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This SOP is adopted with modifications from McDonald et al. (2018a) and SOP 1.2.14 Wadeable Stream Reach Selection and Location of Sampling Points—Version 1.0 (McDonald et al. 2018b).

Differences in methods

- NGPN will only sample one reach for each park unit, unlike the paired reaches in McDonald et al. (2018b). Sampling reaches will be paired with NGPN water quality monitoring sites.
- Added reach selection criterion of proximity to existing NGPN water quality monitoring sites.
- NGPN will not establish or survey reaches that are not entirely within park ownership boundaries.
- Rebar with metal tags will be used for permanent marks instead of concrete benchmarks. Installation instructions differ accordingly.
- Crews will take initial reach photos after installing markers following NGPN-specific procedures.

Introduction

This standard operating procedure (SOP) describes selecting and setting up stream monitoring reaches. First, we describe how to select stream segments for monitoring. This is mostly an office-based process, using GIS and consultation with park staff, followed by field site evaluation before making a final decision. This SOP also describes field identification, measuring, and installing markers at selected reaches.

Throughout the reach selection process, NGPN will work closely with park staff to ensure regulatory compliance, promote safety, and establish quality data collection. Park resource managers must review and approve proposed monitoring reaches before field suitability evaluation, final site selection, or field setup of a sample reach. The Aquatic Ecologist will work with resource managers to submit research permit applications and complete reviews in the NPS Planning, Environment, & Public Comment (PEPC) system.

Procedures

Reach Selection

Three levels of selection criteria are applied to all sample reaches: 1) relevant management concerns; 2) proximity to existing stream gauges and NGPN water quality monitoring sites; and 3) field suitability evaluations.

Potential reaches must be evaluated for suitability in the field because available geospatial data is often too imprecise or low resolution to determine the suitability of any given reach. A probabilistic

approach to reach selection was not used due to the limited number of potential reaches within each park as well as due to network resources.

Reaches are selected in four stages:

- identification of potential stream segments in GIS
- consultation with park staff
- field suitability evaluation
- final decision, with park staff input

Each stage is further discussed below. See SOP 1.2.14 Wadeable Stream Reach Selection and Location of Sampling Points—Version 1.0 (McDonald et al. 2018b) for more detail.

Identification of potential stream segments in GIS

Network staff will select potential stream segments from the NHD that are:

- perennial (as classified by the NHD)
- at least 400 feet (122 m) in length
- entirely within park ownership boundaries
- geographically relevant and hydrologically coupled to NGPN water quality monitoring sites

The resulting GIS data is used to discuss potential survey locations with park staff and to locate these locations in the field.

Consultation with park staff

Once all potential stream segments are identified in GIS, consult a resource manager at each park to identify areas with current or potential management concerns, identify access issues, and determine the long-term applicability of each stream segment.

One important consideration for long-term monitoring is the need to have access to the stream segment in perpetuity. NGPN will not establish or monitor sites that are not entirely within park ownership boundaries. After an updated and annotated list of potential stream segments is assembled, all accessible potential stream segments need to be evaluated in the field.

Field suitability evaluation

Field surveys need to be conducted on each accessible stream segment to locate a stream reach within the candidate segment that is suitable for data collection. Field crew safety takes precedence over all other considerations when evaluating stream segments. The goal is to identify a representative reach within the stream segment while striking a balance with crew fatigue and resources.

Reject stream segments that are:

- potentially unsafe (e.g. due to extreme entrenchment or potentially toxic waste material)
- not wadeable (e.g. too deep or swift to cross much of the stream)
- not a free-flowing and perennial single channel (e.g. no segments obstructed by beaver impoundments or that only flow part of the year)
- only accessible by traversing large wetlands
- obstructed by impenetrable vegetation or manmade obstacles that prevent sampling of a reach of sufficient length (typically, 20 times the mean wetted width)

While conducting the field suitability evaluation, the objective is to provide a general understanding of the stream segment and identify a potential representative reach within the segment that can be monitored. While conducting the evaluation, make notes about the following characteristics:

- Is the stream wadeable?
- Channel width
- Bank heights
- Bank angles
- Amount and degree of bank undercutting
- Riparian coverage
- Dominant bed sediment
- Amount and types of geomorphic channel units
- Amount and degree of floodplain development
- Anthropogenic disturbance (i.e., trails (official and social) and refuse)

Finish the evaluation of each segment by taking a photograph of the potential survey reach within the stream segment and record the latitude and longitude of the spot where the picture was taken.

