Flow Duration Protocol

Adapted from NM and PNW Assessment Methods

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The purpose of the protocol is to combine two existing field methods into one field protocol to increase efficiency in the field. This protocol will be used to assess field indicators of streamflow duration in the arid southwest and western mountains. Section 1 includes introductory material and background information to prepare for field data collection and to consider upon arrival at a site (e.g., selecting an assessment reach). Section 2 includes instructions on how to assess indicators and fill out the datasheets in Attachment 2.

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Section 1 – Background and field assessment preparations

A. Introduction

Streams may exhibit a diverse range of hydrologic regimes, which contribute to their ability to provide different ecosystem services. One of the most important aspects of hydrologic regime is streamflow duration—the length of time that a stream can support sustained flow. Unfortunately, requisite hydrologic data to determine flow duration is unavailable at the majority of sites where management decisions occur. Therefore, there is a need for rapid, field-based methods to determine flow duration in the absence of long-term hydrologic data.

For the purposes of this protocol streamflow duration was defined as:

- *Ephemeral streams* flow only in direct response to precipitation. Water typically flows only during and shortly after large precipitation events. Ephemeral streams may or may not have a well-defined channel, the streambed is always above the water table, and stormwater runoff is the primary source of water. An ephemeral stream typically lacks the biological, hydrological, and in some instances physical characteristics commonly associated with the continuous or intermittent conveyance of water.
- *Intermittent streams* are channels that contain water for only part of the year, typically during the wet season, where the streambed may be below the water table and/or where the snowmelt from surrounding uplands provides sustained flow. The channel may or may not be well-defined. The flow may vary greatly with stormwater runoff. An intermittent stream may lack the biological and hydrological characteristics commonly associated with the continuous conveyance of water.
- *Perennial streams* contain water continuously during a year of normal rainfall, often with the streambed located below the water table for most of the year. Groundwater supplies the baseflow for perennial streams, but flow is also supplemented by stormwater runoff or snowmelt. A perennial stream typically exhibits the biological, hydrological, and physical characteristics commonly associated with the continued conveyance of water.

B. Considerations when assessing indicators of streamflow

i. Spatial variability

Spatial variation in stream indicators occurs within and among stream systems. Sources of variation between stream systems are due primarily to physiographic province (geology and soils) and climate (seasonal patterns of precipitation, snowmelt, and evapotranspiration). For example, riffles and pools result from in-channel structures and these structures can vary between rocks and boulders in the mountains and roots and wood debris in the alluvial valleys.

A substantial amount of spatial variability can also occur along the length of a given stream system. Common sources of variation within a stream system include:

- Longitudinal changes in stream indicators related to increasing duration and volume of flow. As streams gain or lose streamflow, the presence of indicators changes.
- Longitudinal changes due to variables such as channel gradient and valley width, which affect physical processes and thus may directly or indirectly affect indicators.
- The size of the stream; streams develop different channel dimensions due to differences in flow magnitude, landscape position, land use history, and other factors.
- Natural sources of variation should also be noted such as fractured bedrock, volcanic parent material, recent or large relic colluvial activity (landslides or debris flows), and drought or unusually high precipitation
- Transitions in land use, for instance from commercial forest to pasture/grazing, from pasture grazing to cultivated farm, or cultivated farm to an urban setting.
- Stream management and manipulation, such as diversions, water importation, dam operations, and habitat modification (e.g., streambed armoring).

ii. Temporal variability

The rate and duration of flow in stream channels is influenced by climate and by recent weather. Recent rainfall can influence the presence of indicators. Evaluators should note recent rainfall events on the assessment form, and consider the timing of field evaluations in assessing the applicability of individual indicators. Flow observations preferably should be taken at least 48 hours after the last substantial rainfall, if possible. Local weather data and drought information should be reviewed before evaluating flow conditions. Perennial systems will have water in their channels year-round in the absence of drought conditions. Therefore, it is recommended that field evaluations be conducted outside of drought conditions whenever possible.

This method is intended to be robust to seasonal variability, as well as short-term climatic variability. However, long-term sources of variability, such as drought or patterns related to El Niño events, may complicate measurement of indicators in certain years. Changes in management practices, such as dam operations, groundwater pumping, or landscape alteration, may also complicate measurement. Although some indicators may reflect these changes immediately, others may take years to adapt to reflect changes in flow regimes.

iii. Ditches and modified natural streams

When assessing a reach that is a ditch or modified natural stream, it is important to walk the entire reach and locate the inflow point or origin as well as the downstream terminus of flow (most often a confluence with another channel). Similarly, any disturbance or modifications to the stream channel should be noted on the assessment form, especially if it affects applicability of assessment indicators. ***For all assessments, disturbances or modifications to the stream or its catchment that may affect the presence of the streamflow duration indicators should be noted.***

iv. Disturbed or altered streams

Assessors should be alert for natural or human-induced disturbances that affect streamflow duration and/or the presence of indicators. Streamflow duration can be directly affected by flow diversions, urbanization and stormwater management, septic inflows, agricultural and irrigation practices, vegetation management, or other activities. The presence of indicators can be affected by changes in streamflow, and can also be affected by disturbances that may not substantially affect streamflow (for instance, grading, grazing, recent fire, beaver activity, riparian management, culvert installation, and bank stabilization). Such disturbances should be described in the "Notes on disturbances or difficult site conditions" section of the field assessment form.

Urbanized and impaired streams experiencing multiple stressors may be poor in biologic species, raising concerns about the effective application of this method in those situations given the importance of macroinvertebrate indicators in drawing conclusions. For example, certain streams in the Arid Southwest are dominated by effluent, which in some cases be unable to support even tolerant mayfly families, such as Baetidae.

C. Field preparation

i. Field Equipment

Field crew chiefs should ensure that all gear is available and functional for each site-visit, and for cleaning gear off-site between visits.

- This document, and copies of paper field sheets
- Clipboard/pencils/sharpies
- A copy of protocols describing the PNW and NM streamflow duration methods
- Site maps and aerial photographs (1:250 scale if possible)
  Global Positioning System (GPS) – used to identify the boundaries of the reach assessed.
- Clinometer – used to measure channel slope.
- Tape measure – for measuring reach width and length.
- Kicknet or small net and tray – used to sample aquatic invertebrates.
- Mechanical tally counter (optional)
- Hand lens – to assist with macroinvertebrate and plant identification.
- iPhone camera (or similar) camera, plus charger. iPhone cameras automatically record metadata, such as time, date, and location, as part of the EXIF data associated with the photo.

- Polarized sun glasses – for eliminating surface glare when looking for fish, amphibians, and macroinvertebrates.
- Shovel, soil augur, rock hammer, pick or other digging tool – to facilitate hydrological observations of hyporheic flow, soil moisture, and hydric soils.
- Macroinvertebrate field guides (e.g., Macroinvertebrate Indicators of Streamflow Duration for the Pacific Northwest: Companion Field Guide4, Blackburn and Mazzacano, 2012; A Guide to Common Freshwater Invertebrates of North America, Bosell and Wright 2002)
- Hydrophytic plant identification guides (e.g., Trees and Shrubs of California, Stuart and Sawyer 2001; Western Wetland Flora: An Introduction to the Wetland and Aquatic Plants of the Western United States. Chadde, 2019)
- The Army Corps List of wetland indicator plants for the Arid West (http://wetland-plants.usace.army.mil/nwpl_static/data/DOC/lists_2016/Regions/pdf/reg_AW_2016v1.pdf) and Western Mountains (http://wetland-plants.usace.army.mil/nwpl_static/data/DOC/lists_2016/Regions/pdf/reg_WMVC_2016v1.pdf), whichever list is appropriate for the site to be visited
- Herpetological field guides (e.g., A Field Guide to Western Reptiles *and Amphibians*, Stebbins, 2003).
- Vials (falcon tubes filled with 70% ethanol) and sealable plastic bags for collection of voucher material, with sample labels
- Site maps and aerial photographs (1:250 scale if possible)
- Survey rod
- Paper towels for soil moisture testing
- Convex spherical densiometer, taped to restrict assessment to the forward-facing 17 assessment points (Figure 3).
- Compass (if not available as part of GPS unit)
- Munsell soil color chart
- Sand-gauge card
- Permits, if necessary
- Field notebook
- First-aid kit

If visiting an instrumented site also bring

- HOBO Pendant Data Field Sheet (See Attachment 3)
- HOBO waterproof shuttle with pendant coupler and USB cable
- HOBOware Pro software installed on a personal computer

ii. Reach selection

Flow characteristics often vary along the length of a stream, resulting in gradual transitions in flow duration. Recognizing that in many streams flow duration exists on a continuum, choosing the reach on which to conduct an assessment can influence the resulting conclusion about flow duration.

Assessments should be made for a representative reach, rather than at one point of a stream. A representative reach for stream assessments is equivalent to ***35 – 40 channel widths*** of the stream

(Peck et al. 2006). Reach length is measured along the thalweg. For narrow streams, the length of the assessment reach should be a minimum of 30 meters. If the assessment reach is near a culvert or road crossing, the assessment reach should begin a minimum of 10 meters from the culvert or road crossing feature.

