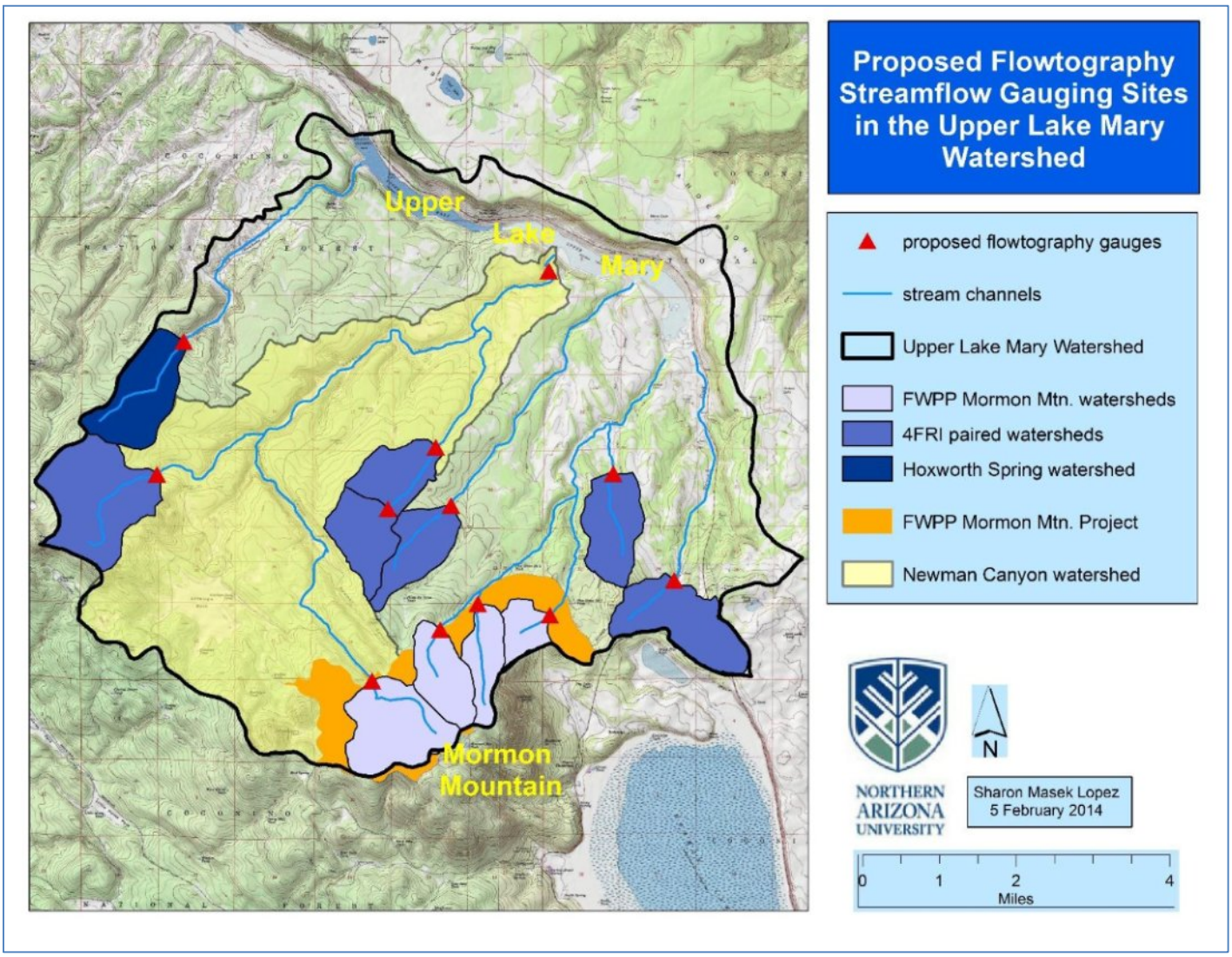
Lake Mary and Walnut Creek Technical Advisory Committee Proposal:

Monitoring Streamflow in the Lake Mary Watershed Using "Flowtography"

PROPOSAL

The Lake Mary and Walnut Creek Technical Advisory Committee is proposing to fund the installation of twelve "flowtography" streamflow gauges on washes that are all tributaries to Upper Lake Mary. The flowtography method is described below. The twelve gauges would be distributed as follows:

- Four on stream channels on Mormon Mountain to monitor runoff effects from Flagstaff Watershed Protection Project treatments,
- Six on washes whose watersheds are part of the 4FRI Paired Watershed Study,
- One located just downstream of Hoxworth Spring, and
- One at the USGS Newman Canyon gauge site.



