DEPARTMENT OF ECOLOGY
State of Washington

Standard Operating Procedure EAP045, Version 3.0

Hemispherical Digital Photography Field Surveys

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Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication information

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Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Hemispherical Digital Photography Field Surveys Conducted as Part of a Temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit Technical Study

Version 3.0

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Signatures on File

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
10/16/06	1	Wrote to SOP from scratch	1,2,3,4,5,6,7	D. Bilhimer
11/10/06	2	Updated Safety info and references	8,9,10	D. Bilhimer
3/16/07	1.2	Minor changes and added lens plate specifications	5,6,8	D. Bilhimer
11/14/07	1.3	Minor changes to definitions and added text about taking photos under canopy. Incorporated James Kardouni's comments	1,3,6,	A. Stohr
3/1/08	1.4	Formatting. Draft incorporation of Forests and fish protocols.	all	A. Stohr
5/08/08	2.0	Extensive changes to incorporate Forests and Fish protocols and James/Jacks comments	all	A. Stohr
6/30/15	2.1	Updated with new equipment and references to recently created supporting SOP (EAP 084). Located and added Appendix A. Previous version referenced it, but was not included.	1,3,4,5,6,7,9,10	N. Mathieu
7/1/2015	2.1	Recertified	all	B. Kammin
11/21/2016	2.1	Updates to cover page, footer		B. Kammin
9/14/2018	3.0	Extensive changes. Updated with new equipment; reorganized section 6; Added instructions for EOS 6D with new mounting box and remote app.	1,2,3,5,6,8,9	N. Mathieu
9/17/2018	3.0	Recertified	all	A. Kaza

Environmental Assessment Program

Standard Operating Procedures (SOP) for hemispherical digital photography field **surveys** conducted as part of a temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit technical study

1.0 Purpose and Scope

1.1 This SOP describes the field methods used by Ecology to characterize forest canopy via hemispherical photography. Hemispherical digital photographs are taken looking upwards from beneath the plant canopy, using a 180° fish-eye lens and digital camera. The photos (Figure 1) are used to estimate visible sky, effective shade, or solar radiation load. After accounting for glare and other image problems, shade and radiation values can be calculated from the photographs using software applications such as Gap Light Analyzer (Frazer et al., 1999) or HemiView© (Rich et al., 1999).

1.2 This procedure covers the field acquisition of digital images only; the computer analysis is covered in another document, Ecology SOP EAP046 (Stohr and Bilhimer, 2008).

Figure 1: An example hemispherical photograph.

2.0 Applicability

2.1 This SOP will be followed during the process of collecting field data for temperature water quality impairment studies (including TMDLs) or Forests and Fish unit projects.

3.0 Definitions

3.1 **Effective Shade:** fraction of total possible solar radiation above the vegetation and topography that is blocked from reaching the surface of the stream and summed over a full day. The effective shade at a particular location (the location of the hemispherical

photo) can be calculated, using HemiView© or Gap Light Analyzer for any day of the year. Because the solar path across the sky changes each day, the solar exposure a particular location receives will also change each day. Note: To date, studies have covered deciduous "leaf on" portions of the year. For winter analysis, it would not be appropriate to analyze a winter "leaf off" date with a summer deciduous canopy photo.

3.2 **Canopy Cover:** The percentage of the sky that is blocked by vegetation or topography. Unlike effective shade, canopy cover does not change dynamically with the angle of the sun. Canopy cover is typically assessed either at full leaf expansion or full leaf drop, during calm conditions (little or no wind). This value can be measured by a densiometer. Canopy cover can be calculated as 1 minus *VisSky* (if using the HemiView©software) or 1 minus *% Canopy Openness* (if using Gap Light Analyzer).

3.3 **Gap Light Analyzer:** free imaging software, developed for scientific/academic research, used to extract forest canopy structure and gap light transmission indices from true-color hemispherical photographs. This software can be found at: www.sfu.ca/rem/forestry/downloads/gap-light-analyzer.html.

3.4 **Gimbal** - A gimbal is a pivoted support that allows the rotation of an object about a single axis. A set of three gimbals, one mounted on the other with orthogonal pivot axes, may be used to allow an object mounted on the innermost gimbal to remain independent of the rotation of its support. With the right setup and balance, this can be used to create a self-leveling structure.

3.5 **Hemispherical photo**: a hemispherical digital picture. A hemispherical photo is a permanent record of canopy condition.

