

RECLAMATION

Managing Water in the West

Reclamation Annual UAS Report: Fiscal Year 2012



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

September 2012

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Reclamation Annual UAS Report: Fiscal Year 2012

prepared by

**Emergency Management and GIS Group
Douglas R. Clark**



**U.S. Department of the Interior
Bureau of Reclamation
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Acknowledgements

Several individuals were instrumental in developing the data and analysis needed for this study. Suggestions and guidance by Mike Hutt (USGS), Jeff Sloan (USGS), Mark Bauer (USGS), Lance Brady (USGS), and Jade Soddell (USBR), throughout this study are gratefully acknowledged.

Background

Just prior to FY2012 Reclamation hosted its first UAS conference entitled *Applications of Near Remote Sensing and Unmanned Airborne Vehicles for Water Resources Management* at the Denver Federal Center. Representatives from NASA (<http://water.jpl.nasa.gov/>), the USGS (<http://rmgsc.cr.usgs.gov/UAS/>), Utah State University (<http://aggieair.usu.edu/aggie.html>), and Time-Science (<http://www.time-science.com/timescience/default.asp>) made presentations touching on current developments in these technologies. Subsequently, a list of possible applications relevant to Reclamation's mission of water management was compiled and included. Each of these needs to be mission-tested to determine whether UAS technology can provide superior results compared with current technology:

- Canal monitoring
- Crop identification and yield forecasting
- Dam and levee inspections
- Emergency management response
- Estimating algae density in sewage lagoons
- ET estimation
- Flood hazard analysis
- Flood risk assessment
- Flow to habitat relations
- Habitat mapping
- Identification of canal encroachments
- Identification of flood plain encroachments
- Imaging to make ortho-rectified maps
- Integrating remote sensing and point data info
- Law enforcement
- Moisture content in snow
- Monitoring dam faces for seepage
- Riparian surveillance
- River corridor change detection
- River restoration monitoring/change detection
- Root zone soil moisture estimation
- Sediment transfer
- Snow depth
- Urban/canal interface mapping
- Volume estimation
- Water spreading
- Water turbidity
- Wetlands classification

Sufficient interest in these topics was generated to justify exploration of the utility of UAS to support Reclamation's mission. This report speaks to two activities that were funded by Reclamation R&D in 2012: (a. creation and facilitation of a Reclamation UAS community of interest and (b. UAS flight missions in the Elwha River valley to both monitor sediment change during dam removal and test the GoPro Hero2 camera.

Research Goals and Objectives

The overall goal of these two efforts was to explore the potential uses of UAS and near remote sensing technologies to advance Reclamation's mission.

In support of this goal, project objectives include:

1. Community of Interest Development
2. Develop UAS Community of Interest Charter
3. Build Relationships with Sister Agencies Conducting UAS Operations
4. Construct a UAS Community of Interest SharePoint site
5. Conduct One or More Interregional Workshops
6. Conduct Two Missions in the Elwha River Valley to Monitor Sediment Removal and Test the GoPro Hero2 Camera Technology.

Accomplishments

The Community of Interest. The Reclamation UAS Community of Interest now contains more than 50 persons from every region. The group includes information resource personnel, dam safety experts, hydraulic engineers, geographic information systems scientists, geographers, group managers, USBR directors, civil engineers, geologists, soil scientists, meteorologists, emergency management staff, remote sensing specialists, and information management specialists. What this shows is that there is wide-spread interest in this technology. Electronic communications occur with the community on a weekly basis.

Charter. A UAS Charter has been prepared and is presently under review. A copy of the draft charter is appended to this document (Appendix A). It calls for a

formalization of community responsibilities. The Aviation Manager for Reclamation will, of course, oversee all UAS policy matters.

Under the terms of the draft charter, a working group will be created that will monitor:

“developments in UAS technology, submit UAS research proposals, organize training workshops, and promote exploration of the potential uses of UAS within Reclamation. The working group will explore UAS best practices, keep track of COA requirements, explore the potential uses of new sensors and platforms to meet Reclamation’s mission, oversee needs assessments for UAS technology, investigate best practices and software for data processing, make recommendations for the UAS SharePoint site, collaborate with other agencies, and disseminate information across Reclamation about UAS policy and technology.”

