Airborne LiDAR and Aerial Photography
Pre-Flight Plan for Flathead Basin, Montana

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September 16, 2009

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LiDAR Data Acquisition

Overview

Watershed Sciences will complete LiDAR data acquisition on ~305,000 acres in the Flathead Basin following the parameters and procedures specified in our proposal to the Montana Dept. of Natural Resources on August 14, 2009.

Schedule

LiDAR Acquisition Start Date: About Sept 21, 2009
Projected Acquisition Length: 9-12 days

Mission Parameters

The mission parameters are summarized in Table 1. The entire area will be collected at a native pulse density of ≥4 pulses/m^2 and a swath overlap of 50%.

Table 1 – Planned LiDAR mission parameters for the Flathead Basin project.

All Areas	
Pulse Density	≥4 pulses/m^2
Swath Overlap	50%
Flight Line Direction	Opposing
Swan Lake Area	
Swath Width	695 m
Scan Rate	Max
Field of View	30°
Pulse Rate	82,000 pulses/sec
Altitude (AGL)	1,300 meters
Line Spacing	278 meters
All Other Areas	
Swath Width	896 m
Field of View	28°
Pulse Rate	128,000 pulses/sec
Altitude (AGL)	1,800 m
Line Spacing	358 m

Pre-Established Survey Control

River Design Group has established eight control monuments spatially distributed in the study area that are within the 13 nautical mile maximum baseline. During the LiDAR acquisition, we will collect 1Hz static data using Trimble R7 GPS units on at least two survey controls during each flight (Figure 1, Table 1).

Study Area Map with Controls

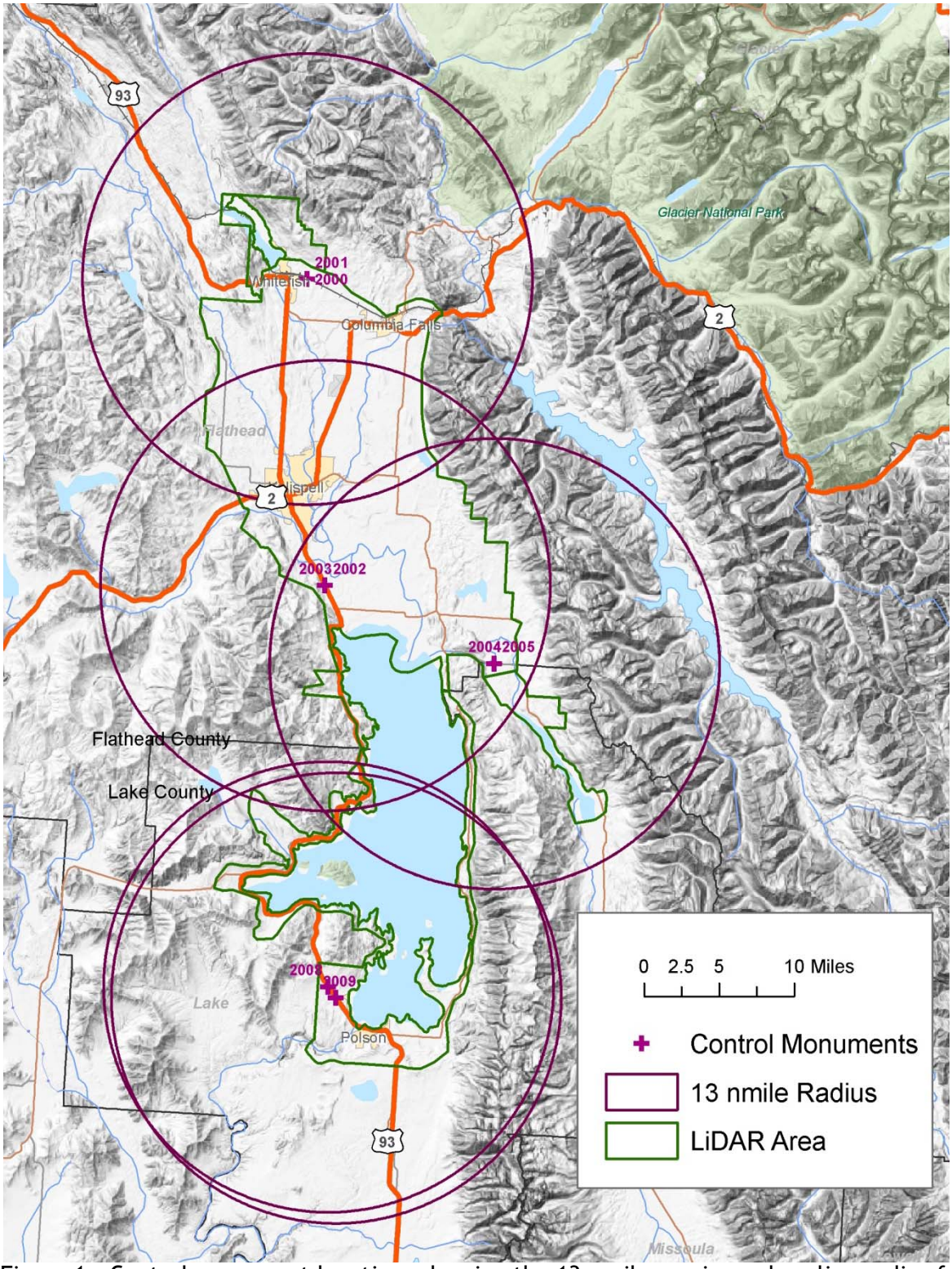


Figure 1 – Control monument locations showing the 13-nmile maximum baseline radius for LiDAR data acquisitions. GPS static control is redundant for each survey area.

