Stream Visual Assessment Protocol for the

Commonwealth of the Northern Mariana Islands

2018

Prepared for the Division of Coastal Resources Management with financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration (NOAA).

This guidance was prepared by the BECQ-DCRM Permitting, Planning, and Water Quality sections to further multiple resource management goals. The resulting SVAP is an adaptation of existing guidance documents from other jurisdictions which has been locally scaled and enhanced by the input and expertise of the following contributors: Erin M. Derrington, Emily Northrop, Kathy Yuknavage, Rodney Camacho, Malcolm Johnson, and Katie Graziano.

Contents

Page intentionally left blank.

Stream Visual Assessment Protocol for the Commonwealth of the Northern Mariana Islands

Preface

In 2013, the Commonwealth of the Norther Mariana Islands' (CNMI) Division of Environmental Quality (DEQ) completed a Surface Water Quality Monitoring Plan (2013 Plan) for six priority CNMI watersheds to support enhanced monitoring and data assessments for the U.S. Environmental Protection Agency's Integrated 305(b) and 303(d) water quality assessment reporting. The 2013 Plan was intended to guide collection of water quality data to enable improved upland management to address impaired water quality. Recognizing the importance of describing the ecological conditions of the streams of CNMI, the 2013 Plan included a "Stream Reconnaissance" assessment form, which describes stream conditions in relation to twenty physical and biological indicators as well as an optional macroinvertebrate survey. However, although watershed monitoring, including sampling protocols articulated in the 2013 Plan have been ongoing, the stream assessment protocol has not been routinely applied.

In 2014, the Division of Environmental Quality (DEQ) merged with the Division of Coastal Resources Management (DCRM) under the Bureau of Environmental and Coastal Quality (BECQ). With a mission to balance resource use with development, today BECQ is leveraging the management expertise of a diverse team of technical staff to support land and water resource management objectives. Watershed monitoring remains an important focus of the agency's mission, and the Nonpoint Pollution and Water Quality Monitoring section continues to implement water quality testing according to the 2013 protocols. Recent efforts to valuate wetland areas resulted in the development of the 2015 Rapid Assessment Methodology (2015 RAM). While the 2015 RAM was intended to quickly enable ecological assessment and valuation of wetland systems, it became apparent that the RAM was not well calibrated to describe streams or seeps, which are included under DCRM's regulatory definition of wetlands. In 2016, BECQ staff researched improved assessment techniques for streams that would be (i) easy to apply in the field and (ii) provide meaningful, quantifiable descriptions of stream systems in CNMI that could be used to indicate ecological quality and change in these systems over time. What follows is a brief description of other methodologies assessed and the selection process of a rapid assessment methodology suitable for CNMI streams.

Rapid assessment approaches are gaining popularity in the resource management sector in order to streamline classification and quantitative measurement of factors that influence resource quality. For streams, assessed elements typically include consideration of major biotic and abiotic factors. Qualitative habitat and multidisciplinary assessments include the US EPA Rapid Bio-assessment Protocol (RBP) (Plafkin et al., 1989), the Ohio EPA Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989), and the Natural Resource Conservation Service

(NRCS) Stream Visual Assessment Protocol (SVAP) (NRCS, 1998) and the updated SVAP2 (NRCS, 2009). Conversely, quantitative stream assessments involve taking physical measurements of various parameters (e.g., channel cross-section surveys, collection and analysis of bed sediment samples, flow measurements, vegetation surveys, biological species collection). Quantitative assessment can take several hours to days to complete at a site and they require high levels of training (Frothingham et al., 2012). Rapid assessment techniques are designed to provide simple reconnaissance-level assessment of ecological conditions.

For example, the 1989 Rapid Bio-assessment Protocols from the U.S. Environmental Protection Agency's Plafkin et al. was designed to provide basic aquatic life data for water quality management purposes such as problem screening, site ranking, and trend monitoring. This methodology included elements of biomonitoring, including fish, benthic macroinvertebrate, and periphyton sampling, as well as habitat assessment, and physicochemical parameters, based on fixed counts of 100 organism samples. Protocols from this guide have been revised several times since the 1989 publication, and are still widely used today. However, the rapid bio-assessment protocols (RBPs) approach is heavily reliant on presence of diverse taxa, with particular attention paid to macroinvertebrate populations, which are not well studied in the CNMI or the Pacific region. Thus, the RBPs approach has not been selected as a viable methodology to support rapid assessment of stream characteristics in CNMI at this time.

In 1998 a user-friendly Stream Visual Assessment Protocol (SVAP) was developed in a joint effort by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture and the University of Georgia to serve as introductory screening–level stream assessment methodology (NRCS, 1998a). SVAP was designed as a versatile, adaptable, and relatively simple technique for use by NRCS field staff who work with agricultural landowners to support conservation practices in the more than 2000 field offices throughout the U.S. In 2001, NRCS supported the development and publication of the Hawaii Stream Visual Assessment Protocol (HI-SVAP). In 2009, NRCS published an updated SVAP Version 2, adding background information, state modifications, and an additional assessment element.