Assessments should begin by first walking the length of the channel, to the extent feasible, from the stream origin to the downstream confluence with a larger stream. This initial review of the site allows the evaluator to examine the overall form of the channel, landscape, and parent material, and variation within these attributes as the channel develops or disappears upstream and downstream. We recommend walking alongside, rather than in, the channel for the initial review to avoid unnecessary disturbance to the stream and maximize the opportunity to observe single indicator organisms (e.g., fish and herpetological species). Walking the channel also allows the assessor to observe characteristics of the watershed such as land use and sources of flow (e.g., stormwater pipes, springs, seeps, and upstream tributaries). Once these observations are made, the assessor can identify the areas along the stream channel where these various sources (stormflow, tributaries or groundwater) or sinks (alluvial fans, abrupt change in bed slope, etc.) of water may cause abrupt changes in flow duration. Similarly, the assessor can identify if the stream segment in question is generally uniform or might best be assessed as two distinct reaches.

iii. A note about indicators adapted from the NM protocol

Most of the NM indicators are scored on a scale ranging from 0 (indicator condition typical of ephemeral or intermittent streams) to a maximum value (indicator condition typical of perennial streams); intermediate scores (up to half a point) are acceptable. Scores are determined by comparing field conditions to guidance provided in this document. Although this process is somewhat subjective, a few steps can improve repeatability among observers:

- Make determinations after evaluating the entire reach, after measuring other indicators
- Intercalibrate assessments among field crews at least once per sampling season
- Where possible, have multiple observers derive scores independently. Reconcile differences before deriving a final score.
- Document any questionable or uncertain scores through field notes and photos.

iv. Photo-documentation

It is important to explain the rationale behind any conclusions reached using this protocol and sometimes photos are just the medium to do that. It is essential to take several photos of the reach condition and any disturbances or modifications that are relevant to making a final hydrology determination. Photos that document the evaluation attributes (e.g. riparian vegetation, macroinvertebrates, presence of hydric soils, etc.) are encouraged and provide excellent supporting documentation for any conclusions reached. All photos will be noted on the field data sheet with location within the reach, direction, and indicator(s) shown.

All digital photos will be downloaded to a laptop at the earliest possible time, generally the same day as sampling.

Section 2 – Conducting the assessment

Data will be collected following the protocols in Nadeau et al. (2015) and NMED (2011), as described below. Where necessary, the assessment steps have been consolidated and modified to make them consistent across protocols. For example, Nadeau et al. (2015) requires a minimum of 15 minutes be spent searching for aquatic insects, whereas NMED (2011) requires only 10; therefore, 15 minutes will be spent to accommodate the requirements of both protocols.

For sites being visited again (resample sites, watershed study sites, and western mountain baseline sites), the same reach should be assessed based on the downstream GPS point used during the first assessment. For watershed study sites and western mountain baseline sites Section B.iv. below and attachment 3 are needed to guide data logger deployment, retrieval, data download and redeployment.

A. General site documentation

At each site, be sure to record the site code/name, assessors, and date of assessment on each page of the data sheet. At each sampling event where two assessors are used, one person shall be designated the recorder, and the other shall review each data sheet for three elements:

- Completeness: Are all required fields are filled out?
- Legibility: Can all text and numbers be read?
- Soundness Do all entered text and numbers represent reasonable values?

Any deficiencies in these three areas will be corrected on-site. Upon completing this review, the “QA” assessor will initial each data sheet.

i. Weather conditions

Note current weather conditions. If technicians have been in the reach catchment within the last 48 hours, and know of a rain event, note precipitation next to current weather conditions, and consider delaying sampling. Technicians are advised to evaluate precipitation data from nearby weather stations after each sampling event to determine if storms may have affected data collection.

ii. Coordinates

Record the latitude and longitude in the center of the reach on the downstream-end of the reach. Record in units of decimal-degrees, and note the datum used.

iii. Disturbed or difficult conditions

Note any disturbances or unusual conditions that may create challenges for assessing flow duration. Common situations include practices that alter hydrologic regimes, such as diversions, culverts, discharges of effluent or runoff, and drought. Note circumstances that may limit the growth of hydrophytes, such as channelization, or vegetation removal that may affect the measurement or interpretation of several indicators (Figure 1). Also note if the stream appears recently restored, for example stream armoring with large substrate or wood additions and recently planted vegetation in the riparian zone.

Figure 1. Examples of difficult conditions where management may interfere with the observation of indicators, such as hydrophytic plants.

iv. Surrounding land use

Note the predominant land-use surrounding the site within 100 m radius. Check no more than 2 categories.

Indicate if the surrounding land use is a potential source of large woody material, (i.e., trees and shrubs > 10 cm diameter) that could create woody jams.

i. Woody jams

The presence of woody jams may be enough to change flow duration by reducing water velocity and increasing connectivity with the hyporheic zone. To count as a woody jam, wood in the reach must possess all the following 3 characteristics (Figure 2):

- It contains at least 3 large pieces of wood (large wood is >1 m long, 10 cm diameter)
- It spans the entire width of the channel and is in contact with the streambed
- During flow conditions, it would disrupt the movement of water or sediment.

On the data sheet, indicate the number of woody jams observed in the reach (up to 10 m above or below the reach).

Figure 2. Examples of woody jams in ephemeral streams.

ii. Hydric soils (adapted from NM protocol)

The presence of hydric soil indicators above the elevation of the channel bottom in floodplain soils adjacent to the channel indicates the presence of a seasonal high-water table. Non-ephemeral stream banks typically are dominated by soils with hydric indicators, such as visually confirmed oxidized rhizospheres or a matrix of gray or black. There are also special considerations regarding the determination of hydric soils in arid regions. Additional information on field indicators of hydric soils is available from the Natural Resources Conservation Service at https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/use/hydric/.

The presence of hydric soils in this protocol should be determined through visual observations, pungent odors, clay, etc. Note that hydric soil indicators may be poorly developed at the seasonal high-water table elevation in young, coarse textured, alluvial soil materials with low concentrations of clay, iron, and manganese, or floodplain soils where moving water fails to become reduced.

Evaluate hydric soils by digging a 15-cm deep trench into the base of the bank, and then examining the soil for indicators. If conditions are ambiguous, examine up to 2 additional locations in the reach.

Streams lacking soils (e.g., concrete channels devoid of sediment deposits) shall be recorded as “not detected”. That is, if there is no soil to measure, it is not possible to develop hydric soils and lack of soil should be noted in the “disturbance or difficult site conditions” section on page 1 of the datasheet.

Circle “present” or “not detected” depending on if hydric soils are found within the study reach.

v. Reach width, length, and slope

Record the channel-width at reach meter mark 0, 15 and 30 m and calculate average.

Record the reach length which should be ~40 times average channel width, but no less than 30 m and no more than 200 m.

Slope is measured as the percent slope between the upper and lower extent of the assessment reach. This task requires a two-person team. One individual stands on the edge of bankfull at one end of the reach and sites the person standing at the opposite end of the reach, on the edge of bankfull. Use a clinometer, sighting a location at eye-level. For example, if team members are of the same height, one individual standing at bankfull at the lower end of the reach would 'site' the eyes of the crew member standing at bankfull at the opposite end of the reach.

This measurement requires direct line-of-site between the lower and upper ends of the reach. If direct line-of-site from the bottom to top of the reach is not possible, the slope of the longest representative portion of the reach should be 'line-of-site' evaluated.

vi. Stream shading (densiometer readings)

Using a convex spherical densiometer, stream shading is estimated in terms of percent cover of objects (vegetation, buildings, etc.) that block sunlight. The method described uses the Strickler (1959) modification of a densiometer to correct for over-estimation of stream shading that occurs with unmodified readings. Taping off (Figure 3) the lower left and right portions of the mirror emphasizes overhead structures over foreground structures (the main source of bias in stream shading measurements).

The densiometer is read by counting the number of line intersections on the mirror that are obscured by overhanging vegetation or other features that prevent sunlight from reaching the stream. If measurements are being taken when leaves of deciduous woody vegetation are not fully expressed, count all grid intersections that lie within the branches of the woody vegetation. So rather than looking at individual tree leaves look at the "zone of influence" of vegetative cover (Nadeau et al. 2018, SFAM Oregon).

All densiometer readings should be taken at 0.3 m above the water surface (or dry streambed surface), and with the bubble on the densiometer leveled. The densiometer should be held just far enough from the squatting observer's body so that his/her forehead is just barely obscured by the intersection of the two pieces of tape, when the densiometer is oriented so that the "V" of the tape is closest to the observer's face.

Take and record four, 17-point readings from the center of each transect: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank. The observer should revolve around the densiometer (i.e., the densitometer pivots around a point) over the center point of the transect (as opposed to the densiometer revolving around the observer).

Read and record densiometer readings at the top, middle, and bottom of the reach.