(USBR UAS Charter)

The working group will communicate frequently with the community of interest to update it on new technological developments, familiarize members with the requirements for organizing a UAS mission, and acquaint them with new policy developments.

A SharePoint administrator will be selected by the work group to oversee the content in the SharePoint site, and as required, make changes to the site design and look.

SharePoint Site. A UAS SharePoint site for Reclamation users has been set up at: <https://dosp/techResc/TR/TSC/UAS/Pages/default.aspx>. The site provides libraries for documents (including research reports), announcements, and photography. It also provides links to important information and personnel at the USGS, Aviation Management Directorate, the Federal Aviation Administration, and Reclamation. Finally, there are both an event calendar and a discussion board.

Build Relationships with Sister Agencies. During FY12, Reclamation has collaborated extensively with the USGS Unmanned Aircraft Systems (UAS) Project Office <http://rmgsc.cr.usgs.gov/UAS/>. This office has provided guidance as to the strengths and limitations of the Raven, T-Hawk, and Predator platforms and sensors. In addition, it has acquainted USBR staff with evolving policies with respect to UAS operations, including certificate of authorization processes, flight hazards analysis, and FAA regulations. Finally, the USGS is actively seeking USBR input in its preparation a roadmap for UAS deployment in Interior.

University Presentation. Jeff Sloan of the USGS conducted a colloquium on UAS usage at the University of Denver in January of 2012 in which he described various missions that had been flown already and plans for the joint venture with

Reclamation on the deltas of Mills and Aldwell Reservoirs on the Elwha River.. Approximately 50 faculty and graduate students attended the session.

Interregional Workshops. An inter-regional workshop on UAS data processing was held on August 9, 2012. There was discussion regarding the challenges of using the Raven for mapping purposes (it was originally used for reconnaissance). These include wind, poor camera resolution (0.3 megapixels), loss of downlink, managing huge quantities of data, and decoding positional data. (Note: the 0.3 megapixel camera has now been replaced with an 11 megapixel GoPro Hero2 camera with good results). The process involves selecting the best video, extracting transects, creating still images, cropping and then exporting images, creating mosaics, and rubber-sheeting. (Presentation materials are available in the document library of the UAS SharePoint site).

A second inter-regional workshop was held on Thursday, September 18th, 2012. Brad Koeckeritz, Senior Training Specialist with AMD, led the workshop. His presentation covered the following topics:

- Overview of AMD's role in DOI aviation
- Descriptions of the UAS platforms
- Descriptions of the sensors
- What the systems have been used for in the past
- Strengths and limitations of the systems
- Possible future uses
- Training course schedule
- Topics covered in the training courses
- The future of UAS in DOI

Nearly 25% of the community of interest personnel attended and several expressed interest in taking the training courses for the Raven and T-Hawk.

The Elwha Missions using the Raven UAS. In the year 2000, DOI purchased Elwha and Glines Canyon Dams in preparation for their removal to support river and fish habitat restoration. Approximately 24 million cubic yards of sediment are being managed as part of the dam removal project. Monitoring the changing topography that occurs as the sediment is eroded and redistributed downstream is critical for adding to the science of dam removal.

In FY2012, the Bureau of Reclamation partnered with Michael Hutt at the USGS National Unmanned Aircraft Systems Project Office to develop a research agenda for monitoring shifting topography as the sediments from Lake Aldwell and Lake Mills are actively being removed by the rejuvenated Elwha River. It was determined that UAS technology shows promise for capturing imagery of this dynamic system. While Reclamation obtained permits for operations within the Olympic National Park, Susan Goplen of the USGS applied for a *certificate of*

authorization (COA) from the Federal Aviation Administration, which is required to operate an unmanned vehicle in US air space.

The USGS Rocky Mountain Science Center (www.rmgsc.cr.usgs.gov/UAS/) has



Figure 1 The Raven UAS. (Photo Courtesy of Lance Brady)

the sediment movement in the Elwha River corridor with the assistance of Denver TSC personnel.