A number of studies have found significant correlations between RBP and SVAP assessments, as well as agreement between qualitative SVAP and indexes based on qualitative stream assessments (Frothingham et al., 2012, citing de Jesús-Crespo and Ramirez, 2011; Hughes et al., 2010; McQuaid and Norfleet, 1999). Results of the analysis assessing usefulness of SVAP as a monitoring protocol of stream corridor conditions concluded that comparing SVAP scores over time can be "an appropriate tool to monitor on-going and post-project stream corridor conditions" (Frothingham et al., 2012). Frothingham et al. go on to discuss that one "notable benefit of the SVAP is the ability to modify the protocol to better suit a particular geographic location and/or a specific watershed management plan (citing de Jesús-Crespo and Ramirez, 2011; Bjorkland et al., 2001; NRCS, 2001b; NRCS, 1998). However, the authors observe that, "[b]ased on the problems associated with reach length encountered during this study, changing the definition of reach length is recommended for monitoring stream corridor conditions over time." A standard reach length could be selected based on what other researchers have done (de Jesús-Crespo and Ramirez, 2011; Hughes et al., 2010; Ward et al., 2003; McQuaid and Norfleet,

1999) or GPS coordinates could be recorded, which would give future field crews the ability to accurately locate each reach. With these recommendations in mind, the CNMI Division of Coastal Resources Management has modified the NRCS SVAP2 and HI SVAP protocols as follows for application of SVAP in CNMI for the purpose of rapid, tier-one stream valuation.

SVAP Version 1 measures a maximum of fifteen (15) elements and is based on visual inspection of the physical and biological characteristics of instream and riparian environments, while the SVAP Version 2 (SVAP2) update measures sixteen (16). In each of the SVAPs, each element is assigned a numerical score relative to reference conditions and an overall score for the stream reach is calculated. A qualitative description of the stream reach, a length of stream with relatively consistent gradient and channel form, is made based on overall numerical score. The CNMI SVAP (CNMI-SVAP) selects 10 of these elements, detailed below.

While SVAP is not intended to replace more robust stream assessment protocols, it provides reliable information that is useful for agencies and landowners alike. The tool assesses visually-apparent physical, chemical, and biological features within a specified reach of a stream corridor.[1] Because of its qualitative nature, the protocol may not detect all causes of resource impacts, especially if such causes are a result of land use actions in other parts of the watershed. However, this tool does provide a means to quickly assess site conditions in the context of the larger watershed. It is also an educational tool through which landowners can learn about conservation of aquatic resources. As such, SVAP2 and HI-SVAP methodology has been adapted in the following guidance to support rapid assessment of stream conditions for the purposes of riparian buffer establishment in the Commonwealth of the Northern Mariana Islands.

[1] In 2002, the University of Hawaii Stream Assessment Protocol Version 3 was published with the addition of Biological Integrity metrics for native macrofauna. In order to support truly rapid stream assessments, macrofauna assessment is not proposed in the CNMI methodology at this time, however, further development of more in-depth analysis with inclusion of the macrofauna considerations are encouraged moving forward.

CNMI-SVAP

This protocol is intended for use in the field for rapid resource assessment. Conducting the assessment with the adjacent landowner provides an opportunity to discuss natural resource concerns and to develop project-specific management and conservation guidance.

Stream Assessment Elements

The ten stream elements considered in the Hawai'i SVAP Protocol and adopted or adapted for the CNMI-SVAP are as follows:

1. YSI Measurements – Turbidity, Salinity, Temperature
2. Visible Nutrient Enrichment / Aquatic Plant Growth
3. Channel Condition
4. Channel Flow Alteration
5. Substrate Embeddedness
6. Bank Stability
7. Canopy Cover / Shade
8. Riparian Width/Condition
9. Habitat Available for Native Species
10. Litter/Trash/Waste Presence

Elements included in SVAP2 which are not listed here include water appearance, salinity, pool presence, and invertebrate presence. If applicable, these elements can be described in the narrative section of this CNMI-SVAP report. BECQ hopes to partner with the Division of Fish and Wildlife to further develop assessment criteria for invertebrate parameters. Details supporting these assessment elements are provided in the "Guidance Documentation" section below. Additional classification information is included in the Appendices of this publication.

Methodology and Guidance for Completing CNMI-SVAP

The following guidance is modified from the NRCS Hawaii Stream Visual Assessment Protocol (HI-SVAP) and NRCS' current Steam Visual Assessment Protocol (SVAP2).