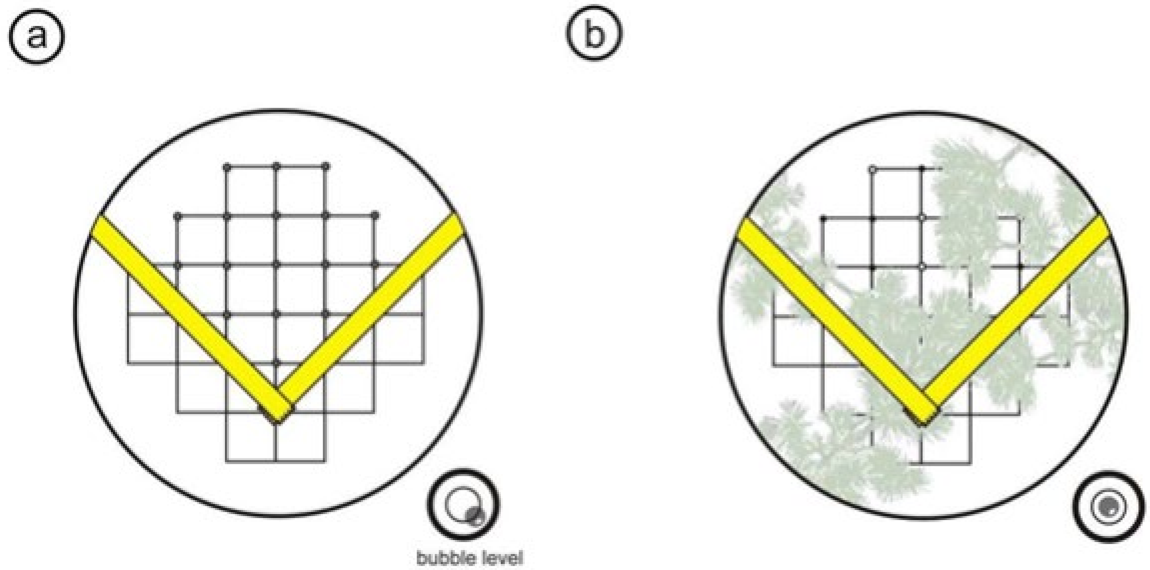

Figure 3. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition (b) is 9 out of 17 possible covered intersection points within the "V" formed by the two pieces of tape.

B. Ancillary information and site sketch

i. Riparian Corridor (adapted from PNW protocol)

Intermittent and perennial streams often support riparian areas that contrast markedly with adjacent upland plant communities. A distinct change in vegetation between the surrounding lands and the riparian area (top of bank and adjacent areas) may indicate the presence of seasonal moisture.

Record the presence or absence of a riparian corridor.

ii. Erosion and Deposition (adapted from PNW protocol)

Does the channel show evidence of fluvial erosion in the form of undercut banks, scour marks, channel downcutting, or other features of channel incision? Are there depositional features such as bars or recent deposits of materials in the stream channel?

Undercut banks and scour marks are the most common signs of fluvial erosion for streams in a floodplain system. In steeper landscapes, channel downcutting and incision may occur. Alluvium may be deposited as sand, silt, gravel and cobble. Sometimes there may be depositional features along the side of the channel or on the lee side of obstructions in the channel (e.g., in the hydraulic shadow of logs, boulders, etc.). Erosion and deposition processes differ between bedrock and alluvial channels; note if the streambed consists primarily of bedrock and indicate in site sketch.

Record the presence or absence of erosional or depositional features.

iii. Floodplain connectivity (adapted from PNW protocol)

A floodplain is a level area near a stream channel, constructed by the stream and overflowed during moderate flow events if there is still connectivity. An active floodplain (at current bankfull elevation, such that it is inundated on an approximate 2-year recurrence interval) shows characteristics such as drift lines, sediment and debris deposits on the surface or surrounding plants or flattening of vegetation. The floodplain of incised streams may be restricted to within the channel itself and the previous floodplain (now a terrace) may be inundated rarely or infrequently, if at all.

Record the presence or absence of a floodplain.

iv. Data Logger Deployment and Retrieval

Two study components, the ASW case studies (study component 2) and WM baseline data development (study component 3), entail multiple visits over a long period and the deployment of data loggers. At each site in these study components, a "STIC"-type data logger will be deployed for long-term recording of surface-water presence or absence following the protocol in Fritz (2017). STIC (Stream Temperature, Intermittency, and Conductivity) loggers are modified HOBO temperature and light pendant loggers (HOBO UA-002-64, Onset Corporation, https://www.onsetcomp.com/products/data-loggers/ua-002-64) in which light sensors have been modified to measure conductivity. Because water is more conductive than air, abrupt changes in conductance may be inferred as drying or wetting events.

Loggers will be calibrated prior to deployment as per Fritz (2017) (Attachment 3) by the SCCWRP or CSUMB Technical Lead. Loggers will be encased in PVC housing, launched to record at least one measurement per hour, and deployed along the thalweg (i.e., the deepest flow-path) that has water depth typical of the reach. Each logger will be attached to the streambed with rebar or a stake. Distance from right and left banks will be recorded, the latitude and longitude of logger (record in units of decimal-degrees, and note the datum used), as well as stream temperature and specific conductivity at time of deployment – See Attachment 3 ("Calibrating, deploying, and retriving Stream Temperature, Intermittency, and Conductivity [STIC] data loggers, and downloading and converting data"). Site pictures will include the deployed logger and view up and downstream from the logger site to facilitate retrieval of loggers and data. Data retrieval will occur at every site visit. Data from loggers will be stored in the same formats as other hydrologic data gathered during site selection (Task 2).

C. Hydrologic indicators

Visually estimate the percentage of the reach length that has flowing surface water, if 100% of the reach has surface water, record it, and DO NOT evaluate % of reach with surface/subsurface flow or number of isolated pools.

Estimate the percentage of the reach length that has flowing surface water or subsurface (hyporheic) flow (see Figures 4A-C below).

If there is uncertainty about how to best characterize percent flow or number of pools within a reach, specific observations should be described on the assessment form, using diagrams in support of observations in the site sketch on page 1 of the datasheet.

Enumerate and record the number of isolated pools with surface water within the reach.

iii. Hyporheic flow

Hyporheic flow is not always easily observed. However, there are some observable signs of the presence of hyporheic flow, including:

- Flowing surface water disappearing into alluvium deposits and reappearing downstream. This is common when there is a large, recent alluvium deposit created by a downed log or other grade-control structure.
- Water flowing out of the streambed (alluvium) and into isolated pools.
- Flowing water below the surface of the streambed, observed by moving streambed rocks or digging a small hole in the streambed.