Table 1 – Control monument locations and coordinates.

Projection: Montana State Plane **Units:** US Survey Feet **Vert. Datum**: NAVD88 US Survey Feet				
ID	**NORTH**	**EAST**	**ELEV**	**Description**
2000	1552499.106	801687.291	3050.276	WF Airport
2001	1552480.098	801677.039	3050.840	WF Airport (secondary)
2003	1445053.801	807984.142	2912.698	NGS F442 (secondary)
2002	1445038.260	807979.152	2912.340	NGS F 442
2004	1417603.007	867472.987	3066.652	Ferndale (primary)
2005	1417607.465	867414.866	3066.608	Ferndale (secondary)
2008	1304227.479	809124.056	3094.623	NGS Z 443
2009	1300323.830	811816.001	2974.945	NGS A 444

Flight Line Directions with Control

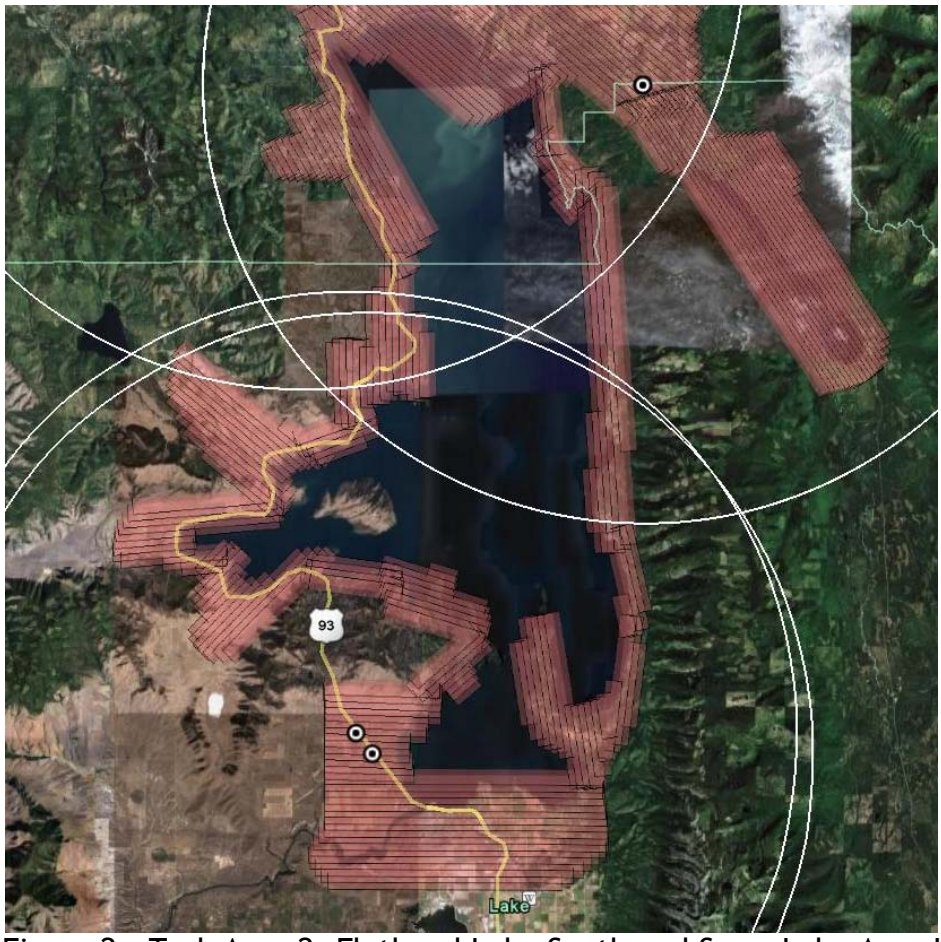


Figure 2 – Task Area 2: Flathead Lake South and Swan Lake Area LiDAR.