The Raven is a hand-launched, battery operated, unmanned aerial system that is 36" in length and has a 4.5' wingspan. Its typical operating altitude is 100-400' above ground level with a speed of about 30 mph, and a flight duration length of about an hour. It carries either an electro-optical video or an infrared-thermal video camera system. At least three persons are required for flight operations of the Raven: one pilots the aircraft; one operates

taken the Departmental lead in evaluating potential uses of UAS. This center has flown Raven missions to monitor such varied phenomena as wildfire, habitat, wildlife, invasive species, ground water discharge, flooding, and mines. In June, 2012 an expedition was flown to monitor



Figure 2 Ongoing Sediment Removal on the Elwha River. Video frame taken from the Raven in June, 2012

the ground-control station; and one or more trained observers are required to maintain visual line of sight of the aircraft.

In June of 2012, the first of two flight operations began with two USGS personnel, Jeff Sloan and Mark Bauer, and one BLM staff member, Lance Brady, piloting the aircraft and manning the ground station. Douglas Clark and Alan Bell from Reclamation observed the operation to determine if the technology can provide USBR with valuable new mapping capabilities. Andrew Ritchie of the Elwha Field Office provided NPS oversight. In total, 14 missions were flown and nearly sixty gigabytes of raw video were taken (see figures 2 and 3). These remotely sensed data were processed to provide ortho-rectified imagery to monitor sediment change in this highly dynamic system. (See also: <http://rmgsc.cr.usgs.gov/UAS/BoRriverSedimentMonitoring.shtml>).

In September of 2012 a second field expedition was conducted using the GoPro Hero2 camera. Image quality was substantially improved. This 11 megapixel camera can be used to capture video, time-lapse (1 frame per 0.5, 1, 2, 5, 10, 30, and 60 seconds), or burst (10 frames per second). Compare, for example, the clarity of images taken from the camera native to the Raven in Figure 4 with that of the GoPro in Figure 5. Instructions for processing remotely sensed data obtained from the Raven are contained in Appendix B.



Figure 3: Dam at Glines Canyon. Video frame taken by the Raven in June, 2012.

Reclamation and the USGS continue to learn about, and come to terms with the strengths and limitations (listed in the Findings section) of UAS technology-- with a view toward identifying discrete niches of use for accomplishing various DOI agency missions.



Figure 4: Elwha Imagery taken with the camera native to the Raven in June of 2012



Figure 5: Imagery taken with GoPro Hero2 Camera mounted on the Raven in September 2012.

Other UAS Research Activity Accomplishments

Briefing Paper. A briefing paper was prepared in July 2012 concerning developments in UAS within Reclamation and presented to Deputy Commissioner Grayford Payne. Previous to that, briefings were prepared for the Dam Safety, Law Enforcement, Technical Services, Policy, and Management Services directorates.

Research Proposals. For FY2013 four research proposals were submitted to the Reclamation S&T program. Two were designed to continue work started in FY2012 on monitoring change in two Elwha river reservoirs and to continue the community of interest work. The first of two new proposals involves testing the Raven, T-Hawk, and Predator for use in an emergency management setting. The second is designed to develop and test UAS educational materials.

Pilot Training and Deployment. Three Reclamation staff, two already possessing pilot licenses, received Raven training in FY12. Two of the three will receive T-Hawk training in FY13. The training was conducted at the Aviation Management Directorate training center in Boise, Idaho. Course content included an overview of UAS operations, system overview, equipment assembly, preflight training, mission planning, flight operations, emergency procedures, the certificate of authorization process, and discussion about the future of UAS. On September 26, 2012 Reclamation's first UAS aviator, Lester Britton (PN) successfully flew the Raven in the vicinity of Aldwell Reservoir on the Elwha River.

Press Coverage. The Elwha flights received local and regional press coverage. The following story, for example, was filed on public station KCTS9 (Seattle): <http://earthfix.kcts9.org/water/article/a-drones-eye-view-of-the-elwha-river/>.

Other UAS Efforts. Jade Soddell, an emergency management specialist and meteorologist with the Emergency Management and GIS Group, worked on a parallel project with the USGS to examine the utility of a hovering craft called the T-Hawk for natural resource and emergency management. Soddell and Clark have partnered to submit an R&D proposal in FY2013 to test the utility of the T-Hawk, the Raven, and the Homeland Security Predator for security and emergency management operations. Soddell and Clark have developed a UAS SharePoint site that will be launched in early August 2012.