3.6 **HemiView©:** a proprietary computer software package for the analysis of hemispherical digital images. This software can be found at: www.dynamax.com/products/leaf-canopy-and-image-analysis/hemiview-hemispheric-image-analysis-system

3.7 **Lens mounting device**: the plate, box, or gimbal structure that holds the fisheye lens and connects with the tripod mount. EAP has designed several iterations of custom lens mounting devices to suit our field needs. Other lens mounting devices (such as the Delta-T Hemiview system) can be purchased from Dynamax at: www.dynamax.com.

3.8 **Magnetic Declination:** The angle between magnetic north and true north. Compass readings are influenced by local magnetic fields and a declination value is needed to obtain true north.

3.9 **QAPP:** Quality Assurance Project Plan

3.10 **Riparian vegetation:** Vegetation occurring along stream corridors.

3.11 **Thermistor**: a temperature data logger

4.0 Personnel Qualifications/Responsibilities

4.1 Persons involved in the field data collection and analysis must have three qualifications: 1) experience and training in the natural, environmental or physical sciences, 2) on the job training conducted by field staff with a minimum of one field season of experience performing this SOP, and 3) have thoroughly reviewed this SOP prior to performing the work.

4.2 Typical Job Class performing this SOP: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3, Environmental Specialist 1/2/3/4/5, Hydrogeologist 1/2/3/4, Administrative Intern 1/2/3.

5.0 Equipment, Reagents, and Supplies

5.1 The field equipment needed for this SOP are as follows:

5.1.1 Digital Camera with capability to mount a fisheye lens such as:
- Older models used by EAP include Nikon Coolpix 995, 990, or 4500
- Newer model used by EAP: Canon EOS 6D

5.1.2 Fisheye Lens such as:
- Nikon FC-E8 Fisheye converter lens 0.21x (Compatible with older Coolpix)
- Sigma EX DG Fisheye – 8mm; f3.5 (Compatible with EOS 6D)

5.1.3 Battery charger for camera batteries

5.1.4 Charged batteries

5.1.5 Camera memory card

5.1.6 Lens Mounting System (Figure 2):
- Coolpix Lens mounting plate with compass, level, and north-south markers (Appendix A)
- EOS 6D water-resistant lens mounting box with compass, level, and north-south markers
- Gimbal-based, self-leveling lens mounting device from Delta-T Devices

5.1.7 Remote shutter release (EOS 6D system only) either:
- Canon EOS Remote App for mobile devices; (free and available from app store)
- Compatible wireless remote control for Canon digital SLR cameras.

5.1.8 Rugged tripod, preferably with a joystick tripod head

5.1.9 Lens cleaner and cloth

5.1.10 GPS receiver

5.1.11 Field notebook

Figure 2: Left: Coolpix lens mount system used by Ecology; Center: Gimbal lens mounting device from Delta-T devices (SLM9). Right: EOS 6D lens mount system used by Ecology.

6.0 Summary of Procedure

6.1 Photograph locations

6.1.1 Photo locations can be distributed along the channel in various ways, based on project specific objectives. These objectives should be outlined in a QAPP or project work plan. Here are two common distributions:

6.1.2 *TMDL:* Photographs are taken at all in-stream temperature monitoring locations. The photographs are typically taken directly at the thermistor location or immediately upstream if that area has a more typical canopy for the stream reach. Two additional hemispherical photos are taken under the riparian canopy, one in the left riparian zone and one in the right riparian zone. The riparian photos are taken along a transect that is perpendicular to the stream and that includes the location of the instream photo. The riparian zone photos allow calculation of canopy density produced by different vegetation types. Calculation of both current and future riparian shade conditions require inputs of vegetation height and density in the riparian zone.

6.1.3 *Forests and Fish:* small channels high in the watershed can warm and cool quickly. Small channel canopy can also vary greatly. Thus, canopy photographs are distributed evenly from confluence to headwall to estimate average canopy and identify sections of channel where canopy may be low. To do this, measure the full channel length with a string box such as a Hip Chain. Then select a random number between 1 and 50. This becomes the point of the first photo. Subtract this number from the total channel length, then divide by 10. This sets the distance between photos. If the project has a pre-harvest vs. post-harvest overstory aspect, hardwire these distances into the data sheet for each basin. Post-harvest photos can then be taken at the same location.

6.1.4 Other hemispherical photo locations usually coincide with channel or vegetation surveys; for further detail, see EAP SOP084 (Swanson, 2013). If the hemispherical photos will be used as a field measure of average effective shade (over the stream's thermal survey reach), then either several additional stream center pictures under typical canopy conditions need to be taken, or a procedure similar to the one outlined in the Forests and Fish section should be used. Often, the solar pathfinder equipment is used for estimation of reach average effective shade, because it can be easily moved.