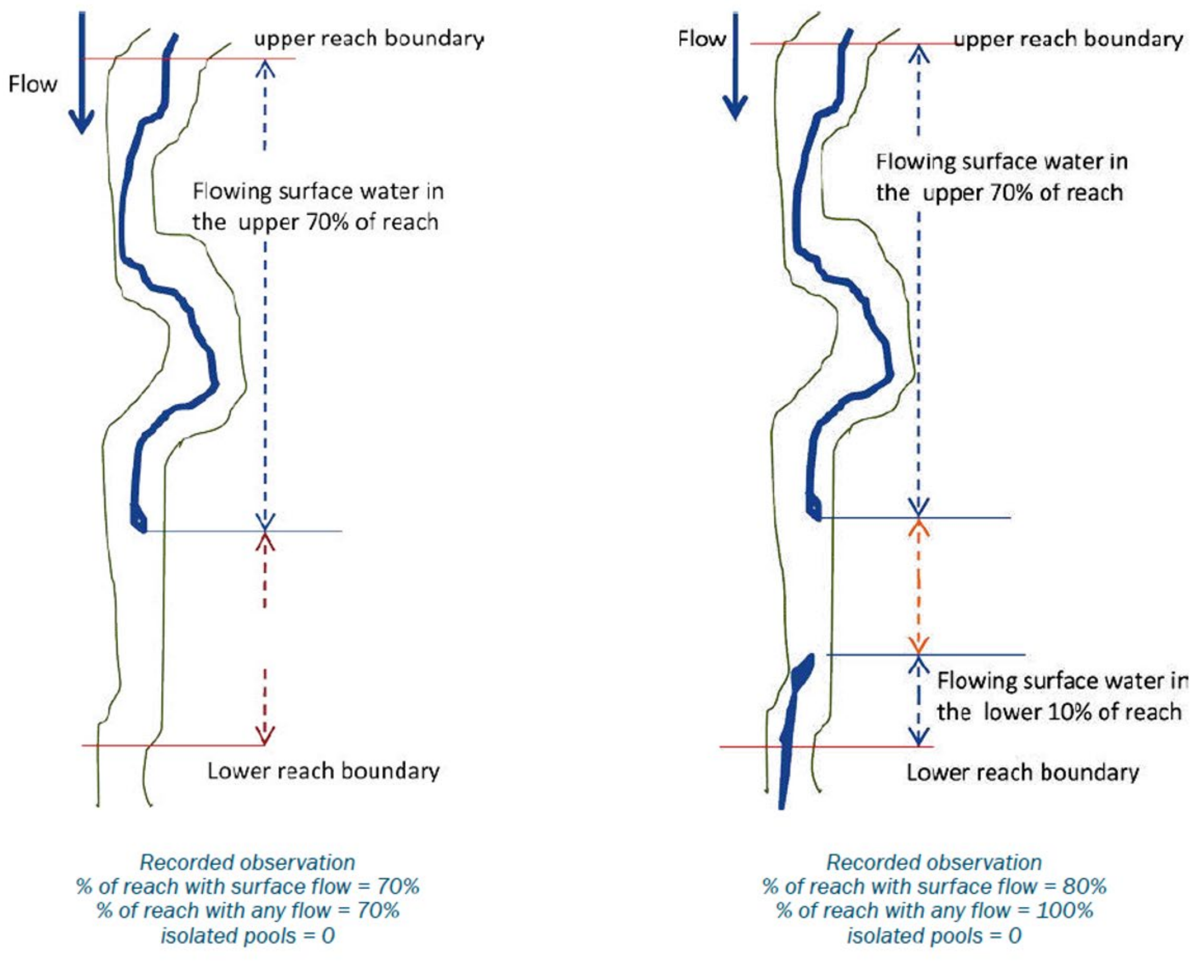

Figure 4. A. Examples of recording hydrologic observations. Figure from R. Coulombe, Nadeau et al. 2011)

Figure 4B. A pool near the bottom of the study reach where surface water is flowing into this area (left). Downstream of the pool (right) there is no sign of surface or hyporheic flow below the pooled area. On the datasheet under hydrologic indicators, record 90% of reach with surface flow, and 90% of reach with surface OR subsurface flow.

Figure 4C: There is NO evidence of flowing water into or out of this long pool. The yellow lines are the assessment reach boundaries. On the datasheet under hydrologic indicators record 0% of reach with surface flow, 0% of reach with any flow, and enumerate one pool. Observation comment "One long stagnant pool covering most of the reach". Photos R. Coulombe, Nadeau et al. 2015).

iv. Pools (adapted from PNW protocol)

Pools are areas of slow-moving or stagnant surface water, which may be crucial for sustaining aquatic life forms during the dry period in non-perennial streams. Enumerate the number of isolated pools within the reach.

For purposes of this protocol, only pools that have surface water during the time of assessment should count.

v. Seeps and springs (adapted from NM protocol)

Look for seeps and springs within one ½ channel width of the channel. They often are present at natural grade controls and headcuts. The presence of this indicator suggests that groundwater is a source of streamflow except during periods of extreme drought.

Look for water dripping or slowly flowing out from the ground or from the side of a hill or incised streambank, laterally into the streambank, or look for "mushy", very wet, black decomposing leaf litter in small depressions near or in the channel.

Circle "present" or "not detected" depending on if seeps and springs are found within the ½ stream channel width of the study reach.

vi. Water in channel (adapted from NM protocol)

Evidence of recent high flows should be noted on the data sheet under "water in channel". Such evidence includes moist or wet sediment on plants or debris and organic drift lines at or above bankfull or in the active floodplain.

Evaluate conditions on the site against the guidance in Table 1. Verify that scoring of this indicator is consistent with observations of hydrology, hyporheic flows, and pool enumeration, as described above.

As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 1. Scoring guidance for Water-in-channel indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	Dry channel. No evidence of baseflows was found.
2	Weak	Dry channel, with standing pools. There is some evidence of baseflows (e.g., riparian vegetation growing along channel, saturated sediment under rocks, etc.)
4	Moderate	Water is present in the channel, but flow is barely discernable in areas of greatest gradient (e.g., riffles). Floating objects may be necessary to observe surface flow.
6	Strong	Flow is evident throughout the reach. Moving water is seen in riffle areas, but it may not be as evident throughout the reach.

vii. Absence of Rooted Upland Plants in Streambed (adapted from NM)

This attribute relates flow to the absence of rooted plants, since flow will often act as a deterrent to plant establishment by removing seeds or preventing aeration to roots. Focus should be on the presence of plants in the bed or thalweg and plants growing on any part of the bank should not be considered. Note, however, there will be exceptions to this attribute. For example, rooted plants can be found in shaded perennial streams with moderate flow but in all cases these plants will be water tolerant (i.e. obligate and/or facultative wetland plants).

Evaluate conditions on the site against the guidance in Table 2. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 2. Scoring guidance for Rooted Upland Plants in Streambed indicator

Score	Evidence of perennial flows	Guidance
0	Poor	Rooted upland plants are prevalent within the streambed/thalweg
1	Weak	Rooted upland plants are consistently dispersed throughout the streambed/thalweg.
2	Moderate	There are a few rooted upland plants present within the streambed/thalweg.
3	Strong	Rooted upland plants are absent from the streambed/thalweg.

vii. Sediment on Plants or Debris (adapted from NM protocol)

Evidence of sediment on plants or other debris in the channel may be an important indicator of recent high flows. Note that sediment production in stable, vegetated watersheds is considerably less than in disturbed watersheds. Look for silt/sand accumulating in thin layers on debris or rooted aquatic vegetation in the runs and pools. For this indicator, evidence of sediment deposition can include thin layers of fine materials on the upper surface of leaves (Figure 5, left), as well as large-scale burial of riparian plants with sand or fine gravel (Figure 5, right).

Figure 5. Left: fine silt deposition on a riparian plant that was recently inundated. Right: burial of riparian plants by sand and fine gravel. Note that the plant is growing through this recently deposited sediment.

When evaluating this indicator, only consider evidence of sediment deposition that likely occurred from a flooding event. If the pattern of deposition suggests a terrestrial (e.g., landslides) or aerial (e.g., extent of deposition in the channel matches deposition on upland plants) source, exclude this evidence when determining the score.

Be aware of upstream land-disturbing construction activities, which may contribute greater amounts of sediments to the channel, and they can confound this indicator. Note these activities on the data sheet if these confounding factors are present under "Notes on disturbances or difficult site conditions".

Are plants in the channel, on the streambank, or in the floodplain covered with sediment? Evaluate conditions on the site against the guidance in Table 3. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 3. Scoring guidance for Sediment-on-plants-and-debris indicator

Score	Evidence of perennial flows	Guidance
0	Poor	No fine sediment is present on plants or debris, no burial of plants on floodplain evident, or all sediment deposition has a clearly terrestrial or aerial source.
0.5	Weak	Evidence of recent sediment deposition is isolated in small amounts along the stream.
1	Moderate	Some evidence of recent sediment deposition on plants or debris within stream channel, although it is not prevalent along the stream. Mostly accumulating in pools.
1.5	Strong	Abundant evidence of recent sediment deposition on plants and debris within the stream channel, on the streambank, and within the floodplain throughout the length of the stream.

viii. Soil moisture

If there is standing water in the reach do not evaluate soil moisture. If there is not standing water in the reach, assess soil moisture qualitatively, as described below.

Qualitative assessment of soil moisture will be made with a 25 mL (handful) of sediment from bottom of 15-cm deep trench used for hydric soil assessment. Soil will be classified as:

- *Saturated* – Sediment has visible water, or immediately wets paper towel when place on it.
- *Partly Saturated* – Sediment left on paper towel in sun for 15 minutes dries or changes color. Soil feels damp, sticky or slippery, and may adhere to skin.
- *Dry* - Sediment left on paper towel in sun for 15 minutes does not change color. Soil is dry to the touch and generally does not adhere to skin.

Dry concrete or bedrock channels lacking sediment deposits shall be recorded as "dry", and lack of soil should be recorded in the "disturbances or difficult situations" section of the datasheet. That is, if there's no soil to assess, there is no soil moisture.

Examine 3 locations within the reach to qualitatively assess soil moisture. Note if recent rains may affect the interpretation of soil moisture data.

viii. Soil texture

Soil texture greatly influences the ability of soil to retain moisture. Soils with high clay content may retain water for several days after rain or inundation, while sandy soils may dry out within minutes. Therefore, soil texture should be assessed at each location where soil moisture is measured. Soil texture can be assessed qualitatively following the process described by Thien (1979), as shown in Figure 6. By moistening a small soil sample, rubbing it between fingers or in the palm of your hand, and noting its ability to retain a shape or detecting the presence of small sand particles, a manual analysis of soil texture may be as accurate as lab-based instrumentation. Note that in some environments, clay aggregates form that are so strongly cemented together that they feel like fine sand or silt; prolonged rubbing can show that these soils are clays and not silt loams.

At every location where soil moisture is assessed, determine the major category of soil texture (i.e., sand vs. clay vs. loam), using the flowchart in Figure 6 as guidance. Where possible, also record the appropriate sub-category (e.g., sandy loam, silty clay, etc.).