Final decision

Final stream segment selection is done by NGPN personnel who can provide the best professional judgment required to adequately assess reach utility, safety, and suitability issues. All final index locations will be geographically collocated with NGPN water quality monitoring sites to monitor multiple vital signs. Chosen stream segments should strike a balance between relevance to management goals, complimenting current and future vital signs monitoring, and accurately representing conditions within the park. All 'final' stream segment selections need to be confirmed

by park staff and reviewed for compliance with all applicable statutes prior to installing permanent markers and conducting the initial reach survey.

Initial Reach Setup

Once the reaches have been confirmed by park staff, load all location data (latitude and longitude) onto a GPS device so that the previously identified suitable stream reaches can be relocated. Initial reach setup includes finding the site, measuring stream width, laying out transects, and installing the permanent index site markers. All subsequent surveys will relocate the reach and transects using GPS and index site markers. Conduct the initial reach setup (and all subsequent surveys) when the stream is running at or near baseflow.

- Prior to going into the field, use the maps created during the field suitability evaluation to determine the safest and most efficient route to each reach. Use slope, land cover, and distance to road/trail networks in this determination.
- Use a GPS receiver or paper map to navigate to the location of the photograph taken during the field assessment (or within about 10 meters of it). This will be the field assessment photograph point.
- On relocating the previously identified suitable reach, conduct a preliminary assessment of stream conditions and record them on the Reach Map Datasheet (see Data Sheets SOP). The purpose of this preliminary assessment is to pick the most representative portion of the stream segment.
- To determine assessment and reach lengths, take six representative wetted width measurements (measured to the nearest cm). To ensure the resultant average wetted width is representative of the segment, be sure to take these measurements on a variety of geomorphic channel units (e.g., on two pools, two runs, and two riffles).
- After determining the mean wetted width (round to nearest 0.5 meter), scout upstream and downstream from the field assessment photograph point 15 times the mean wetted width in each direction (for a total distance of 30 times the mean wetted width). Look for any natural or man-made impediments or hazards that would make the reach unsuitable for sampling. Exact distance is not critical in this process, so crews can use a laser rangefinder for rapid distance measurements and mapping while scouting.
- While scouting, draw an initial reach assessment map noting:
 - Riparian vegetation
 - Bank condition
 - Evidence of disturbance
 - Anything that would endanger the safety of the crew or make the reach unsuitable for sampling

- If a reach is unsuitable for any reason, note the conditions that make it unsuitable and continue to the designated alternate reach (see previous section ‘Final Decision’).
- If a reach is suitable, finish the reach assessment map by recording a general description of the reach, then begin marking the reach.

Choosing the Middle of the Reach

Using the Reach Map as a guide, choose the location of the middle of the reach. Ensure that the stream can be surveyed for the required distance (10 times the mean wetted width) upstream and downstream (total of 20 times the mean wetted width).

When choosing the middle of the reach, be sure to choose a location that is representative of the assessment area. Areas that are relatively free of vegetation, while easier to survey, may not be representative of the stream segment.

Although the goal is to select a representative reach on a stream segment rather than select a reach for ease of access, it is also important to consider crew fatigue and strike a balance between the two.

Reach Length and Standard Transect Locations

After identifying the middle of the reach (transect 6), determine the locations of the other standard transects:

- Total reach length is calculated by multiplying average wetted channel width by 20 (see Equipment and Supply Lists SOP), and the distance between standard transects is determined by dividing total reach length by 10 (distance between transects will equal two times average wetted width).
- Using a reel tape or other measuring device, mark five transects downstream from the center and five transects upstream from the center transect (11 total). Distances should be the curvilinear distance between the banks measured from the center of the stream channel.
- Mark the location of each transect with a highly visible temporary flag or chaining pin marked with flagging. Number the transects so that transect 1 is the furthest downstream transect, and transect 11 is the furthest upstream transect (Figure 1). The reach midpoint will always be transect 6.
- After flagging all 11 transects, install the permanent index site markers.

Installing Permanent Index Site Markers

On the left side of the stream (determined while facing downstream), select locations at the first, sixth, and eleventh transects to install permanent index site markers. Identify locations on right side of the stream, along the same transects and perpendicular to flow to install secondary markers (**Error! Reference source not found.**). If impenetrable vegetation, unsafe bank conditions, or

bedrock prevent total station surveying of the first, sixth, or eleventh transect, move the permanent index markers/detailed transects to the closest suitable transect.

