark can mean serious problems with earthworks volumes.

A practice that I would recommend to your industry, especially when you have a reasonable expectation of carrying an assignment through from the initial topographic survey to layout or other future work in the development process, is to establish control points at locations bordering the property that will survive throughout the development history of the project. Valley lands are not subject to grading disturbance so bars or other suitable measures installed in these areas will survive throughout the development process. As an example in other areas, a cut cross can be provided on concrete structures. While understandably not always possible, having the control points survive the site development process is going to leave you in a strong position of proving the validity of your work. Another suggestion is tying an attribute to each independent shot that identifies the control point it was based on. Thus if problems do arise you may be able to demonstrate that a systemic error with a single control point only affected measurements within a limited area of the site which could not possibly have generated the magnitude of earthworks imbalance (and costs) that is occurring. Rest assured problems exist on the engineering side and it's easy to get responsibilities confused during the analysis after the fact when the documentation all around is insufficient. The best defense in these circumstances is to ensure your own house is in order.

Contractor Verification:

A practice I followed in dealing with earthworks was to include a clause in the earthworks contract that stated:

- The contractor is to satisfy himself as to the validity of the site topographic elevations before undertaking disturbance of the site. In the event that substantial grading work proceeds and the contractor brings forward information disputing the disturbed ground surface areas the original topographic information as provided by the engineer will remain the basis of computing EW payments unless otherwise directed by the Engineer at his sole and unfettered discretion.

The purpose of this clause was to try and head off conflicts between two different surveys (one as supplied by the site surveyor and the other by the contractor) after the area in dispute is disturbed and neither survey is verifiable. While you may not have the ability to put this clause into the contract (in some cases you may know the engineer well and he/she may take this suggestion if offered) you can, if attending a preconstruction meeting, ask the contractor if he has satisfied himself that the topographic information you have supplied and he is working with is accurate. Recorded in your field book the answer could prove very valuable later.

The Product:

I have heard suggestions from surveyors that to limit liability they do not provide DTM's directly to the engineer. I have a little difficulty following this line of reasoning. If you provide only elevations and they are not sufficient for building an accurate DTM in the form they are provided to the engineer it would be surprising if the liability for a problem DTM surface was successfully shifted to the engineer with this course of action. As the party having been tasked with collecting topographic data to correctly represent the site surface the end product should be the DTM. It is best to proof it directly and issue it yourself as the first use of the point information you provide is to build one if a DTM is not provided. I can recall a few cases where I have received survey files of points only. Break lines that the surveyor deemed necessary to accurately contour the site were not provided in the digital files forwarded to us (the engineer). How did I discover this? Our first step in starting a site earthworks design when a DTM was not provided was to build a DTM surface, contour it and overlay the results with the surveyor's contour plan (Tip: the contours from each source were colour coded for easy visuals).

Having been on the site and collected the data, the surveyor is the party best suited to create the original ground DTM surface and ensure its veracity. In the end, the best limitation on liability is a good product.

Hopefully you have found something of value in the foregoing material. Should you have any feedback please e-mail your thoughts to **mcgill_dev_services@rogers.com.** If I receive some good points, questions or tips they will be presented in a final article. Names will be changed to protect the innocent so do not hesitate to send in material.