Before leaving the office to assess a stream, a preliminary assessment of watershed features should be conducted and findings should be recorded in the office. The Stream Visual Assessment Overview Data Sheet (CNMI-SVAP Part 1) provides a standardized form for recording information and data collected during both the preliminary and field portions of the assessment. Include information as it is available. If there have been other evaluations or assessments conducted of the stream or the watershed, this information can be included in the comments of the stream/reach assessment sub-section.

Preliminary Watershed Assessment

Before conducting a site visit, the following watershed-level assessment steps are recommended:

- *Become familiar with watershed conditions before visiting the assessment site.* Stream conditions are influenced by the entire watershed including uplands that surround the assessment site. Changes in upland conditions can change the discharge, timing, and duration of streamflow events that affect stream conditions. Aerial images, topographic maps, stream gauges, and any other source of available data can be used to obtain information about watershed conditions before conducting the SVAP on a stream.

- *Gather land use information about the watershed to provide context for the stream and site conditions.* For example, road crossings and water control structures may prevent movement of aquatic species, while agriculture or urbanization can influence water quality and quantity as well as stream corridor conditions. Understanding the impacts of upland land uses can support analysis within the SVAP.

- *Review available water resource information for the watershed and stream reach.* For example, water control structures and/or activities outside of the assessment reach may be affecting streamflow. Understanding upstream influences can support analysis within the SVAP.

- *Become familiar with potential riparian plant species and community types appropriate to the area to be assessed.* Understanding the local biota will support further analysis within the SVAP.

Field Preparation

Before entering the field to conduct a site-specific stream visual assessment, review the following checklist to ensure you are field ready.

Equipment List

Rubber boots / footwear that can get wet
Protective, field-appropriate clothing
Camera / GPS unit
Paper map of stream(s) to mark assessment location(s)
Measuring tape (100m water resistant recommended) – ensure same measurement units used consistently
Meter / yard stick (for depth measurements)
Calculator
Watch with second counter
Temperature probe
Velocity meter
Flow meter
Sunscreen / mosquito repellant as needed
See Water Quality Sampling Protocol and Checklist if water samples will be taken

As with all field work, basic safety protocols, including conducting site visit with a partner and informing office staff of the site being assessed and expected duration of site visit are recommended. For more remote locations, adding a basic first aid kit to your equipment list is also advisable.

Delineate Assessment Reach

Once you arrive on the site, assess one or more representative reaches and evaluate conditions on both sides of the stream. It is standard practice to distinguish the left and right banks while looking downstream. As described in more detail below, *an assessment reach for this protocol is, at minimum, a length of stream equal to 3 times the bankfull channel width.* Longer reaches may be appropriate, based on best professional judgement, depending on the objectives of the assessment. Use your GPS to mark the start and end of each assessed segment for mapping and georeferencing purposes once you return to the office. Use of biodegradable flagging tape may be appropriate to mark sections if periodic assessments are planned.

A *stream reach* is a length of stream with relatively consistent gradient and channel form.

A bankfull *channel width* is the stream width at the bankfull discharge, or flow rate that forms and controls the shape and size of the active channel.

Bankfull discharge or *bankfull flow* is the flow rate at which the stream begins to move onto its active flood plain, if one is present. On average, the bankfull discharge occurs every 1.5 to 2 years, depending on local stream channel and weather conditions. Figure 1 illustrates the relationship between baseflow (low flow), bankfull flow, and the flood plain.

Bankfull width is determined by locating the first flat depositional surface occurring above the bed of the stream. The lowest elevation at which the bankfull surface could occur is at the top of the point bars (an alluvial deposit that forms by accretion on the inner side of an expanding loop of a river) or other sediment deposits in the channel bed. These generally occur on the inside of the meanders (white part of the figure 1, below).