Install index markers at least 10 to 15 meters outside areas of active geomorphic activity (e.g., at least 10 meters from the top of cutbanks or point bar crests). Choose locations where they will not affect visitor experience and are unlikely to be vandalized. Additionally, all markers need to have a line-of-sight to at least one other marker so that they can be tied together when conducting the total station surveys. If the geography of the reach or impenetrable vegetation prevents a line-of-sight connection of the marker network, install an additional ‘tie-in’ marker(s) so that all markers can be tied together.

When installing the index site markers:

- Wear eye and hand protection.
- Be sure that the primary and secondary index site markers form a line perpendicular to the active stream channel.
- Drive a 0.5-meter (~ 20”) long piece of ½” diameter rebar into the ground as the marker. Fit a rebar driver over the end of the rebar, hold the rebar vertically with a pair of locking pliers, and use a urethane-faced dead blow hammer or mallet to drive the rebar into the ground. Leave 1 to 3 cm of rebar above the ground – do not drive it flush with or below the surface of the ground.
- Mark a brass tag or rebar cap with the Program ID, monitoring code SCM (i.e., Stream Channel Monitoring), index site name, park code, site number and date established (Figure 2). Attach the tag or cap to the rebar.
- Collect GPS coordinates (using NAD 83 datum, decimal degrees) for both markers installed along the transect
- Take a compass bearing for each transect and measure the distance from the primary index marker to the secondary index marker to help relocate the secondary index marker during subsequent surveys.
- A metal detector will be needed on subsequent surveys to relocate the index site markers.

Once all index site markers are installed and all the compass bearings are recorded, reach setup is complete and the reach is ready to be photographed and surveyed.

Initial Reach Navigation Photos

To aid in relocating the index site markers and transects, take the following photos, in this order, at each permanently marked transect (all from eye height while standing):

Site and marker location photos (four per index transect)

- the primary index marker and immediate surrounding area, including a whiteboard or paper sign with site ID, date, and transect number,
- from three meters away from the primary index marker, looking past it toward the secondary index marker¹,
- the secondary index marker and immediate surrounding area,
- from three meters away from the secondary index marker, looking past it toward the primary index marker,

In-channel photos (six per index transect)

- from the transect midpoint in the stream, facing:
 - downstream
 - upstream
 - left bank
 - right bank
- from the left bank facing the right bank,
- from the right bank facing the left bank.

Use the Photographic Record Datasheet (see Data Sheets SOP) to record the photo number from the camera, the location, and content of each photo.

Take additional photos that document relevant habitat features at the reach. Capture any distinctive, permanent features that will persist through time. These photos should characterize the overall character of the reach. Record them on the Photographic Record Datasheet and include a brief description along with the location.

¹ Make sure both the index marker and opposite index marker's locations are easily seen in the photo, to aid with relocation. Use flagging, pin flags, or equipment in the photo to show the location, and note this on the photo record data sheet.