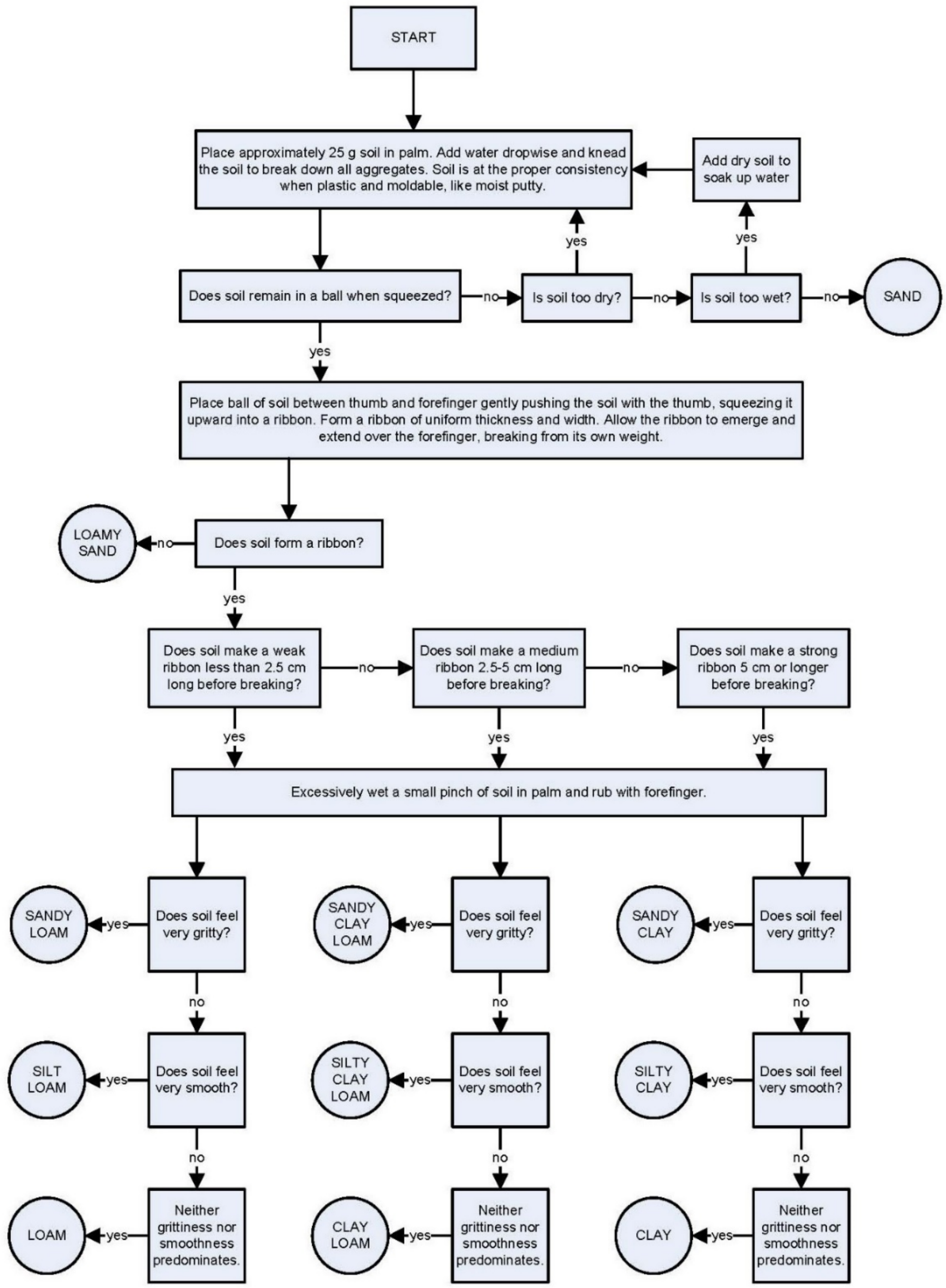

Figure 6. A flow diagram for determining soil texture following Thien (1979).

D. Geomorphic indicators

i. Sinuosity (adapted from NM protocol)

Sinuosity is a measure of a channel's "curviness" (NCDWQ 2010). While ranking, take into consideration the size of the stream (e.g. 1st, 2nd, 3rd order, etc.), which may also influence the stream sinuosity. It is measured by dividing the total stream length (SL) by the straight line valley length (VL; Figure 7). The higher the ratio (SL/VL), the more sinuous the stream. Sinuosity can also be estimated using a GPS's trip computer function to measure channel length and valley length. Note the method used to determine floodplain channel dimensions on the datasheet (e.g. visual estimate in field, survey etc.). Evaluate conditions on the site against the guidance in Table 4. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

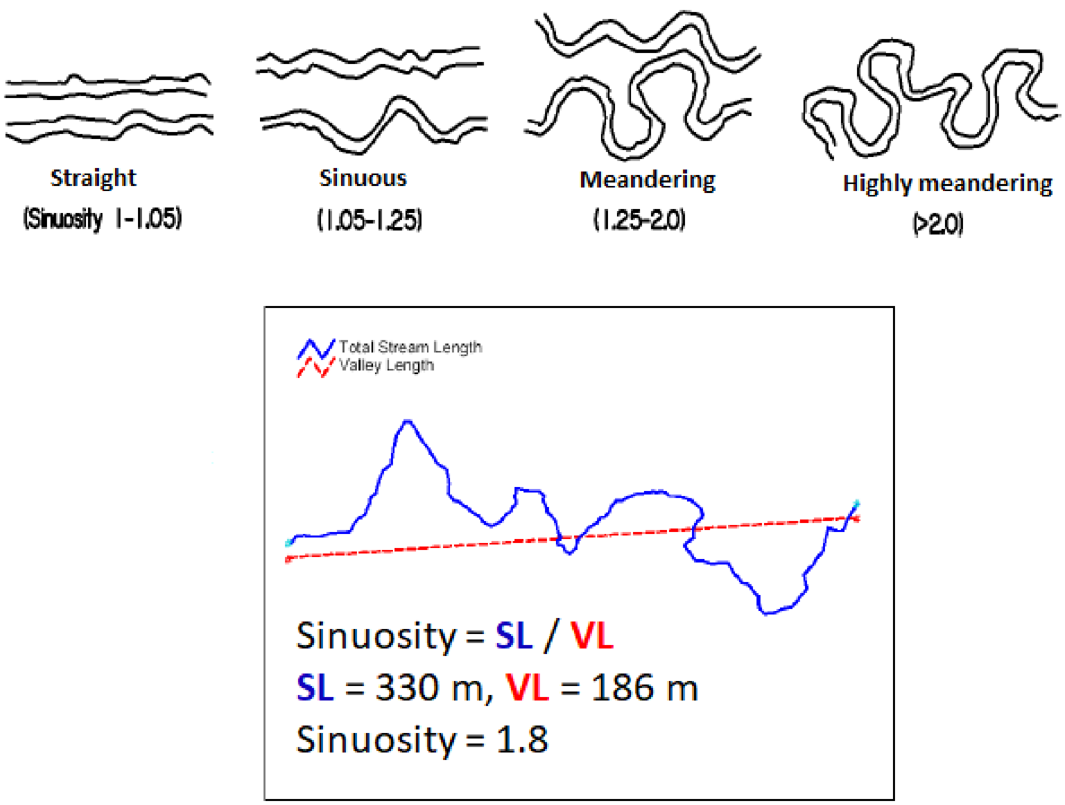

Figure 7. Top: Examples of streams with weak sinuosity (Straight, 1-1.05) compared to strong sinuosity (Highly meandering >2.0; Garcia 2016). Bottom: How to calculate sinuosity from measures of total stream length (SL, blue) and valley length (VL, red; FISRWIG 1998).

Sinuosity can also be estimated using a GPS's trip computer function to measure channel length and valley length. Note the method used to determine floodplain channel dimensions on the datasheet (e.g. visual estimate in field, survey etc.).

Table 4. Scoring guidance for Sinuosity indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	Ratio of valley length: Stream length < 1.05. Stream is completely straight with no bends
1	Weak	Ratio between 1.05 and 1.2. Stream has very few bends, and mostly straight section.
2	Moderate	Ratio between 1.2 and 1.4. Stream has good sinuosity with some straight sections.
3	Strong	Ratio > 1.4. Stream has numerous, closely-spaced bends with few straight sections.

ii. Floodplain and channel dimensions/entrenchment ratio (adapted from NM protocol)

Although one of the difficulties of characterizing dryland ephemeral channels is their enormous variability in form, they tend to have low entrenchment ratios relative to intermittent and perennial channels (Knight et al. 1999). When determining entrenchment, it is important to distinguish whether the flat adjacent to the channel is a frequent floodplain, a terrace (abandoned floodplain), or is well outside of the flood-prone area.

The entrenchment ratio is the ratio of the width of the flood-prone area to the surface width of the bankfull channel (Rosgen 1994). The flood-prone area width is measured at the elevation that corresponds to twice the maximum depth of the bankfull channel as taken from the established bankfull stage (**Error! Reference source not found.**8). Bankfull is the height on the streambanks where water flow fills the channel during moderate events and begins to overflow onto the flood plain.