Findings

Reclamation interest. Interest in UAS technology is widespread within Reclamation. Potential applications range from emergency management to infrastructure monitoring to habitat mapping to seepage detection to wildlife

monitoring. Testing each possible application will take time and funding. Reclamation can depend upon the services of the USGS for some of these applications, but demand for services from the UAS offices is starting to exceed to supply. Whether the USGS will add manpower to its current capacity is not known at present.

High Resolution Cameras. Use of the GoPro Hero2 camera has greatly enhanced the imagery being captured by the Raven.

Strengths and Limitations of the Raven. Based upon 2012 UAS activities on the Elwha River and a growing body of research and experience, the *strengths* of UAS include:

- Reduced costs for deployment compared with piloted craft. This is particularly important when many return field investigations are required.
- The ability to fly in areas considered to be too dangerous for piloted craft.
- The ability to gain imagery in cloudy areas that would make satellite imagery and high altitude aerial imagery unsuitable or impossible.
- Capture of higher resolution compared with satellite imagery and high altitude aerial photography.
- Capability of collecting real time data.
- Portability of the aircraft and ground control units
- Flight operations do not require a landing strip
- The Raven is generally safe for the pilot to use.
- The growing availability of small, high powered cameras.
- Suitability for surveillance, intelligence, and reconnaissance missions.

On the other side, *limitations* surrounding the use of UAS are emerging:

- There are concerns about privacy relating to the collection of spatial data over private lands and structures.
- Concerns have arisen regarding the use of model aircraft (aircraft flown for hobby or recreation) in the national airspace. FAA is constrained from developing rules or regulations for model aircraft. The FBI reported a plot to use a model aircraft armed with explosives to attack government buildings in 2011 has highlighted the potential for model aircraft to be used for destructive purposes.
- Concern has arisen over the disruption of the control of UAS operations through the jamming and spoofing of the Global Positioning System between the UAS and ground control station. (See, for example: <http://pjmedia.com/blog/gps-hijacking-team-of-u-s-faculty-students-take-control-of-drone/>).
- The certificate of authorization process can be lengthy and it is labor intensive, often extending beyond 6 months. (Movement to ameliorate this problem has been slow, but progress is being made).

- Though no landing strip is required, a football-sized field is required for optimal take offs and landings.
- Imagery is subject to distortion owing to pitch, yaw, and roll. (Increasingly image processing software can manage these issues).
- Windy conditions can cause cancellation of a flight.
- Flying over bodies of water can be problematic. The Raven, for instance, will not float on water. Newer craft will float.
- Line of sight must be maintained; thus it is only possible to fly in a limited area at a single time, then it is necessary to pack up the equipment and move to the next area. This can consume a lot of time and effort. Daisy-chaining of observers is not allowed.
- Line of sight can be difficult to maintain in a confined and complex area like canyon containing a reservoir.
- Modifications to UAS aircraft require recertification for air-worthiness.
- Pilots must be trained on the specific craft they are flying.
- Non-commercial aircraft have been known to enter UAS air space causing potential safety hazards. At Elwha in June the pilots had made notifications to the local airport that they were operating in the area of Aldwell Reservoir and had made a number of radio announcements that they were flying in the area. Nevertheless, a non-commercial Piper Cub entered the area.
- In addition, pilots of non-commercial aircraft may not have radios. There may be no way to communicate with them if they enter the UAS air space.
- Shipping UAS equipment can be costly.
- For the Raven, part of the equipment must be a generator, used to recharge batteries. Caution must be used when hauling gasoline for the generator.
- Aircraft are occasionally lost or severely damaged, requiring replacement.