The sites

The Mormon Mountain gauges would capture most of the Mormon Mountain FWWP treatment effects on water yield to Upper Lake Mary. Forest thinning treatments are anticipated on Mormon Mountain in 2018. These watersheds are in mixed conifer forest in the upper elevations and ponderosa pine forest in the lower elevations. The gauges will give some of the first insights into restoration treatment effects in mixed conifer forest in Arizona.

The proposed 4FRI Paired Watershed Study watersheds are 450 to 1,100 acres in size. Over the course of 20+ years, the paired watershed study will measure water balance (snow water storage, soil water storage, evapotranspiration, groundwater recharge, and surface water discharge) changes due to forest restoration treatments. Timing is critical for gauging streamflow at these locations. Preliminary flow data are needed to design weirs and flumes to gauge streamflow over two decades. Since June 2013, flow data have been collected by SRP on four paired watersheds in the Sycamore Creek watershed using flowtography. Flowtography measurements will be overlapped by at least one year with and flume measurements to verify flowtography accuracy.

The Hoxworth Spring watershed has had intermittent, seasonal hand measurements of streamflow collected by Dr. Abe Springer using a small portable Parshall flume since 1997. This watershed will undergo restoration treatments as part of the Elk Park Project starting in 2014. Collecting continuous flow measurements with flowtography before, during, and after forest thinning treatments will allow analysis of surface water and groundwater response to restoration treatments in the shortest possible timeframe, since other forest treatments in the Upper Lake Mary watershed may not occur for a 2 to 8 years.

The Newman streamflow gauge location is at the site of a proposed relocation of a City of Flagstaff streamflow gauge. This flowtography placement would provide a check on the accuracy of the flowtography method for a much larger drainage area (>14,000 acres) than the other flowtography sites in the Upper Lake Mary watershed that are approximately 450 to 1,200 acres.

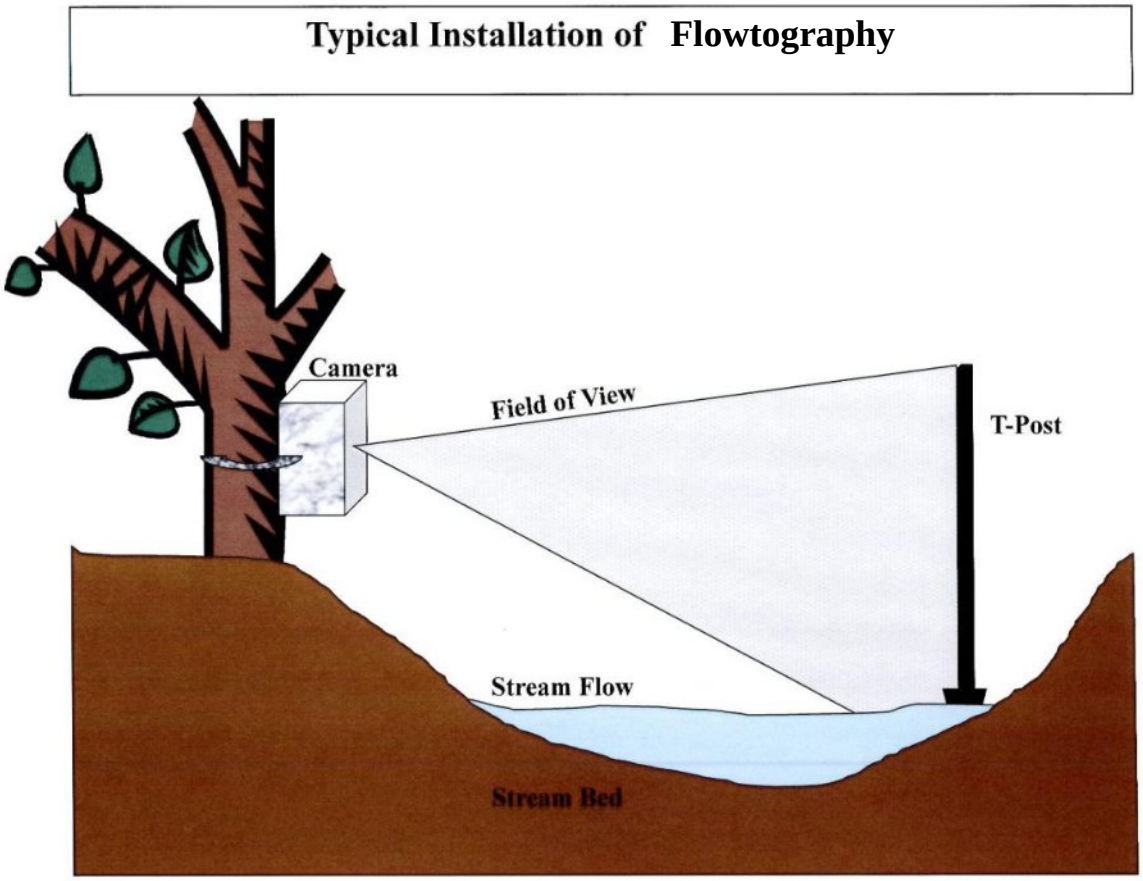
This stream gauging effort would be a collaboration of the City of Flagstaff, Northern Arizona University, the Ecological Restoration Institute and Salt River Project. It would provide critical information in a timely manner. The gauges would contribute to our understanding of surface water runoff response to forest thinning treatments, as well as enable coordinated water quality sampling efforts. Resulting data may inform measures to protect Upper Lake Mary's water quality and quantity.