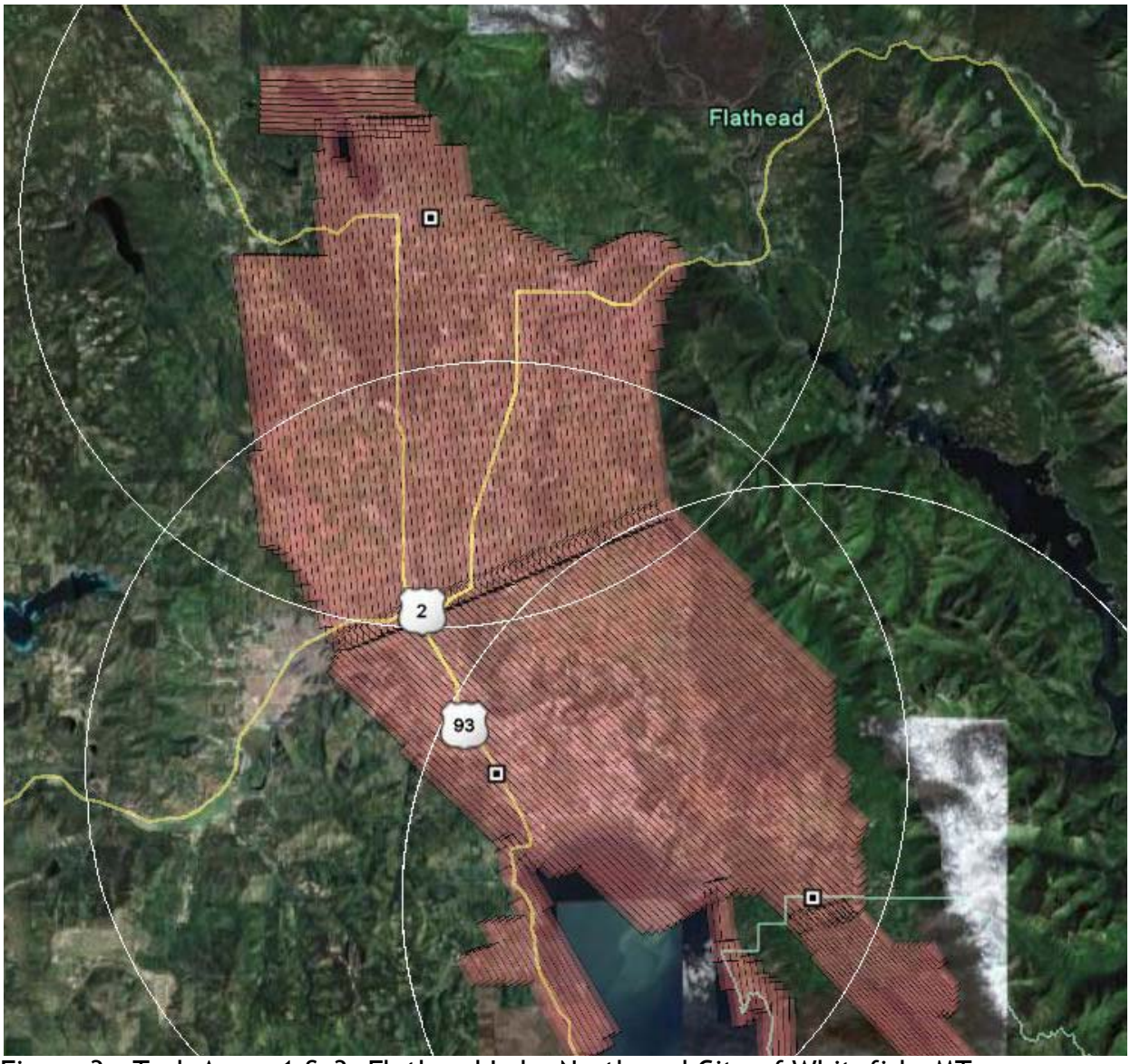


Figure 3 – Task Areas 1 & 3: Flathead Lake North and City of Whitefish, MT.

Pre-Flight Calibration

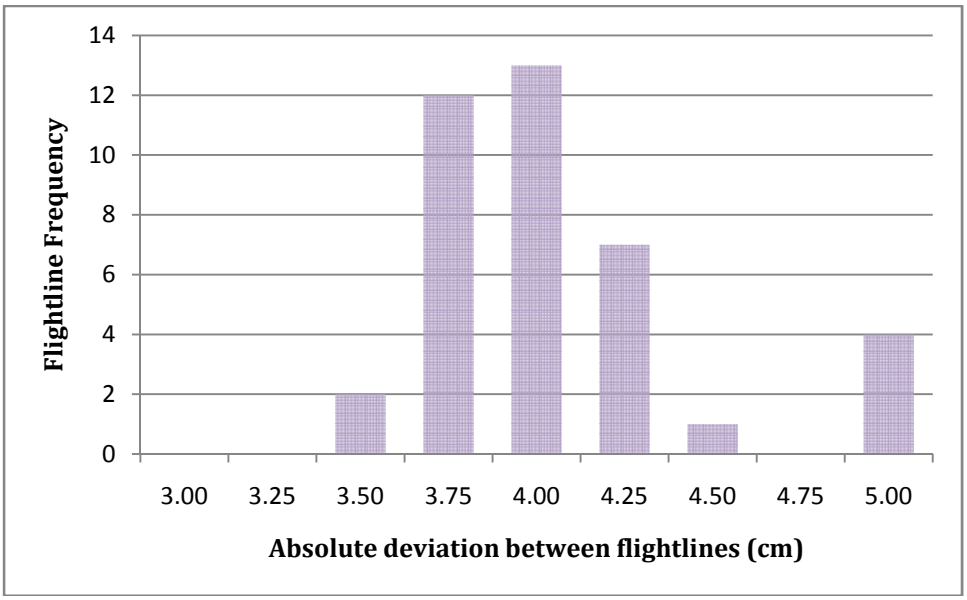
Watershed Sciences will deploy a Leica ALS 50 Phase II (serial #94) mounted on a Cessna Caravan. This sensor calibration was last checked on July 31st and documentation from this calibration is provided below. The calibration verifies both absolute and relative accuracy of the LiDAR data. The calibration report from July 31st shows the sensor is well within expected tolerances. The sensor calibration will be verified for each mission in the Flathead Basin.