6.1.5 Never select a location where the visible sky is obstructed by a bridge or building, unless explicitly part of the project objectives, as these photos will be unrepresentative of the reach or river as a whole.

6.2 General procedures and preparation

6.2.1 The pictures can be taken at the same time as the channel surveys or they can be taken independently. Photos that will be used to evaluate summer stream temperatures need to be taken after deciduous trees/shrubs reach full leaf growth and before they begin losing their leaves in autumn. For best between year comparisons, photos should be taken at about the same time each year. Forests and fish projects target June to early July to optimize the chance of consistent results.

6.2.2 Always make sure you start the day with a fully charged camera battery, a back-up battery and enough space on the memory card. Also confirm that the correct image resolution is selected and used consistently. Refer to your project lead or photo analyst for guidance.

6.2.3 For best comparison, all photographs should be taken at approximately the same height above the channel. Forests and Fish projects, for example, generally adjust the tripod so that the top of the platform is roughly 1.3 m.

6.2.4 The weather will also affect the quality of the image. The best hemispherical photos are taken during overcast sky conditions because the contrast between the sky and shading vegetation is best. However, due to tightly planned field schedules you may not have a choice of sky conditions in which to take the hemispherical photos. Corrections may be necessary if the solar disc appears in the image or there is poor contrast between sky and vegetation. These corrections can be performed using digital image processing software such as Adobe Photoshop Elements©. Hemispherical photo correction techniques and analysis using Hemi-view© are covered in the hemispherical image analysis SOP EAP046 (Stohr and Bilhimer, 2008).

6.3 Declination Adjustments

6.3.1 Each photograph must be oriented to either true or magnetic north in the field. It's possible to either adjust for magnetic declination at the site or at the image analysis stage. Typically, TMDL staff align the red N arrow of the compass to exactly 0° (magnetic north) in the field and then adjust for magnetic declination during the photo analysis stage; Forests and Fish staff adjust for magnetic declination in the field by

aligning the red N arrow to the calculated declination value (true north). Either way, use your method consistently and note how declination was handled on the data sheet. Otherwise, this correction could be applied twice, introducing error in the solar load calculations.

6.3.2 To adjust for declination at the site, estimate the latitude and longitude of your photography points via a GIS program such as ArcMap or some other method. As declination does not vary greatly across the state (e.g. a few degrees), high precision is not needed. Three decimal places is adequate. Then pick one of the free declination calculators on the web (there are many) and punch in latitude and longitude of the target site. NOAA's National Geophysical Data Center provides a good online calculator at: www.ngdc.noaa.gov/geomag-web. If study sites are scattered widely, repeat this effort for other sites to find out how they vary.

6.3.3 Alternatively, a map of declination for the state can be made using the 1:100,000k or larger topographic grid and putting declination values into each cell. If the project is wide-ranging, such as for Forests and Fish, the result can be printed and given to the field crew

6.4 Photograph Procedure

6.4.1 At the field vehicle or other secure location, attach the camera to the fish-eye lens and the mounting device securely. Never attach the camera to the mounting plate while holding over the water. If using the EOS 6D water-resistant mounting box, turn camera on before securing inside the box.

Note: The threaded lens ring on the Coolpix camera is a soft metal and it is very easy to cross-thread and strip out the threads. Use caution to prevent this from happening; replacing the ring requires sending the camera to an authorized repair facility.

6.4.2 Attach the lens mounting device to the tripod mount.

6.4.3 Extend the tripod legs so that when the camera and tripod are placed at the hemispherical photo location at the center of the stream the camera and lens will not get wet.

6.4.4 Place the tripod at the desired location (see section 6.1). Large rivers may require a boat for over-water photos. Photographs may be taken from the boat using the tripod as a camera stand as previously mentioned. When taking canopy photos from a boat remain still because movement may disrupt the orientation and level of the camera platform.

6.4.5 Turn on the camera (if it's not already on) and adjust the zoom so it is at the camera's widest angle. The full circular image should be seen in the camera LCD, if not then keep zooming out.

6.4.6 Alternatively, users can select the hemispherical or fisheye lens setting programmed into the CoolPix 900 and similar camera. This fixes many settings for consistency between images. Using these settings, images are clear and of consistent pixel size.