Flowtography can be a valuable resource for coordinating water quality sampling. Because photos are taken at 15-minute intervals and thumbnails are sent to the service provider's website hourly where they can be viewed online, streams can be easily monitored to determine whether flow events are occurring. With this knowledge, teams can be sent to collect grab samples for water quality analysis. This would be more cost-effective and involve less risk to equipment than placing multiple automatic water samplers.

Methods

"Flowtography" is a simple, inexpensive way of monitoring streamflow, which was developed by Lee Ester of Salt River project. It is composed of a time-lapse camera (powered by a small solar panel and battery) and a T-post driven in the stream channel on which the camera is focused. First an appropriate stream channel area is found that has a generally symmetric cross-section, good lateral control (no spilling into a side channel), a straight approach from upstream for at least 50 feet, and sufficient drop. The channel cross-section and profile are surveyed, and a roughness coefficient is selected based on channel substrate. A dark green T-post with reflective tape affixed in 6 inch increments is pounded into the lowest part of the channel cross-section. A camera is mounted in a tree adjacent to the channel, along with the solar panel and battery and all parts are camouflaged with spray paint. The camera is focused on the T-post from ≤50 feet away either upstream or downstream. It takes pictures every 15 minutes, 24 hours per day.

StealthCam Drone time-lapse camera with cellular data connection



The camera has a cellular phone data connection (optional, but highly recommended) that periodically sends thumbnail images to a service provider's website. A technician views thumbnail images online to determine whether flow events are occurring. Based on the frequency of flow events, the technician goes to the camera, swaps data cards and brings the data card back to the office for download, interpretation, and data archiving. More frequent field visits are needed during snowmelt and monsoon periods to avoid data loss, since the card will overwrite with new images once it is full. Onscreen photos of the water level on the T-post are measured using an engineering scale to determine water level height. Using water height, channel cross-section and profile, and channel roughness the Manning Equation is used to calculate flow.

Surveying channel cross-section.

Setting the T-post in the channel

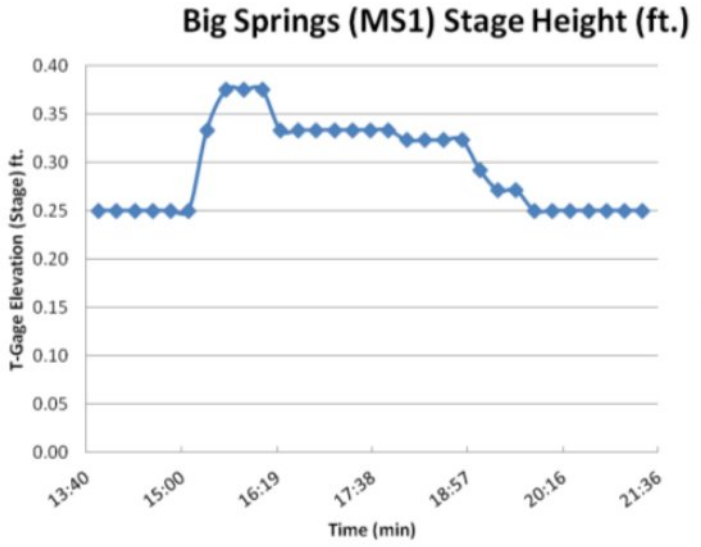
Mounting the battery (left) and camera (right) in a tree.