Calibration Report – July 31st, 2009

System:	ALS50 Phase II
Sensor #:	SN - 94
Aircraft:	Cessna Caravan (604MD)

**Statistics based on absolute deviation between overlapping flight-lines.*

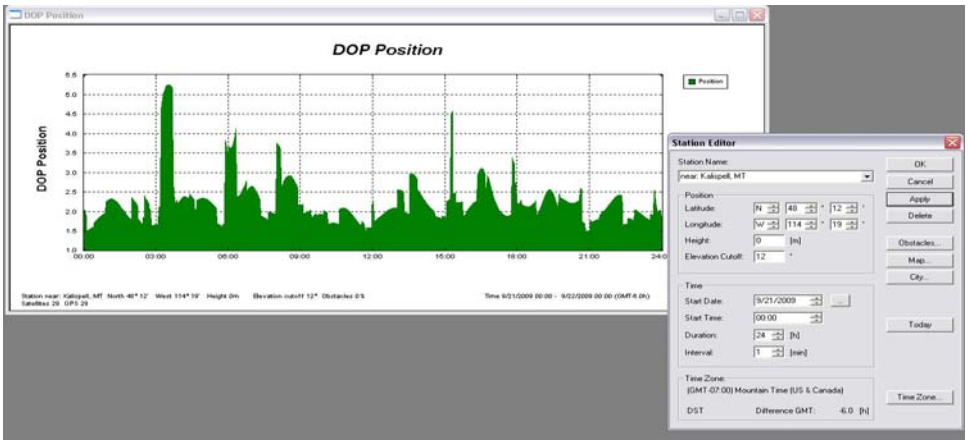
Total # of flight-lines:	n = 39
Total # of points:	n = 163,078,112
Mean:	0.039m
Standard deviation:	0.004m
Minimum:	0.034m
Maximum:	0.049m



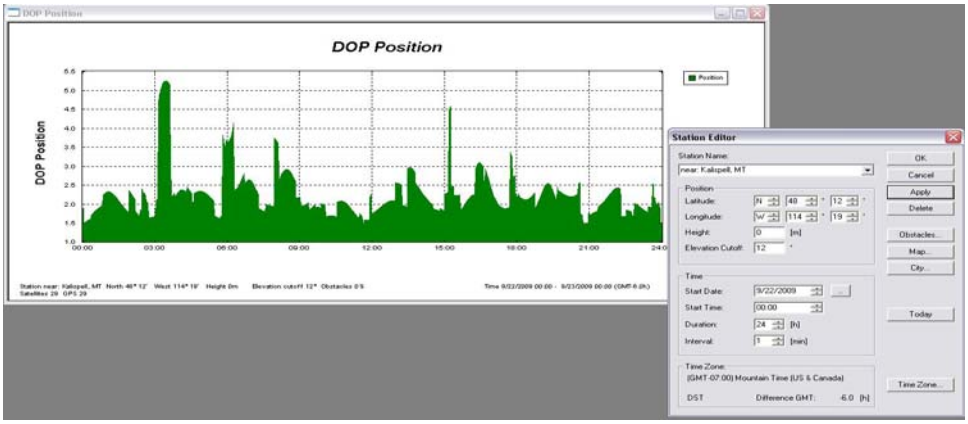
Planned Data Collection Periods

The LiDAR flights will be conducted when GPS Positional Dilution of Precision (PDOP) is less than 3.0. The project GPS PDOP windows for dates 9/21-27/09 are provided below. The plots were generated using Trimble Planning Software with a 12° antenna mask. The proposed acquisition times are provided to pilots and sensor operators. Operators also monitor the PDOP in real time during the acquisition. Similar plots/planning will be conducted for acquisition dates extending outside this window.