6.4.7 Squeeze the tripod mount trigger and maneuver the lens mounting device so that both the bubble level bubble is in the center of the bulls-eye and the compass needle is aligned with north (if you will be adjusting for declination during analysis). If you are adjusting for declination on site, the compass needle should point toward the appropriate declination value (see 6.3). Aligning the photograph with the compass will ensure that the North and South fixed markers (red and white reflective tape) on the top surface of the lens mounting plate will show in the correct location on the photo.

6.4.8 Duck below the lens mounting plate so that you are not in the picture frame, and make sure that any other field personnel are also out of the picture.

6.4.9 Trigger the shutter release on the camera by either 1) pushing the shutter release button on the camera; 2) setting the delayed shutter release timer; 3) using the remote control or app (if using EOS 6D).

6.4.10 Confirm that the image was taken either by viewing the LCD or browsing the images in the EOS remote app.

6.4.11 Write down the following information on your field notes: the picture location, station id, date, time, field crew names, the picture number (this is not 1 or 2 of "x" number of pictures, but the actual filename like 0011.jpg, see camera instructions for help), and note which of the markers (red or white) points north on the lens mounting plate, and the latitude and longitude (NAD83) if the location is not associated with a monitoring station.

6.4.12 As an added precaution to maintaining photo order, Forest and Fish crews take an ID photo prior to the canopy photo. This is useful because photo order is maintained on the photo card. Thus, each canopy photo is paired with an ID photo. The crew is supplied with a small erasable board and an erasable marker, on which should be noted date, basin and stream id, photo location, and assigned photo ID. Forest and Fish uses a compound ID system based on basin name, survey year, and unique numeric photo ID.

7.0 Records Management

7.1 Field information to document hemispherical photos can be written on the vegetation survey maps (see riparian vegetation survey SOP EAP084; Swanson, 2013), in the comments section of another form being used at the time, or on blank, waterproof, field notebook sheets. Each picture must have all the documentation information provided in section 6.4.10. The north marker color can be written down once during the survey since this will not change unless a different lens mounting plate is used.

7.2 Field notes must be retained for use in the computer analysis.

8.0 Quality Control and Quality Assurance Section

8.1 View each picture in the camera LCD before moving on to the next location. Pictures should be retaken if the following apply:

8.1.1 The solar disk obscures too much of the image.
8.1.2 Field personnel, buildings, bridges, or other man-made structures are in the picture and obstruct a clear view of the riparian canopy.
8.1.3 Incorrect compass orientation.
8.1.4 Camera platform not level.

9.0 Safety

9.1 Proper fieldwork safety procedures outlined in the EA Program Safety Manual (EAP, 2017) for working in rivers and streams; and working near traffic and from bridges.

9.2 A proper safety assessment of the sampling reach of the stream is extremely important when deploying and retrieving periphyton artificial substrate samplers, given that the stream must be waded in order to perform these tasks.

9.2.1 Assess whether or not the velocity and depth of the stream are low enough to safely wade across it. As a rule-of-thumb: Do NOT wade in flowing water when the product of depth (in feet) and velocity (in feet per second) equals 10 or greater. For example, if the stream is estimated to be 3 feet deep and have a velocity of 4 ft/s, do NOT wade across the stream. This is only a general rule, take extra precautions where the substrate is unstable (slippery or moving), water visibility is impaired (high turbidity or glare), or other challenges are present.

9.2.2 Never wade across a stream where: a) potentially fatal entrapments/obstacles are located downstream (such as strainers, dams, large boulders, frowning (upstream V) rapids, etc.); or b) medium to large debris pieces are floating down the stream.

9.2.3 For a more complete list of river hazards see: www.ccadc.org/instruction/ACA_RKTLA_Class/TLHazard/RiverHazards.html.

9.3 ALWAYS a) wear a PFD while wading in the stream, b) wear a tight wading belt with waders, c) wear wading specific boots with good traction, d) work with a partner, and e) have the non-wading partner carry a throw-bag (and make sure they know how to use it).

9.4 All field activities must follow the EAP SOP#070: Standard Operating Procedures to Minimize the Spread of Invasive Species (Parsons et al., 2012).

10.0 References

10.1 Environmental Assessment Program (EAP), 2017. Environmental Assessment Program Safety Manual. Washington State Department of Ecology. Revised 03/17.

10.2 Frazer, G.W., Canham, C.D. and Lertzman, K.P., 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, user's manual and program documentation. Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York, 36.

10.3 Parsons, J., D. Hallock, K. Seiders, B. Ward, C. Coffin, E. Newell, C. Deligeannis, and K. Welch, 2012. Standard Operating Procedure to Minimize the Spread of Invasive Species. Version 2.1. EAP070. Environmental Assessment Program, WA Department of Ecology.