Bankfull levels can be identified by:

- The presence of a floodplain at the elevation of initial flooding,
- The elevation associated with the *highest* depositional features,
- An obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel,
- A transition from exposed sediments to terrestrial vegetation,
- Moss growth on rocks along the banks,
- Evidence of recent flooding,
- Presence of drift material caught on overhanging vegetation, and
- Transition from flood- and scour-tolerant vegetation to that which is relatively intolerant.

Entrenchment ratios may be estimated visually and compared to scoring guidance, although direct measurements are allowed. The evaluator(s) should start by selecting a representative reach for obtaining bankfull data. In general, the easiest location to measure bankfull channel width is within the narrowest segment of the selected reach. Deflectors such as rocks, logs, or unusual constrictions that make a stream especially narrow should be avoided.

1. Select a representative location where banks are easily identified.
2. Measure the bankfull width and depth.
3. Identify the floodprone depth at twice the bankfull depth.
4. Measure the floodprone width at the height noted above.
5. Divide the floodprone width by the bankfull width to estimate the entrenchment ratio.
6. If necessary, conduct this assessment at multiple locations to determine the entrenchment ratio typical of the reach.

Evaluate conditions on the site against the guidance in Table 5. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 5. Scoring guidance for Floodplain Channel Dimensions / Entrenchment indicator.

Score	Evidence of perennial flows	Guidance
0.0	Poor	Ratio of floodprone width to bankfull width < 1.2. Stream is incised, with a noticeably confined channel. Floodplain is narrow or absent, and typically disconnected from the channel.
1.5	Moderate	Ratio between 1.2 and 2.5. Stream is moderately confined. Floodplain is present, but may only be active during larger floods.
3.0	Strong	Ratio > 2.5. Stream is minimally confined, with a wide, active floodplain.

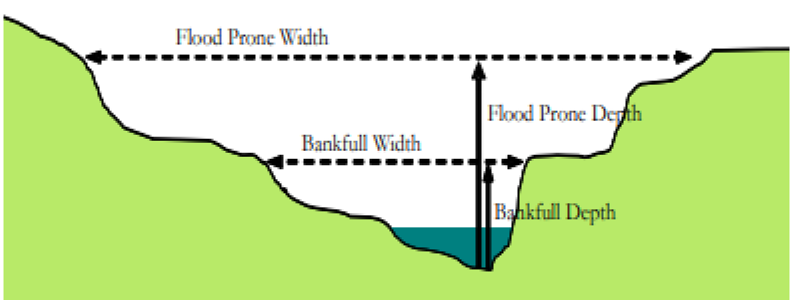

Figure 8. Measurement of entrenchment is based on the ratio of the flood-prone width to the bankfull width.

iii. In-channel structure / Riffle-pool sequence indicator (adapted from NM method)

A repeating sequence of riffle/pool (riffle/run in lower gradient systems, ripple/pool in sand bed systems, or step/pool in higher gradient systems) can be observed readily in perennial systems. Riffle-run (or ripple-run) sequences in low gradient systems are often created by in-channel woody structures such as roots and woody debris. When present, these characteristics can be observed even in a dry channel by closely examining the local profile of the channel.

A riffle is a zone with relatively high channel slope gradient, shallow water, and high flow velocity and turbulence. In smaller streams, riffles are defined as areas of a distinct change in gradient where flowing water can be observed. The bottom substrate material in riffles contains the largest sedimentary particles that are moved by bankfull flow (bedload). A pool is a zone with relatively low channel slope gradient, deep water, and low velocity and turbulence. Fine textured sediments generally dominate the bottom substrate material in pools. Along the study reach, take notice of the frequency between the riffles and pools.

Evaluate conditions on the site against the guidance in Table 6 for all streams regardless of the presence of surface flow. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 6. Scoring guidance for In-channel Structure / Riffle-pool Sequence indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	There is no sequence exhibited
1	Weak	The stream reach mostly has areas of either riffles <u>or</u> pools.
2	Moderate	Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult.
3	Strong	Demonstrated by a frequent number of riffles followed by pools along the entire reach. There is an obvious transition between riffles and pools

iv. Particle size or streambed sorting (adapted from NM protocol)

This feature can be examined in two ways.

1) In channel versus outside channel. Determine if the sediment texture in the bottom of the channel is similar to the texture outside the channel. If this is the case, then there is evidence that erosive forces have not been active enough to down cut the channel and support an intermittent or perennial system. Sediment in the bed of ephemeral channels typically have the same or comparable texture (i.e. particle size) as areas close to but not in the channel. Accelerated stormflow resulting from human activities may produce deep, well-developed ephemeral or intermittent channels but which have little or no coarse bottom materials indicative of upstream erosion and downstream transport. The bottom substrate of non-ephemeral systems often has accumulations of coarse sand and larger particles.
2) Substrate sorting: Look at the distribution of the particles in the substrate in the channel. In lower-gradient, sand-bed streams one may need to look for size variations among sand grains – for instance, coarse versus fine sand. Note, however, the usefulness of this attribute may vary among ecoregions. For instance, in the plateaus or tablelands the variability in the size of substrate particles will probably be less than in the mountains.

For whatever method is chosen, repeat procedure for an area close to but not in the channel for comparison purposes. Step outside the bankfull width or above the bank onto the floodplain or first terrace and repeat the procedure used in the bankfull channel. Avoid areas of dense vegetation and soil accumulation. Beware of cactus, snakes, and other hazards when "blindly" picking up particles outside of the channel or even in dry streambeds.

Evaluate conditions on the site against the guidance in Table 7. As with all "scored" indicators, intermediate scores are allowed (to one-half a score).

Table 7. Scoring guidance for Particle size/ Streambed sorting indicator.

Score	Evidence of perennial flows	Guidance
0.0	Poor	Particle sizes in the channel are similar or comparable to particle sizes in areas close to but not in the channel. Substrate sorting is not readily observed in the channel.
1.5	Moderate	Particle sizes in the channel are moderately similar to particle sizes in areas close to but not in the channel. Various sized substrates are present in the channel and are represented by a higher ratio of larger particles (gravel/cobble).
3.0	Strong	Particle sizes in the channel are noticeably different from particle sizes in areas close to but not in the channel. There is a clear distribution of various sized substrates in the channel with finer particles accumulating in the pools, and larger particles accumulating in the riffles/runs.

E. Biological Indicators

v. Abundance of key biological indicators (adapted from NM and PNW protocols)

Aquatic organisms are thought be more abundant in perennial systems than intermittent, and they tend to occur only rarely in ephemeral streams. The abundance of fish, aquatic macroinvertebrates, and filamentous algae are therefore used as indicators of flow duration.

For all three indicators, the abundance is scored following the guidance in Table 8. As with all "scored" indicators, intermediate scores are allowed (to one-half a score). Aquatic macroinvertebrates and filamentous algae require additional measurements, as described below.

Table 8. Scoring guidance for Abundance of fish, benthic macroinvertebrates and filamentous algae and periphyton.

Score	Evidence of perennial flows	Guidance
0	Poor	Organisms not observed

1	Weak	Takes 10 or more minutes of extensive search to observe
2	Moderate	Found with little difficulty, but not consistently throughout the reach.
3	Strong	Found easily and consistently throughout the reach.

vi. Fish

When looking for fish, all available habitats should be observed, including pools, riffles, root clumps, and other obstructions (to greatly reduce surface glare, the use of polarized sunglasses is recommended). In small streams, the majority of species usually inhabit pools and runs. Fish should be easily observed within a minute or two. Also, fish will seek cover once alerted to your presence, so be sure to look for them slightly ahead of where you are walking. Check several areas along the sampling sample reach, especially underneath undercut banks.

If the only fish observed in the reach is mosquitofish (*Gambusia* sp.), make a note, as this species is frequently stocked in streams of all flow durations, particularly in urban areas.

vii. Aquatic macroinvertebrate

Many macroinvertebrates require the presence of water, and in many cases flowing water, for their growth and development. Such macroinvertebrates are good indicators of streamflow duration because they require aquatic habitat to complete specific life stages. For example, clams cannot survive outside of water, in contrast to some stoneflies or alderflies that resist desiccation in some seasons of the year by burrowing into the hyporheic zone. Some macroinvertebrates can survive short periods of drying in damp soils below the surface, or in egg or larval stages resistant to drying. Others are quick to colonize temporary water and complete the aquatic portion of their life cycle during the wettest part of the year when sustained flows are most likely.

The macroinvertebrate indicators used here are assessed within the defined reach using a single search. During the 15 minute search the full range of habitats present, including: water under overhanging banks or roots, in pools and riffles, accumulations of organic debris (e.g., leaves), woody debris, and the substrate (pick up rocks and loose gravel, also look for empty clam shells washed up on the bank in the coarse sand).