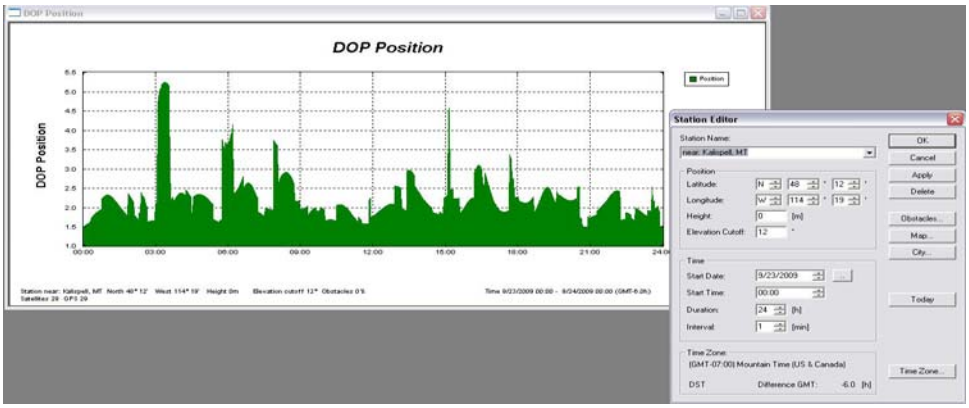
Date: Monday September 21, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0835-1330, 1350-1510
Total Acquisition Hours: 6.25
PDOP Spikes: 0800-0835, 1330-1350, 1510-1520, 1620-1640, 1745-1755



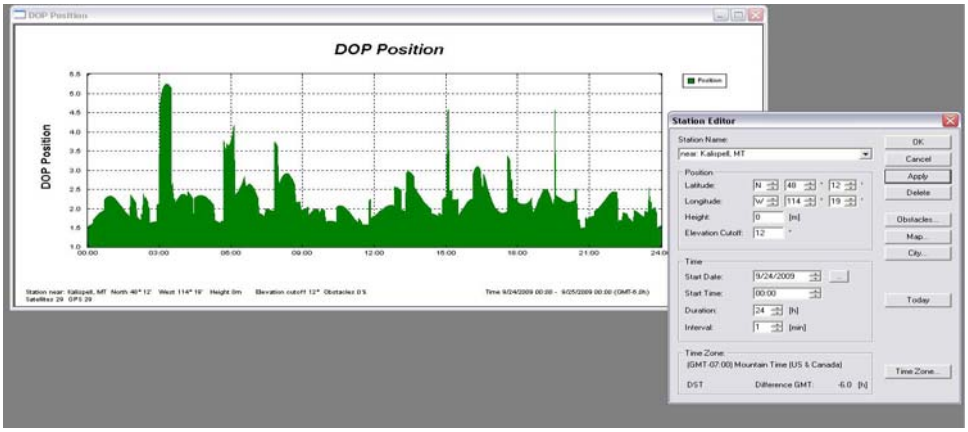
Date: Tuesday September 22, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0830-1325, 1350-1505
Total Acquisition Hours: 6.1667
PDOP Spikes: 0755-0830, 1325-1350, 1510-1515, 1615-1640, 1740-1750



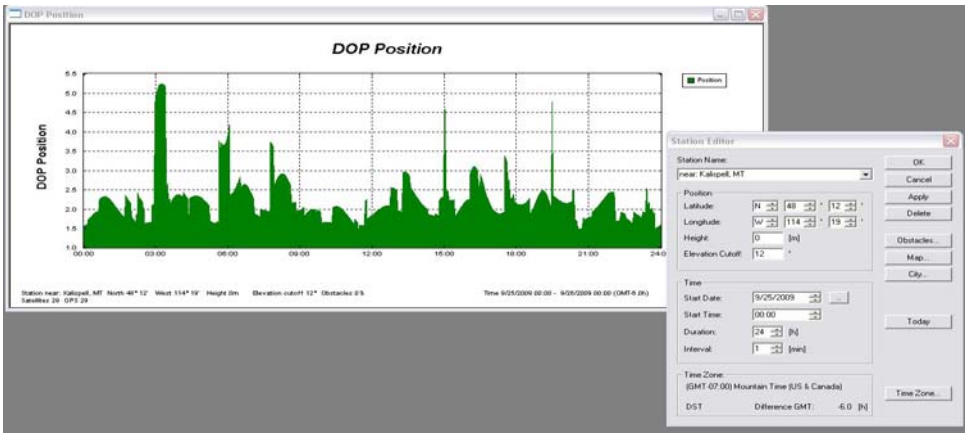
Date: Wednesday September 23, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0830-1320, 1345-1505
Total Acquisition Hours: 6.1667
PDOP Spikes: 0750-0830, 1320-1345, 1505-1515, 1610-1635, 1735-1745