The Path Forward

As interest in UAS technology continues to grow, the community of interest will start to have regular meetings, the SharePoint site will be upgraded, more Reclamation staff will receive flight training on both the Raven and the T-Hawk. The PN region in FY2013 will make presentations to its leadership regarding the merits of UAS technology. If management approval is obtained, Kristen Swoboda and Lester Britton of the PN Region have several missions ready to fly, once COAs are obtained. In Denver, one of the community's priorities will be to provide training to at least one staff member on the preparation of COAs. Other TSC personnel have expressed an interest in obtaining training. The USGS and Reclamation will produce a joint report on the Elwha work, which will include a mission planning guide for Reclamation personnel. The Denver TSC and PN Region will also begin to gain experience using PhotoScan and other software products used to process UAS imagery. TSC personnel will be testing the accuracy of the digital elevation models the USGS will have prepared of the Aldwell and Mills Reservoirs. Policy challenges will be vigorously investigated.

APPENDIX A

Reclamation UAS-Near Remote Sensing Community of Interest

Statement of Purpose

- DRAFT -

Background

In meeting its mission to manage, develop, and protect water and related resources in an environmentally and economically sound manner, Reclamation regularly uses and produces remotely sensed data. Most prominent among the uses of these data sets are those for monitoring habitat, analyzing water quality, generating topography, mapping land use/cover, classifying crops, and measuring evapotranspiration.

Each remote sensing platform and sensor is subject to certain limitations. Satellite imagery may be insufficient and inadequate for many Reclamation applications, yielding as it does, regional scale images with limited temporal and visual resolution. Satellite based observations are also hindered by static sensor capabilities, weather conditions, and acquisition cycles that are often measured in days or weeks.

Manned aircraft flights can be problematic owing to long flight duration requirements, unpredictable weather, day and night data requirements, and associated operating costs. Over-flights are effective, but their costs limit frequency and image post-processing is difficult.

Traditional land and boat surveys are effective tools at the micro-scale, but it is difficult to conduct extensive surveys over wide areas and these surveys are typically limited to ground-level sampling. These surveys are also expensive, short in duration, logistically challenging, focus on relatively small areas, and generally occur only once in a season or even less often.

Unmanned aerial systems (UAS) equipped with multispectral sensors; near remote sensing high-resolution camera networks; giga-pixel time-lapse cameras; and wireless sensor arrays offer real-time data transmission. These technologies have the advantage of being generally small and cost effective.

Unmanned aerial systems can be used for ecosystem, agriculture, stream, and atmospheric or other monitoring. Examples would include: landslide monitoring, stream channel and geo-morphological studies, support for river restoration

activities, monitoring of archeological sites, and searching for canal encroachments.

UAS range from long to medium to short endurance and range aircraft. Like other platforms and sensors, each has its own limitations. Smaller aircraft have limited utility in the presence of wind, and require ground observers to maintain “line of sight” with the aircraft. In addition, limited battery life and fuel supply can sharply curtail flight times. Finally, flight altitudes are generally limited to approximately 400-600’. Small UAS, however, is not subject to long periods of down time due to project limitations such as narrow or steep canyons, and they do not require an airport to take-off, refuel, or land. Larger UAS require landing strips, but are not as subject to the same weather, line of sight, fuel, or flying height restrictions that pertain to smaller aircraft.

UAS technologies have been found to be particularly useful for data gathering roles which have been called “dull, dirty, or dangerous” (DDD). Extended surveillance can be a dulling or numbing experience for aircrews, requiring many hours of observation without relief-- sometimes leading to loss of concentration and, thus, mission effectiveness. Ground-based operators of UAS can readily be relieved in a shift-work arrangement. Near remote sensing technologies with high resolution color video, low light level TV, thermal imaging cameras or radar scanning, can be more effective as well as less costly to deploy and operate in such roles.

UAS technologies can also be deployed in “dirty” environments such as those characterized by chemical contamination, where air crews might be at risk. Herbicide spraying of non-native plants with toxic chemicals is another “dirty” roll which is now conducted very successfully by UAS.

In addition, UAS can be effective in dangerous conditions, such as power-line monitoring and forest fire control—again where air crews might be at risk. For fire-fighting, UAS has a potential role to play in incident command; logistics; monitoring fire spread, direction, rate of speed, and intensity; fire boundary monitoring. They also have the capability to capture real time observations to inform strategies and tactics for fire operations and movement of ground-based or aerial resources. There may also be post-fire roles for UAS, such as evaluation of habitat, vegetation, soils and other natural resources in support of restoration and rehabilitation activities. In addition to fire monitoring, UAS can fill current gaps in acquiring remotely sensed data over isolated, scarcely populated, harsh, and often volatile land and water areas.