A kicknet or D-frame net and a hand lens are required to collect and identify specimens. Begin sampling at the most downstream point in the assessment reach and move upstream to each new sampling site. Place the kicknet perpendicular against the streambed and stir the substrate upstream of the net for a minimum of one minute, empty contents of the net into a white tray with fresh water for counting and identification. Many individuals will appear the same until seen against a contrasted color background, and some bivalves and other macroinvertebrates can be pea-sized or smaller.

Dry channels: The reach should first be walked to ascertain whether it is completely dry, or if areas of standing water where aquatic macroinvertebrates may collect remain. Focus the search on areas of likely refuge such as any remaining pools or areas of moist substrate for living macroinvertebrates, the sandy channel margins for mussel and aquatic snail shells, and under cobbles and other larger bed materials for caddisfly casings. Casings of emergent mayflies or stoneflies may be observed on dry cobbles or on stream-side vegetation. In summary, we recommend a sampling methodology consistent to that recommended by the Xerces Society report on using aquatic macroinvertebrates as indicators of streamflow duration (Mazzacano and Black 2008).

Searching is complete when:

- at least 6 samples have been collected across the range of habitat types and a minimum of 15 minutes of effort expended (not including specimen identification time), or;
- all available habitat in the assessment reach has been completely searched in less than 15 minutes. In dry stream channels with little bed/bank representation and little habitat diversity, a search may be completed in less than 15 minutes.

The 15-minute estimate for searching does not reflect time spent on identifying individuals; rather it is wholly focused on the searching and gathering effort. It is important to complete the search for macroinvertebrates, as described above, prior to identifying taxa necessary to evaluate the three indicators. The data sheet includes an area for noting observed macroinvertebrates.

Each taxon encountered shall be identified to family level (where possible) and enumerated (up to 10 individuals). Collect vouchers (where permitted) for any specimens that are new to the observer or are challenging to identify in the field. Use a regionally-appropriate field guide to guide the identification of benthic macroinvertebrates. For example, “Macroinvertebrate Indicators of Streamflow Duration for the Pacific Northwest: Companion Field Guide” (Blackburn and Mazzacano 2012) developed specifically for use with the PNW method, provides a useful, compact field guide for identification of aquatic macroinvertebrates, including as indicators of streamflow duration in Pacific Northwest streams. It is available at: http://www.xerces.org/wp-content/uploads/2009/03/Macroinvertebrate-Guide_EPA_SFD_PNW_Final_060620123.pdf.

These indicators do not differentiate between live organisms and shells, casings, and exuviae (i.e., the external coverings of larvae and nymphs). In other words, mussel shells are treated the same as live mussels, and caddisfly cases are treated the same as live caddisflies. However, if mosquito (family: Culicidae) are the only observed aquatic invertebrate (in larval or pupal form), this should be noted.

The assessment is based only on what is observed, not on what would be predicted to occur if the channel were wet, or in the absence of disturbances or modifications. Disturbances and modifications should be described in the “Notes” section of the data form and taken into account when drawing conclusions.

In addition to the abundance estimate described in the NM method (above), record on the data sheet:

- Taxonomic name (generally, Family).
  - Where possible, Corydalidae should be further identified to genus-group: *Neohermes-Protochauliodes* group, which have bright yellow/orange head capsules with a distinctive black pattern vs. the *Oreohermes-Dysmicohermes* group, which has a plain, reddish-brown head and thorax.
- Abundance (1-10 or >10 specimens)
- If the taxon is a mayfly (Ephemeroptera)

- Whether the taxon is a perennial indicator taxon (Table 9)
- Whether the taxon was detected solely as dead material (e.g., casings, exuviae)

Table 9. Perennial indicator taxa

Mollusks	Insects (larvae or pupae only)	
Snails: • Pleuroceridae • Ancylidae • Hydrobiidae Bivalves: • Margaritiferidae • Unionidae	Caddisflies: • Rhyacophilidae • Philopotamidae • Hydropsychidae • Glossosomatidae Stoneflies • Pteronarcyidae • Perlidae	Beetles: • Elmidae • Psephenidae Dobsonflies • Corydalidae ○ *Orohermes-Dysmicohermes* group[1] ○ *Neohermes-Protochauliodes* group[1] Odonates • Gomphidae • Cordulegastridae • Calopterygidae

viii. Filamentous algae and biofilms

These forms of algae are attached to the streambed substrate and require an aquatic environment to persist. They are visible as a pigmented mass or film, or sometimes hair-like growths on submerged surfaces of rocks, logs, plants and any other structures within the channel. Periphyton growth is influenced by chemical disturbances such as increased nutrient (nitrogen or phosphorus) inputs and physical disturbances such as increased sunlight to the stream from riparian zone disturbances.

In addition to the abundance estimate scored as in Table 8, visually estimate the relative coverage on the streambed (active channel only) of live or dead and dying algal mats in the following categories:

- Not detected
- ≤2% cover
- 2 to 10% cover
- 10 to 40% cover
- >40% cover

Live algal mats typically have a dull to bright green color. In contrast, dead algal mats are typically dull brown under wet conditions, or powdery white when desiccated (Figure 9). Estimate the extent of live and dead mats separately. Note that it is possible to observe dead algae mats submerged under water if a stream has only recently started to flow.

Figure 9. Dead and drying algal mats.

In some circumstances, it may be possible to determine if an algal mat originated locally, or if they washed in from an upstream location. Sloughed algal mats tend to collect in snags or on top of boulders, and rest unevenly on the streambed, or may be attached to overhanging branches. In contrast, mats with a local origin are often found in pools, depressions, or areas of flow accumulation. In some cases, algal mats may wash in from upstream and continue to grow if local conditions are favorable. Indicate on the data sheet if evidence suggests that algal mats *strictly* have an upstream origin.

ix. Presence of other biological indicators

a) Iron Oxidizing Bacteria/Fungi (adapted from NM protocol*)*

These features are often (although not exclusively) associated with groundwater. Iron oxidizing bacteria/fungi derive energy by oxidizing iron, originating from groundwater, in the ferrous form (Fe^{2+}) to the ferric form (Fe^{3+}). In large amounts, iron-oxidizing bacteria/fungi discolor the substrate giving it a red, rust-colored appearance. In small amounts, it can be observed as an oily sheen on the water's surface (Figure 10). This indicates that the stream water is derived from a groundwater source, and these features are most commonly seen in standing water on the ground's surface or in slow moving creeks and streams. Filmy deposits on the surface or banks of a stream are often associated with the greasy "rainbow" appearance of iron oxidizing bacteria. This is a naturally occurring phenomenon where there is iron in the groundwater. However, a sudden or unusual occurrence may indicate a petroleum product release from an underground fuel storage tank. One way to differentiate iron-oxidizing bacteria from oil releases is to trail a small stick or leaf through the film. If the film breaks up into small islands or clusters, it is most likely bacterial in origin. However, if the film swirls back together, it is most likely a petroleum discharge.

Figure 10. Oily sheen on water surface due to iron-oxidizing bacteria.

b) Aquatic life stages of snakes, turtles, and amphibians (adapted from the PNW protocol)

Amphibians are typically associated with aquatic habitats, and some amphibians require aquatic habitat for much or all their lives. In the West, there are likewise three snake species that require aquatic habitat for significant portions of their life cycle. Pond turtles (*Actinemys* sp) are found in both perennial and intermittent streams. This indicator focuses on the life history stages of salamanders, frogs, toads, and snake species that require aquatic habitat by indicating life history stages for these species as facultative (FAC), facultative wet (FACW), or obligate (OBL).

This indicator is assessed using a minimum 20-minute search time, within one channel width from the top of both stream banks, to sample the range of habitats present This search can be conducted concurrently with the macroinvertebrate search for greatest efficiency. Various life stages of frogs and salamanders can be found under rocks, on stream banks and on the bottom of the stream channel. They may also appear in benthic samples. Using kicknets or smaller nets is recommended. Certain frogs and tadpoles, as well as adult and larval salamanders, typically inhabit the shallow, slower moving waters of stream pools and near the sides of banks. Note if any frog vocalizations are heard, even if no frogs are visually observed.