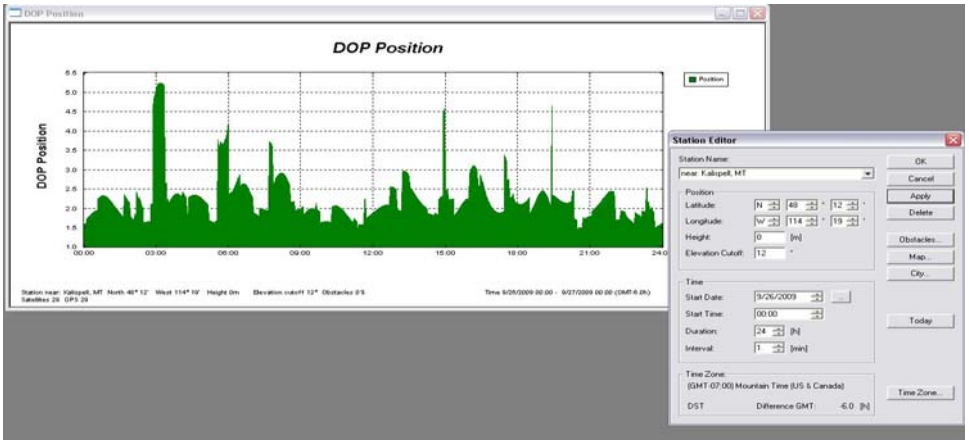
Date: Thursday September 24, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0830-1315, 1340-1500
Total Acquisition Hours: 6.0833
PDOP Spikes: 0750-0830, 1315-1340, 1500-1510, 1605-1630, 1733-1743, 1930-1935



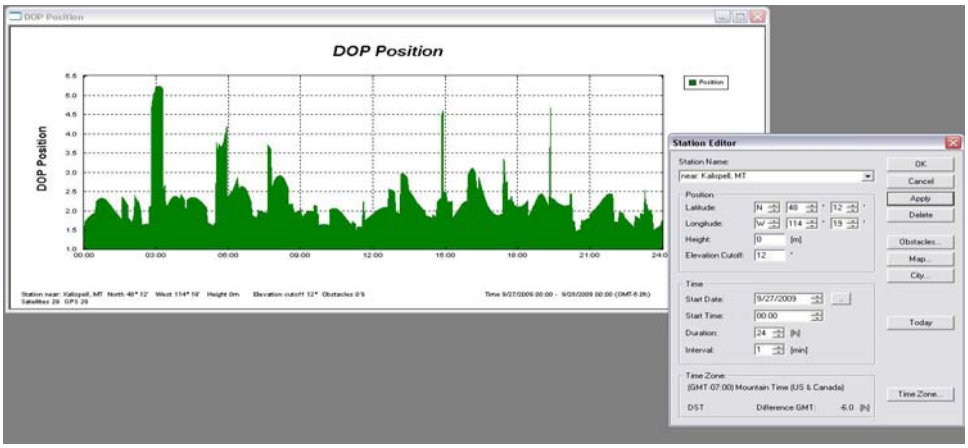
Date: Friday September 25, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0825-1310, 1335-1455
Total Acquisition Hours: 6.0833
PDOP Spikes: 0745-0825, 1310-1335, 1455-1505, 1605-1625, 1730-1740, 1925-1930



Date: Saturday September 26, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0820-1310, 1335-1450
Total Acquisition Hours: 6.0833
PDOP Spikes: 0740-0820, 1310-1335, 1455-1500, 1600-1620, 1725-1735, 1922-1927



Date: Sunday September 27, 2009
Location: near Kalispell, MT
Proposed Acquisition Times (MST): 0815-1305, 1330-1450
Total Acquisition Hours: 6.1667
PDOP Spikes: 0735-0815, 1305-1330, 1450-1455, 1555-1615, 1720-1730, 1917-1923



Contingency Plans

In addition to monitoring system status during flight, Watershed Sciences will perform quick look evaluations of the data after the flight. If any flight lines are suspect, the flight will be re-flown while the aircraft and crews are still in the area. If problems are observed after the crew has left the project area, the aircraft and crew will return to the area (at our expense) and re-fly the affected line(s).

Risk Assessment

The primary risk on this project is weather. The size of the project and potential for snow cover in October create the primary risk of starting the project area but not finishing due to poor weather and snow cover. Consequently, we strongly advise starting acquisitions immediately in order to minimize this possibility.

If poor weather precludes finishing the acquisition, Watershed Sciences will mobilize back to the study area to finish the acquisition when conditions allow. We will coordinate all decisions with Montana DNR.

Contact Information

Name	Role	email	Phone
Brian Dwyer	Acquisition Manager (1)	bdwyer@watershedsciences.com	541-207-7139
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Russ Faux	Project Manager	faux@watershedsciences.com	541-760-1835

Orthophoto Flight Plan

Overview

3Di West will complete orthophoto acquisition on ~305,000 acres in the Flathead Basin following the parameters and procedures specified in the Watershed Sciences' proposal to the Montana Dept. of Natural Resources on August 14, 2009.

Schedule

Photo Acquisition Start Date: About Sept 22, 2009
Projected Acquisition Length: 1-2 days

Mission Parameters

The mission parameters are summarized in Table 2. Imagery will be collected with a Vexcel UltraCam-X digital mapping camera with integrated GPS/IMU. Exposure stations are portrayed in Figure 4.

Table 2 – Planned Photo Acquisition parameters for the Flathead Basin project.