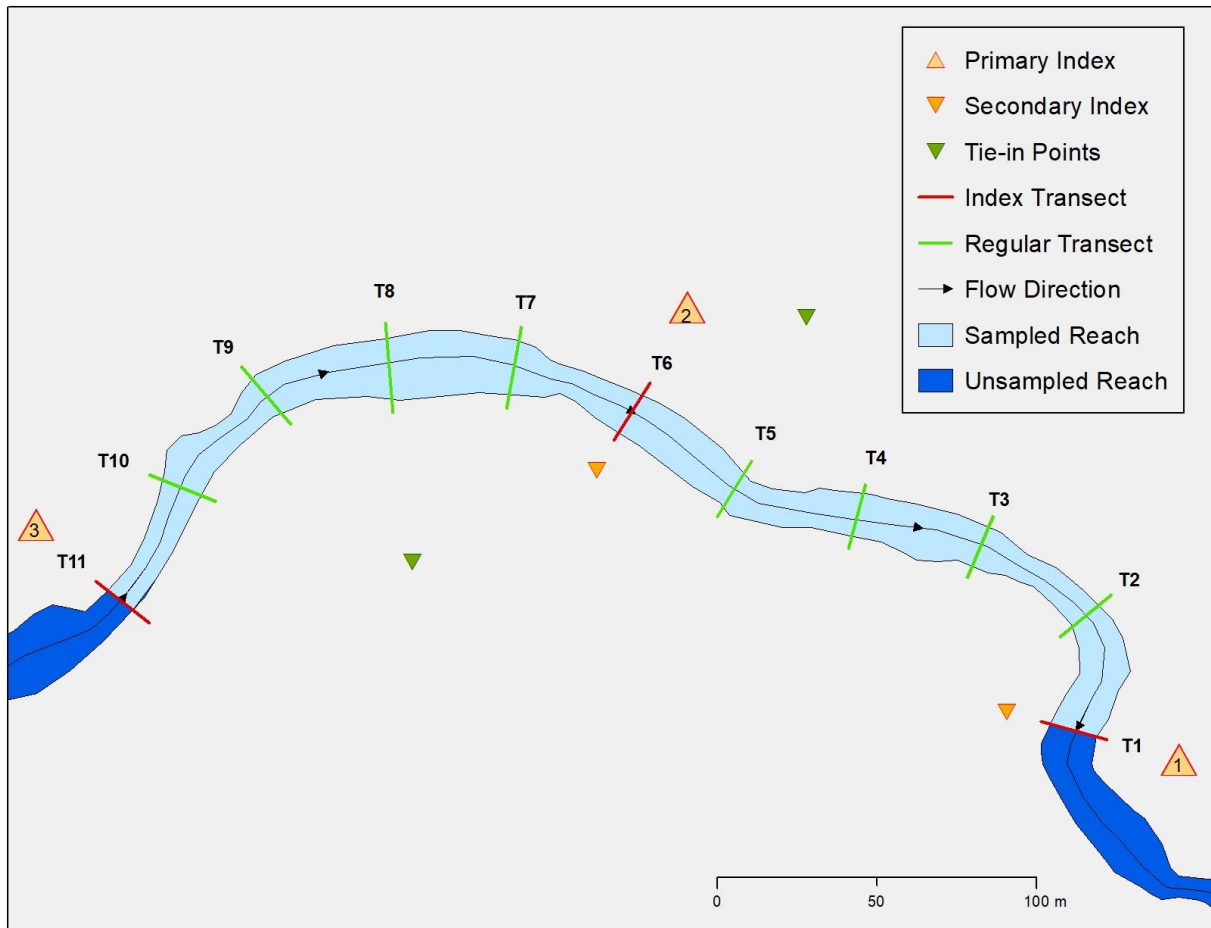


Figure 1. Example layout of stream reach with index locations, and transects. The distance between each transect is equal to two times mean wetted width. Total reach length is equal to twenty times mean wetted width, established on initial site visit.

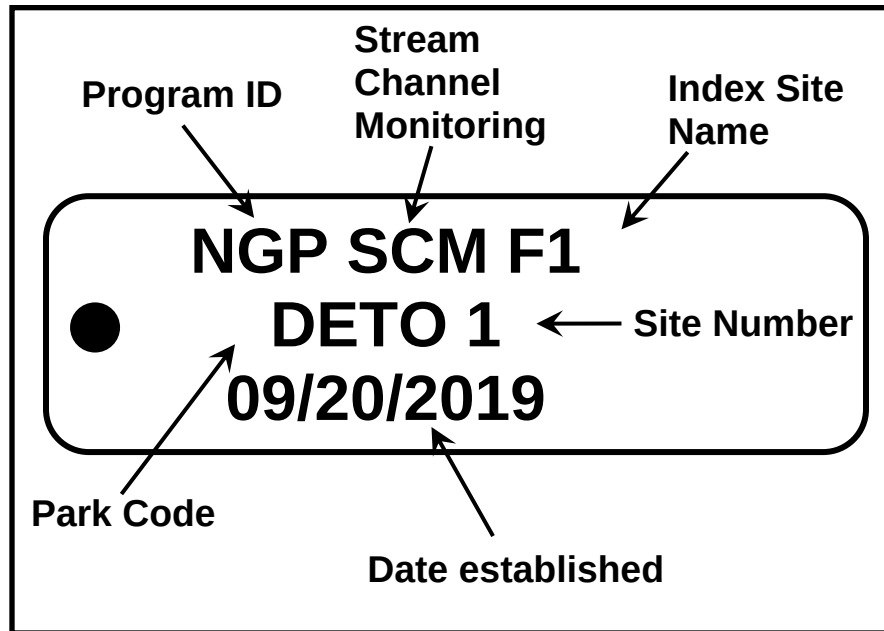


Figure 2. Example tag for index site markers.

Literature Cited

- McDonald, J. M., M. B. Gregory, J. W. Riley, and E. N. Starkey. 2018a. Monitoring wadeable stream habitat conditions in Southeast Coast Network parks: Protocol narrative. Natural Resource Report NPS/SECN/NRR—2018/1715. National Park Service, Fort Collins, Colorado
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