Photogrammetry Via Use of Drone to Support Remediation at a Former Mining Site

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Project Background and Setting

- Abandoned open pit, cyanide heap leach gold mine developed in highly sulfuric rock. Operations began in 1800s; ceased in 1999. Added to NPL in 2000
- Retained by USACE to install new pipeline/pumping systems, dewater ponds and pits, construct sludge disposal cell and transfer sludge to it, plug mine openings, blast to generate material to fill pits, and restore site
- Primary mine disturbance area - approximately 360 acres
Project Surveying Requirements

• Establish initial excavation limits

• Develop as-built drawings of acid rock drainage collection systems, sludge cell construction, mine openings plugged, borrow pit boundaries, roadways, and pipelines

• Document end-of-work conditions

• Document progress of remedial action & provide verifiable quantities for various remedial action activities
Why Drone Surveying at the Site

• Registered Land Surveyor (RLS) and aerial drone used to document construction progress where performance metric based on quantities of soil removed or placed

• Advantages of using aerial drone:
  • Field work uninterrupted during the survey
  • Allows for surveying of inaccessible areas
  • Eliminates need for RLS staff to navigate dangerous terrain/access potentially hazardous areas
  • Can be conducted more efficiently than traditional survey methods, which helps project schedule
Drone Equipment in Use at the Site

• DJI Phantom 3 Professional drone
• Sony 16mp CMOS camera
• Photogrammetry processing software
• AutoCAD software

Use of a drone involves several regulatory, safety, and quality control considerations - FAA Small Unmanned Aircraft Systems (UAS) Rule (new part in title 14 of the CFR: Part 107)
Operational Parameters – Pre Flight

• Pre Flight Checks
  • Notifications (Onsite personnel notified of drone operations)
  • Check weather
  • Verify battery power
  • Calibrate controls
  • Activate motors and power
  • Check First Person View (FPV) with onboard camera to verify transmission
  • Verify connection quality with remote controller and GPS
  • View launch area for possible conflicts
Operational Parameters – During Flight

• Operation
  • Launch drone
  • Position drone at beginning point of operational area
  • Drone begins predetermined flight path; collects data as the flight commences
  • FPV provides collision avoidance and visual awareness to the operator
  • Drone completes flight operations and maintains position – flight data is verified by the drone pilot
  • Drone is piloted to the home location and safely landed
Operational Parameters – Post Flight

• Post Flight
  • Data is retrieved from the drone using data cable connection and SD card
  • Data is downloaded onto the processing computer
  • Data is uploaded to the processing software
  • Control data is input into the processing software
  • Data is processed and final solution/3D point cloud is finished
  • Control points are utilized to verify accuracy of final point cloud
  • Additional survey data (randomly selected points) are utilized to verify accuracy of final point cloud
Drone Data

• Data collected via drone = plus or minus 1.5-inches compared to traditional land surveying methods

• Data generates a “point cloud” with potentially millions of data points - greatly increases accuracy of the survey, which no RLS could replicate.

• Process starts with defining the survey area

• Multiple aerial surveys can be conducted and joined together within the software utilizing the survey control points

• Although flight time is limited, a large quantity of data and corresponding photos at specific intervals can be obtained in a short amount of time
How Data is Used

• Used for Intermediate Surveying and Progress Quantities
• 37-acre Heap Leach Pile - ~2.5M CY of material - surveyed in 30 minutes compared to 3 - 4 days for typical GPS surveyor
• Data post-processed using photogrammetric software - accesses aerial photos and control points to generate point cloud of ~2M data points
• End product was a figure overlaid on a 3D AutoCAD file and geo-referenced orthographic aerial photograph
• Drone is also used to collect general project activity photos
Accuracy

• An 8.1-acre area was surveyed to determine payment quantities

• Subcontractor’s 2/21/18 survey = 226,807 CY

• Drone flight 2/22/18 quantity = 230,872 CY

• Daily logs from contractor indicated movement of 3,169 CY between 2/21 and 2/22

• Delta between Subcontractor’s and drone flight quantity = 896 CY
Accuracy

Yellow = drone survey, Green = subcontractor survey
Accuracy

Yellow = drone survey, Green = subcontractor survey
Accuracy

Yellow = drone survey
Green = subcontractor survey
Contact Information

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