10.4 Rich, P.M., Wood, J., Vieglais, D.A., Burek, K. and Webb, N., 1999. HemiView user manual. Helios Environmental Modelling Institute, LLC.

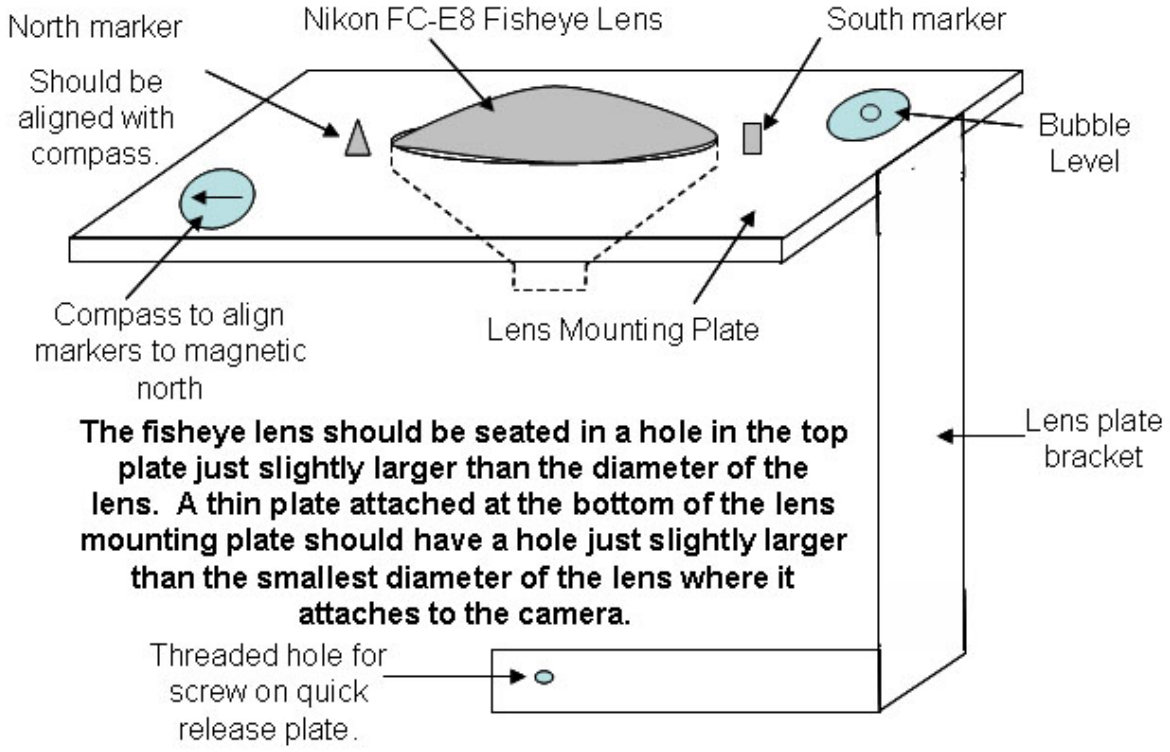
10.5 Stohr, A. and D. Bilhimer, 2008. Standard Operating Procedure for the computer analysis of hemispherical digital images collected as part of a temperature Total Maximum Daily Load (TMDL) or Forests and fish Unit technical study. EAP046. Environmental Assessment Program, WA Department of Ecology.

10.6 Swanson, T. 2013. Standard Operating Procedure for Conducting Riparian Vegetation and Stream Channel Surveys in Wadeable Streams for Temperature TMDL Studies. EAP084. Environmental Assessment Program, WA Department of Ecology.

Appendix A – Coolpix Lens Mounting System Design Specifications

Lens Mounting Plate for Hemispherical Photography Setup

Nikon makes a fisheye lens (model FC-E8) as an option for their Coolpix series of digital cameras. Ecology has been using a Coolpix 990 and 995 for hemispherical photography with a 128MB Compact Flash Card. The lens mounting plate attaches to the quick release plate of a Manfrotto joystick tripod head and Manfrotto Neotec Pro Photo tripod. The joystick head allows the plate to be leveled using a bubble level in virtually any tripod position.



The fisheye lens should be seated in a hole in the top plate just slightly larger than the diameter of the lens. A thin plate attached at the bottom of the lens mounting plate should have a hole just slightly larger than the smallest diameter of the lens where it attaches to the camera.