Background – camera mounted in a tree

Mid-ground – downloading images via data card to a lap top and viewing

Foreground – T-post at which the camera is aimed

Example of Results



Budget

LMWCTAC is requesting approval of funds to support the purchase of time-lapse cameras and associated equipment and materials for the installation of 12 flowtography gauges. Installation costs are outlined in the table below. Please, note that Salt River Project (SRP) has committed to help with installation of the six paired watershed gauges. SRP staff will lead installation of the first six gauges and train City and University staff and students on installation methods, so that these skills can be used for installation of the remaining six gauges. SRP will also assist with the remaining six if their schedule allows. The value of SRP's contribution ($15,891 to $31,781, depending on staff availability) exceeds the cost of equipment and materials being requested of the City by LMWCTAC ($12,000). In collaboration with NAU and Kaibab National Forest, SRP has already installed four flowtography gauges on national forest lands southeast of Williams. It is anticipated that the Coconino National Forest's hydrologist will contribute some of his time to the installation, as the soils scientist on the Kaibab National Forest did previously (estimated $7,440 value).

An operating budget will be needed, but the LMWCTAC is not requesting operating funds at this time. We anticipate that operations will be a combined effort of City of Flagstaff, NAU, and SRP staff. An operating plan and budget are being developed. However, the requested equipment purchase is time sensitive. Equipment must be purchased soon to allow time for installation, preferably before the end of spring snowmelt and certainly before summer monsoon season.

Item	price	number	cost	SRP	LMWCTAC
Equipment					
time-lapse camera	$600	12	$7,200		$7,200
solar panel, cables and wiring	$150	12	$1,800		$1,800
Optima heavy duty, long-lasting battery	$200	12	$2,400		$2,400
data cards	$30	12	$360		$360
T-posts	$10	12	$120		$120
reflective tape	$30	4	$120		$120
equipment total					*$12,000*
Labor		hours			
Lee Ester	$62	120	$7,440	$7,440	
SRP Engineering Intern	$30	120	$3,600	$3,600	
Sharon Masek Lopez	$37	120	$4,440	$4,440	
labor total				*$15,480*	*$0*
Transportation					
vehicle rental	$45	6	$270	$270	
mileage (67 miles round trip)	$0.35	402	$141	$141	
transportation total				$411	*$0*
TOTAL INSTATALLATION COST				*$15,891*	*$12,000*
*per unit cost**				*$2,648*	*$1,000*

* per unit cost for SRP is based on 6 installations; up to 6 additional installations may be possible depending on staff availability

Timeframe

The various flow monitoring objectives have different timeframes, based on data needs for each project:

- The Mormon Mountain flowtography streamflow gauges would be installed in 2014 and operate continuously until at least 6 years after restoration treatments occur (estimated 2018).
- The paired watershed gauging would extend from Spring 2014 to Spring 2016 for the six paired watershed study sites, overlapping by one year with flumes that will be installed in 2015. The flowtography data will be highly valuable in developing flume design for long-term stream-gauging.
- For the Hoxworth Springs site, work would begin in Spring 2014 and extend though at least Spring 2018 to capture changes in discharge following restoration treatments that are expected to occur in 2014.
- The Newman Canyon flowtography gauge would be installed in 2014 coincident with installation of the new City of Flagstaff or USGS streamflow gauge and remain in place for a period of 2 to 4 years as a verification of the flowtography method at a larger watershed scale.

Progress reports will be provided quarterly. Annual data and analysis summary reports will also be provided. It is our understanding that the LM-WC TAC equipment purchase for each site is pending until development of a data collection and management plan/SOP, or something similar, and commitment to data collection for at least two years, is provided to the LM-WC TAC.

Other Considerations

Access: Road access is limited to the twelve locations. During winter months all sites will have to be accessed by foot. Four of the five paired watershed sites have to be accessed by foot any time of year due to road closures that are part of the Travel Management Rule. Three of the paired watershed sites are only accessible by foot or horseback from August 15 to December 31, because they are in a designated non-motorized quiet area.

Permits: A permit will be obtained from Coconino National Forest (CNF). Sharon Masek Lopez has already met with a Forest Service representative about the permit. There will be a simple exchange of letters between SRP and CNF. The request letter from SRP will be very similar to a letter that was submitted to Kaibab National Forest for the same purpose. Technically the Forest Service does need to permit flowtography, due to the nature of the activity (the use of cameras is similar to how many others mount wildlife cameras for hunting purposes, which does not require permit), but SRP feels more comfortable having the Forest Service acknowledge the activity.