Altitude (AGL)	11,000 ft
Flight Speed	210 knots
Horizontal Overlap	30%
Vertical Overlap	60%
Side Boundary Area Overlap	25%
Ground Sample Distance	1 ft
Scale	1:200'
Spectral Bands	NIR, R, G, B
Sun Angles	≥30°

Pre-Established Survey Control

For the photo flight, the primary vertical control will be static base stations located on two of the eight control monuments established and certified by River Design Group surveyors. The base stations will be located one each in the Northern and Southern portions of the study areas. Continuously Operating Reference Stations (CORS) located in Kalispell and Polson will be used as back-ups or alternate sites. In addition, in coordination with 3Di-West, River Design Group surveyors have established pre-marks (visible air targets) at locations distributed throughout the study area (Table 3; Figure 5).

Table 3 – Air target locations & coordinates.

Projection: Montana State Plane **Units:** US Survey Feet **Vert. Datum**: NAVD88 US Survey Feet		
ID	**NORTH**	**EAST**
SV-1	1579712	772422
SV-2	1553661	806357
SV-3	1537624	844181
SV-4	1513608	768565
SV-5	1481399	815650
SV-6	1460366	863057
SV-7	1407752	806428
SV-8	1357841	858462
SV-9	1373050	900876
SV-11	1308890	806318
SV-10	1340563	769727
SV-12	1282986	843889

Study Area Map

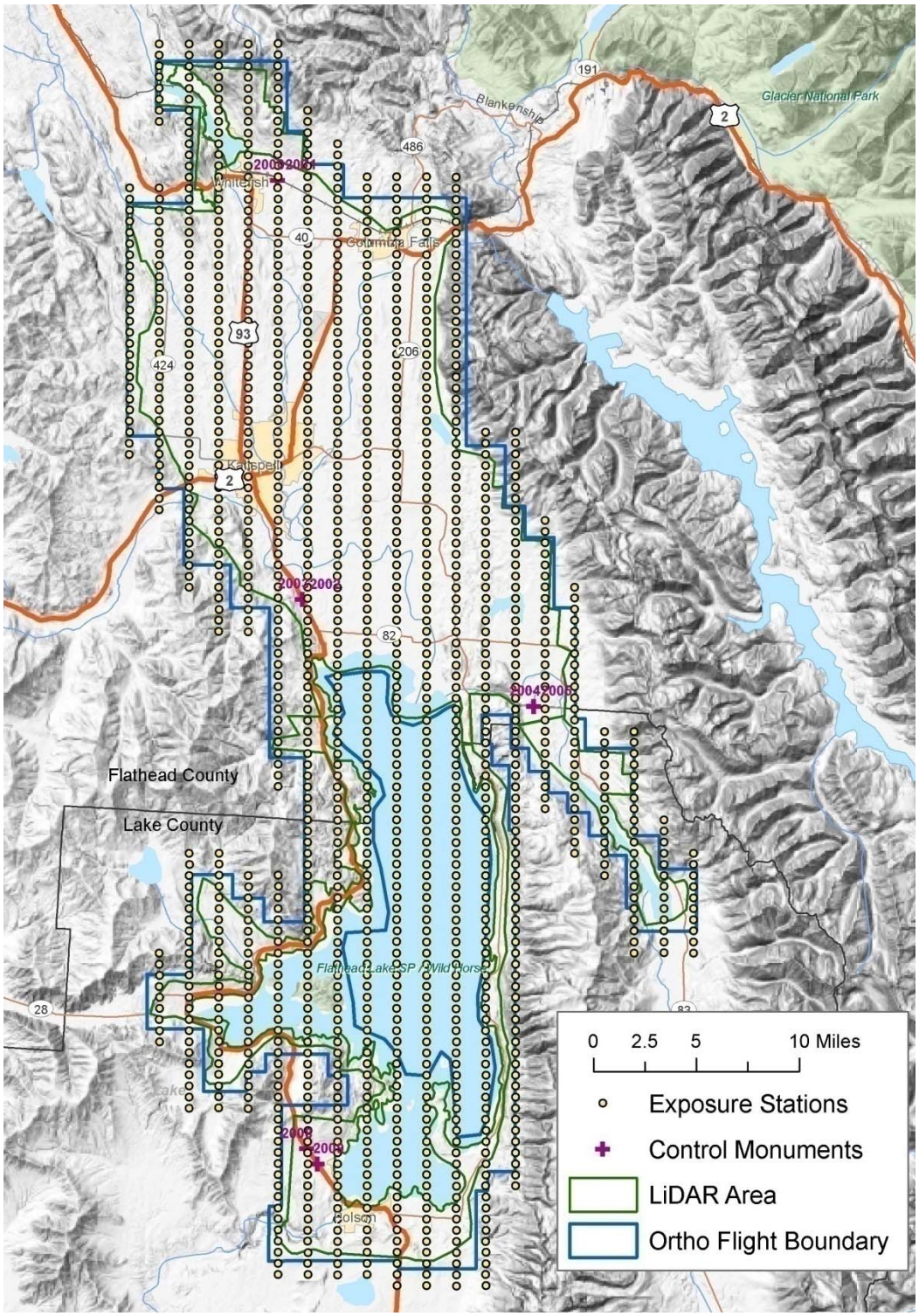

Figure 4 – Map showing the orthophoto flight boundary and exposure stations.