UAS technologies have frequently been deployed for surveillance, intelligence-gathering and reconnaissance, for instance, in policing or emergency management operations. Finally, they are often useful in environmentally critical roles where they will frequently cause less environmental disturbance or pollution than manned aircraft. UAS and NRS technologies will frequently be smaller, of lower

mass, and consume less power, thereby producing lower levels of emission and noise.

The Department of the Interior (DOI) has therefore recognized the need to investigate the utility of these technologies to further its bureau missions. The DOI National Business Center Aviation Management Directorate oversees all UAS policy, training, equipment, safety, and inspections. Since 2009, the USGS has taken the lead and is assisting other DOI agencies with UAS operations suitable to their missions. Naturally, Reclamation is interested in examining the utility of UAS technology for water management. Initially, the emphasis will be on understanding what niches these new technologies can fill, the cost effectiveness of their use for various data gathering missions, and the policy requirements and challenges associated with their deployment. In addition, Reclamation must create mechanisms to ensure that the growing UAS community of interest will have a single point of contact to obtain reliable information related to UAS technology. To begin addressing these issues the Reclamation Research and Development Office has funded both an initiative to cultivate a community of interest and two exploratory UAS projects .

Objectives

The overall goal of the UAS Community of Interest is to evaluate the utility of UAS technology for to further Reclamation's mission.

The community of interest will:

- Investigate the utility of UAS technology for managing Reclamation infrastructure; enhancing safety, security, and emergency management capabilities; serving its customers and the public; and preserving ecological resources.
- Increase agency knowledge of best practices, standards, and methodologies for the use of UAS technology
- Investigate and implement the policy and legal requirements pertaining to UAS.
- Investigate best practices and technologies for the processing of data derived from UAS sensors.
- Keep abreast of state-of-the-art UAS technologies as they emerge.

Approach

To meet these objectives the UAS Community of Interest will begin by:

- Engaging with other government agencies and participating in joint UAS activities with them.
- Working with Reclamation's Aviation Manager and the Aviation Management Directorate to learn and implement laws and policies relevant to UAS usage.

- Conducting research testing various UAS platforms and sensors for their usefulness
- Conducting needs assessments within Reclamation regarding the deployment of UAS technology
- Identifying key issues, gaps, and opportunities that need to be addressed successfully implement the use of UAS technology
- Developing bureau-wide communication capabilities such as a SharePoint site, and
- Beginning to formulate priorities and strategies.

Outcomes

Anticipated outcomes of the UAS Community of Interest:

- A white paper documenting the state of practice within DOI, options and recommendations for taking advantage of best practices within and outside the agency.
- A bureau-wide workshop of interested staff and managers to exchange information and participate in strategic planning for advancing in this area. Key external partners with biological resources and data management expertise will also be invited to participate in this workshop.
- Development of Science and Technology Program proposals to explore the utility of UAS to meet Reclamation mission requirements.
- Implementation of a SharePoint site to facilitate communication amongst community members.

Responsibilities

Reclamation Aviation Manager: Oversees aviation policy within Reclamation. All policy questions related to UAS use within Reclamation will come under the jurisdiction of this office. Writes the Reclamation Aviation Management Plan. Invited to all UAS Working Group activities; attends at his/her convenience.

Chair, UAS Working Group: This rotating position within the UAS working group will oversee the group activities, schedule working group meetings, organize documentation, and act as a liaison with the Reclamation Aviation Manager with respect to UAS activities.

UAS Working Group: A core group of interested Reclamation personnel who will discuss developments in UAS technology, submit UAS research proposals, organize training workshops, and promote exploration of the potential uses of UAS within Reclamation. The working group will explore UAS best practices, keep track of COA requirements, explore the potential uses of new sensors and platforms to meet Reclamation's mission, oversee needs assessments for UAS technology, investigate best practices and software for data processing, make recommendations for the UAS SharePoint site, collaborate with other agencies,

and disseminate information across Reclamation about UAS policy and technology.