Vertebrates must be identified at the assessment site and left at the site following identification. We recommend that a series of photographs be taken of any species in question to allow further identification to be done off-site, if necessary. Please note that several animal species, including fish and amphibian species, are protected by state and federal laws.

x. Bryophyte cover in streambed

Bryophytes (i.e., mosses and liverworts) tend to occur more abundantly in moist environments, and their presence may indicate longer duration flows.

a) "Streamer" mosses

Mosses come in two forms: upright, unbranched acrocarps mosses, and more prostrate, long-formed, branched pleurocarps (Figure 11). The latter is considered a potential indicator of long-duration flows, whereas acrocarps are often found in much drier conditions. Estimate percent cover in these categories:

- Not detected
- ≤2% cover
- 2 to 10% cover
- >10% cover

Figure 11. Pleurocarps (left) indicate wetter conditions, whereas acrocarps (right) frequently occur in dry, upland conditions..

b) Liverworts

Liverworts are flat-bodied bryophytes that may also indicate the presence of long-duration flows (Figure 122). Note that, unlike bryophytes, liverworts may be particularly inconspicuous under dormant conditions (e.g., during dry periods). Estimate the relative cover of liverworts within the active channel, focusing only on areas likely to come into contact with water during baseflow conditions. Estimate percent cover of liverworts (both active and dormant, combined) in these categories:

- Not detected
- ≤2% cover
- 2 to 10% cover
- >10% cover

Figure 12. Liverworts under active (left) and dormant) conditions.

xi. Differences in Vegetation (adapted from the NM protocol)

As a rule, only perennial and intermittent systems can support riparian areas with distinct riparian communities. Ephemeral streams generally do not possess the hydrological conditions that allow true riparian vegetation to grow. Although water flows down ephemeral channels periodically, the water table does not occur sufficiently close to the soil surface to allow water loving vegetation to access the greater quantity of water they need to grow. Vegetation growing along ephemeral watercourses may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but generally there are no dramatic compositional differences between the two. Even along those ephemeral channels where vegetation composition differs somewhat from the adjacent uplands, that vegetation does not require as much soil moisture as true riparian plants. Note if riparian vegetation is absent due to man-made activities on the data sheet. Although riparian vegetation consists largely of hydrophytic species (e.g., *Salix*) in certain streams, distinct riparian corridors of some streams may consist exclusively of upland or non-hydrophyte taxa (e.g., *Chilopsis, Prosopis*), particularly in the desert.

Evaluate conditions on the site against the guidance in Table 10. As with all “scored” indicators, intermediate scores are allowed (to one-half a score).

Table 10. Scoring guidance for Differences in Vegetation indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	No compositional or density differences in vegetation are present between the banks and the adjacent uplands
1	Weak	Vegetation growing along the reach may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but there are no dramatic compositional differences between the two
2	Moderate	A distinct riparian vegetation corridor exists along part of the reach. Riparian vegetation is interspersed with upland vegetation along the length of the reach

3	Strong	Dramatic compositional differences in vegetation are present between the banks and the adjacent uplands. A distinct riparian vegetation corridor exists along the entire reach – riparian, aquatic, or wetland species dominate the length of the reach

xii. Wetland Plants (hydrophytes) in or Near Streambed (adapted from PNW protocol)

To determine the wetland indicator status of a plant, consult the National Wetland Plant List (NWPL). The NWPL, formerly called the National List of Plant Species that Occur in Wetlands, was revised by the USACE, U.S. Fish and Wildlife Service, USEPA, and the Natural Resource Conservation Service in 2013, and is available at: http://wetland-plants.usace.army.mil/. First, determine whether the site is in the Arid West or the Western Mountains region (Figure 13). The wetland indicator of status may change across the two regions. For example, red alders (*Alnus rubra*) are FACW in the Arid West, and FAC in the Western Mountains, whereas California sycamores (*Platanus racemosa*) show the opposite pattern. Therefore, make sure to consult the correct list when determining indicator status.

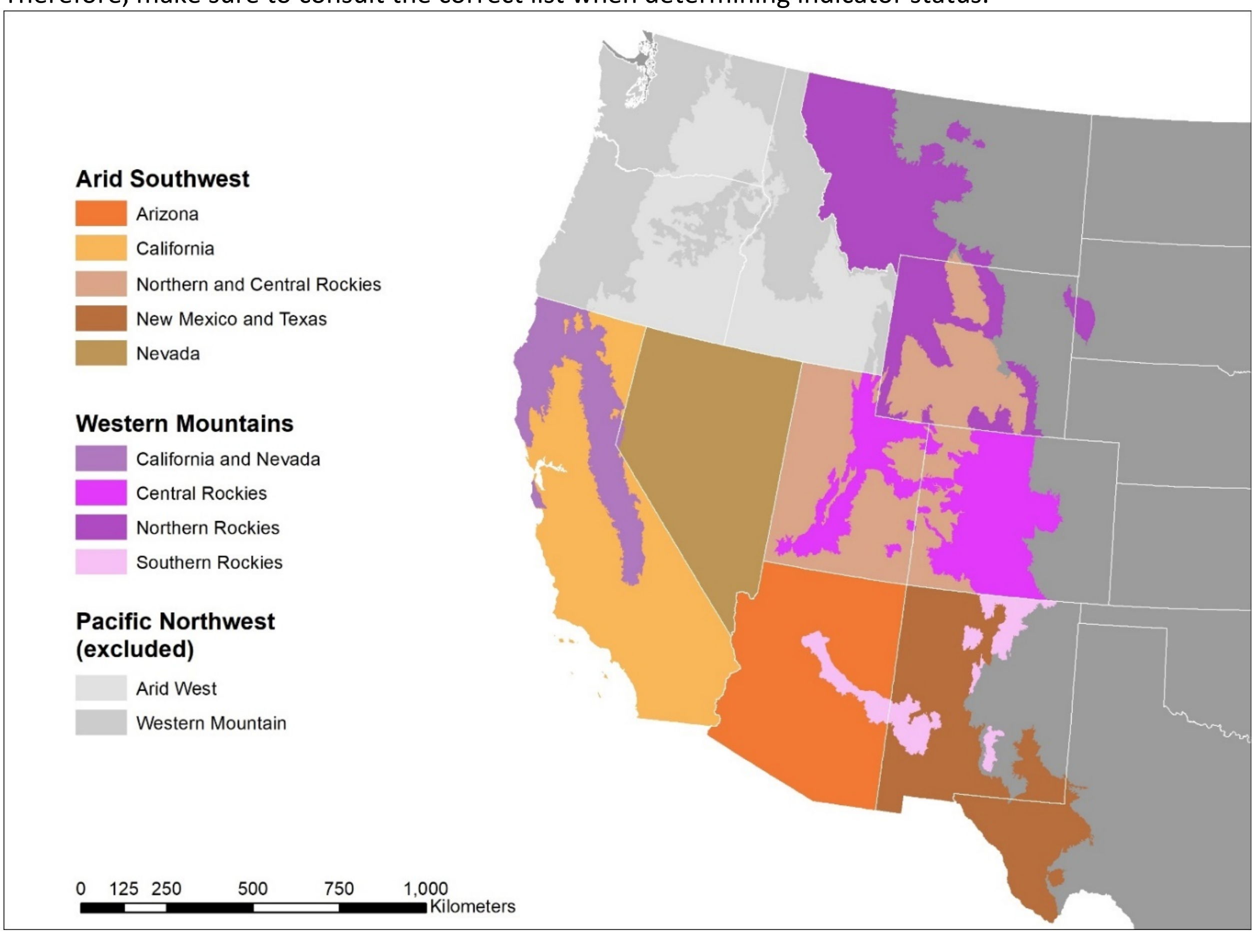

Figure 13. Map of the Arid Southwest and Western Mountain regions.

Within the assessment channel, and within one-half channel width of the stream on either bank, are there any plants with a wetland indicator status of FACW or OBL, or is there submerged aquatic vegetation present? If so, there are hydrophytes present in the assessment area.

The wetland plant indicator is assessed based on the *single* most hydrophytic wetland plant found in or within one-half channel width of the assessed reach, even if that plant is not a dominant species. Nonetheless, it may be useful to record all co-dominant species (>10% coverage) found within the assessment area. For each species, record its name and indicator status. Make note of any unusual circumstances that could affect the interpretation of this indicator, such as:

- Hydrophytes that occur in a very limited distribution (<2% of assessment area)
- Long-lived hydrophytes that are exclusively present as specimens less than 1 year old
- Long-lived hydrophytes that are exclusively present as old, declining specimens

It is recommended that a photo voucher be taken of every species identified at every site.

xiii. Voucher specimen handling (if needed)

Samples are not collected as part of this protocol. However, voucher specimens may be collected and taken to SCCWRP or CSUMB to confirm identifications if the field technicians disagree on the identification or are unsure of the family of the macroinvertebrate or wetland vegetation indicator status, vouchers will be taken, and a chain of custody form will be started. Plant vouchers will be stored in a dry plastic ziplock bag, and invertebrate vouchers will be stored in falcon tubes filled with 70% ethanol (stored in a secondary bag to contain spills). Any potential species of concern shall only have photo vouchers taken. It is expected that all vouchers from a single site will be stored in the same bag or jar.

The Chain of custody form shall identify the date, time and location of collection, voucher collector, a unique specimen ID, the number of containers, type of preservation (if any), and signature blocks for relinquishment of samples. This information will be recorded on the field data sheets and in the field notebook for the project and all chain of custody forms will be scanned into the project file. If specimens (macroinvertebrate or vegetation) are not able to be identified by SCCWRP or CSUMB personnel in the lab, the steering committee will be contacted for determination of next steps, which may include sending to an outside lab (e.g., Aquatic Bioassessment Lab, at the California Department of Fish and Wildlife) at which time QAPP will be supplemented as appropriate.

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