Orthophoto Air Targets

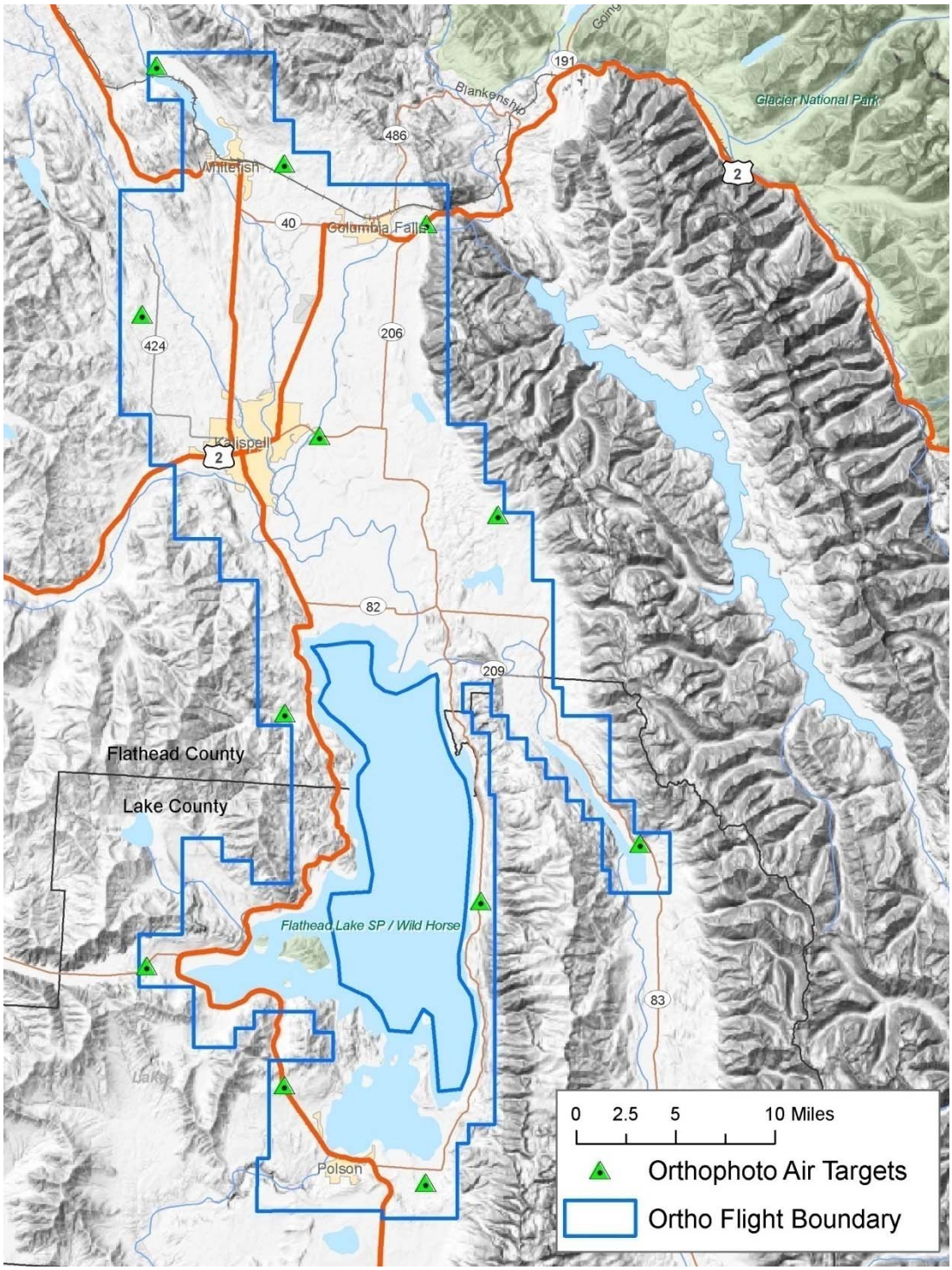

Figure 5 – Map showing the location of air targets providing horizontal control for the orthophoto flight.

Planned Data Collection Periods

The photo flights will be conducted on clear days with sun angles greater than 30° (35° preferred) above the horizon. These sun angles occur from ~10:00 to ~15:00 local time during the week of September 21.

Contingency Plans

The image collection will be monitored during the flight and quick look data will be examined after the flight to ensure quality image collection. If necessary, flight lines will be re-flown (at our expense) to capture data to specification. However, we recognize that this is more difficult in an image acquisition than for LiDAR due to sky and sun angle constraints.

Risk Assessment

As with LiDAR, the primary risk on this project is weather and we plan to start acquisitions as soon as conditions allow. The acquisition is planned for 1-2 days. Delays due to weather will result in less desirable sun angles as we progress into the fall months.

Contact Information

Name	Role	email	Phone
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