UAS SharePoint Administrator: Oversees the currency, accuracy, integrity, and quality of the data within the UAS SharePoint site. As needed, makes changes to the site design. Grants read and write privileges to site users.

UAS Community of Interest: This group of Reclamation personnel with a shared interest in the exploration of UAS technology will learn about, make use of, research, and exchange ideas about near-remote sensing and UAS technology. The working group will communicate frequently with the community of interest to help them make use of near-remote-sensing and understand the process for organizing and executing a mission.

APPENDIX B

Processing UAS Imagery

Software Requirements for Creating a Photo Mosaic.

The GOM Player is a 32-bit media player for Microsoft Windows with the capability to play media files of all types, no matter how obscure. It has the capability to display incomplete or damaged files. It also has the ability to find external computer programs called “codecs” to decode a digital stream or signal.

Microsoft Office Picture Manager manages, edits, shares, and views pictures from where they are stored on the computer. The Locate Pictures feature, as the name suggests, locates pictures. *Picture Manager* corrects pictures. A picture editing tool crops, expands, or copies and pastes.

Microsoft Photo Gallery. Import your photos into *Photo Gallery* from the camera or mobile phone to make it possible to edit, organize, and share them.

Initial Steps.

To get started, connect a camera or mobile phone to your computer and turn it on. *Open Photo Gallery* and on the Home tab, click Import. Choose a camera or device from the list, and then click Import. Click Review, organize, and group items to "Import" or "Import all" new items now. Then click Next.

Photo Gallery has tools to locate and organize the photos and videos by the information the camera adds—like the date a photo was taken—or by information the user adds—such as tags, captions, and other information. *Photo Gallery* also has editing tools to improve the appearance of the photos by changing their alignment, exposure, color settings, and more. With *Photo Gallery*, it is possible to remove red eye, retouch photos, and add color and tonal effects to photos.

Photo Gallery also has the capacity to stitch several photos together to create a panorama. This allows for the capture of landscapes and other subjects that are too large for a single photo.

Processes for Creating a Landscape Mosaic.

Using the *GOM Player*, open the Raven video, then run the ‘Burst Capture’ routine. This will automatically capture still frame images at set intervals. Open these still frame images into *Microsoft Office Picture Manager* and select all the images that must be ‘cropped’. For the selected images, crop out borders and/or labeling. This can be done in a batch mode.

Once this has been done, the user can open the cropped and rotated images into *Windows Live Photo Gallery*, select all the images, and create a stitched panoramic mosaic. Following this, the stitched image can be adjusted for contrast, brightness, and sharpness.

Finally, using a program such as *Global Mapper*, *ArcGIS*, or *AutoDesk AutoMap* 3D rubbersheeting/GeoTiff processes can be initiated. Georeferencing is a process by which a geographic data layer is warped so that it can be joined to an adjacent geographic layer.

Alternate GeoTiff Production using Agisoft PhotoScan Pro.

PhotoScan generates high resolution, georeferenced orthophotos and a digital elevation model. It provides for aerial triangulation, polygonal model generation (plain/textured), setting coordinate systems, georeferenced digital elevation model (DEM) generation, and georeferenced orthophoto generation.

Once the generated images are loaded and masks created, processing occurs in three phases. In Stage I, the photos are aligned. The software searches for common points on photographs and matches them. It also determines the camera position for each photo and refines calibration. Ultimately, a point cloud and a set of camera positions are formed. The point cloud represents the results of photos' alignment. This set of camera positions is required for further 3D model construction. Stage II is geometry construction, based on the estimated camera positions and the photos themselves, a 3D polygon mesh, representing the object surface, is built by *PhotoScan*. Having built the mesh, editing is possible, using simple or advanced tools. After geometry (i.e. the mesh) is satisfactory, Geotiff generation can proceed. (For more information see the *AgiSoft Photoscan User Manual*). Orthophoto generation is also possible. Ground control may also be introduced, if required. Figure 6 shows a mosaic of Lake Mills on the Elwha River produced by Mark Bauer (USGS) from imagery captured from the GoPro Hero2 camera in September of 2012 and processed by the USGS in November of the same year.

Image processing technology is evolving quickly and the USGS UAS team is taking the lead on development. For further information, please contact Jeff Sloan (USGS) at: 303-236-1308 or Mark Bauer (USGS) at 303-236-1247.

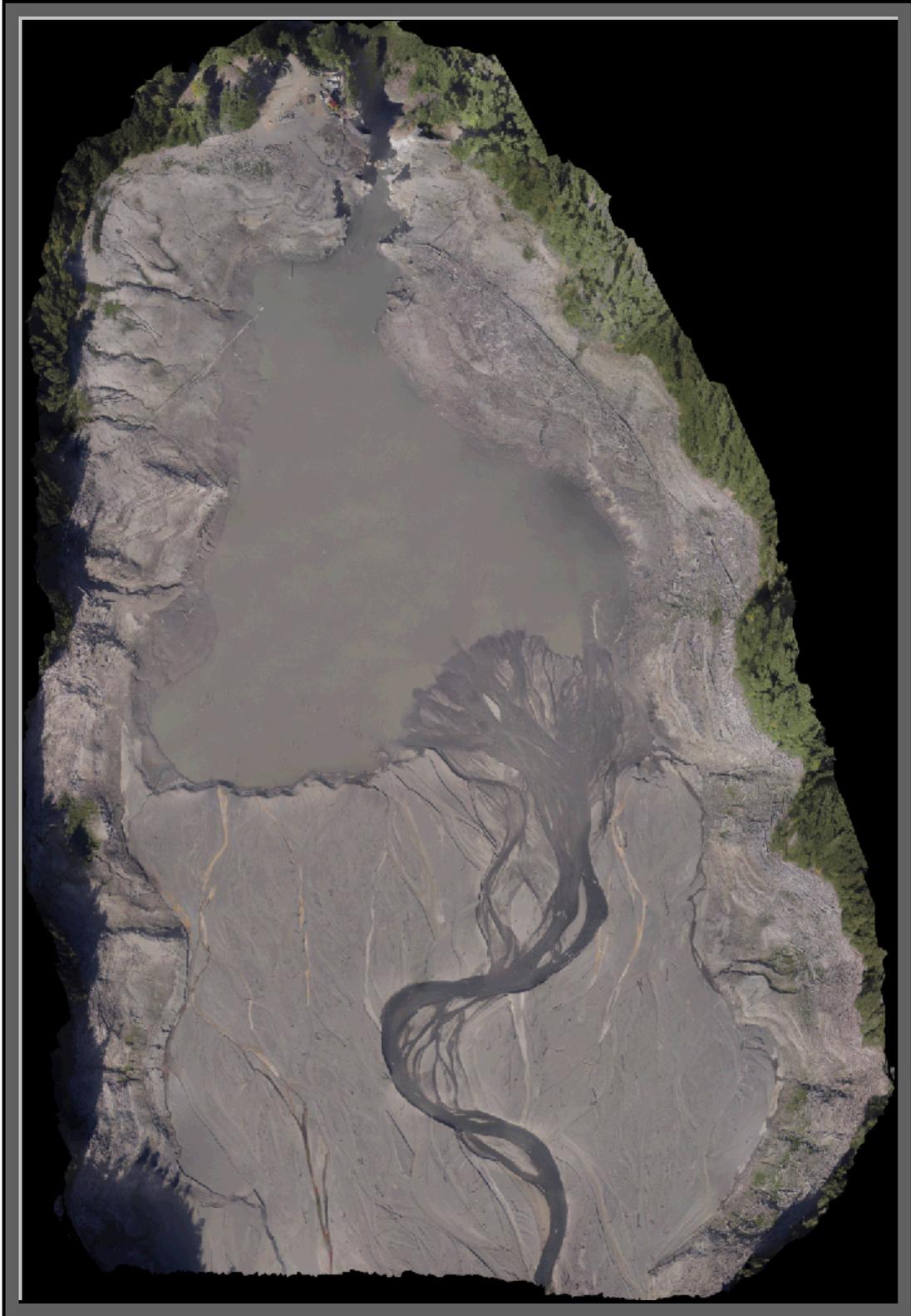


Figure 6: Photo Mosaic of Lake Mills, September 2012.