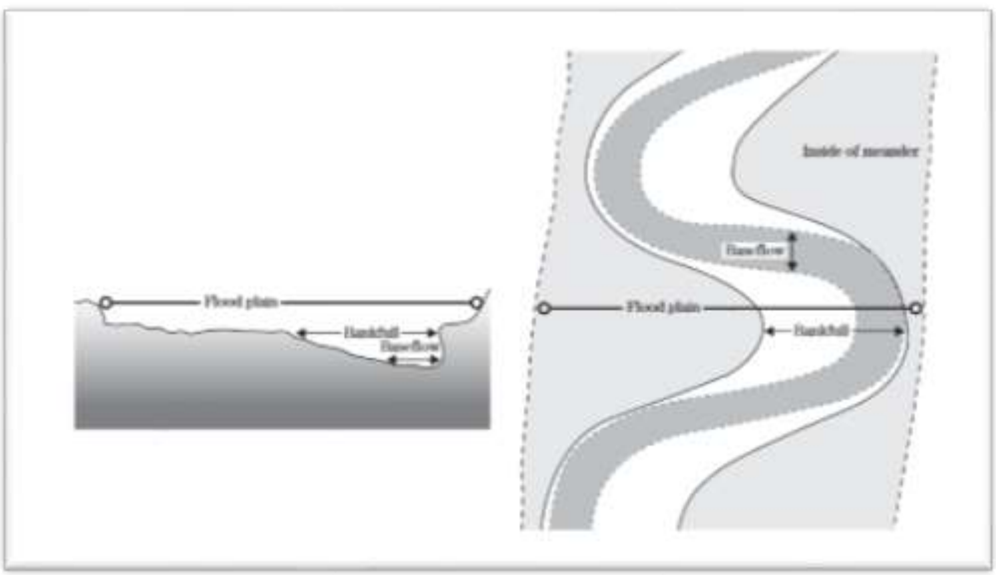
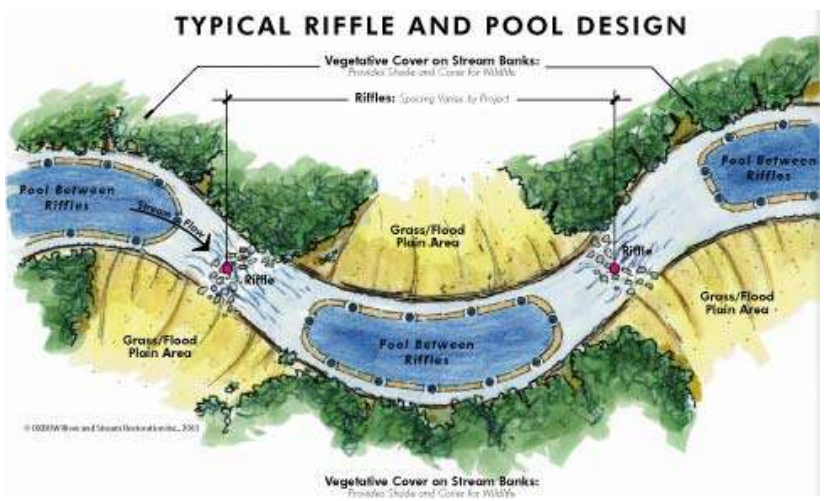


Figure 1 Baseflow, bankfull, and flood plain locations (Rosgen 1996), from NRCS SVAP2, Dec. 2009

Other indicators of bankfull elevation include a break in slope on the bank, vegetation changes or exposed roots, a change in the particle size of bank material, and wood or small debris left from high waters. In temperate areas, vegetation can grow into depositional bars below some bankfull indicators. Therefore, look for signs of well-established vegetation at the elevation level with the top of point bars to help identify bankfull stage.[2]

NRCS notes that often the stream length within the landowner's property boundaries is shorter than the minimum length needed to adequately determine conditions using the SVAP. While obtaining permission to access privately held lands is always encouraged, streams in the CNMI are considered public waterbodies, and as such, access is protected. Therefore, in most cases it is most appropriate to evaluate an adequate length of the stream to determine stream conditions. If, however, stream segments are unpassable or unsafe, the assessment reach length will be the length that is within the accessible area, and limitations should be noted in the CNMI-SVAP form narrative. When large sections of stream are to be assessed and there are constraints that prohibit assessing the entire stream length, representative reaches of the stream on the property should be subsampled.

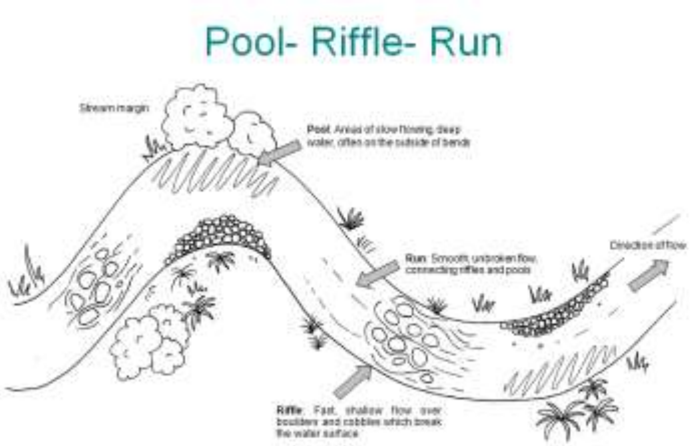
Using aerial images, topographic maps, and various stream classification methods, streams can be stratified into smaller units (stream reaches) that share common physical characteristics such as stream gradient and average bankfull width, which is the channel width at bankfull discharge.[3] The degree of stratification will depend on the reason for assessing the stream. If simply providing an opportunity for the landowner to learn about the general conditions of the stream, perhaps only one reach is assessed. If the SVAP is being conducted to identify potential improvement actions, the entire stream within the property should be assessed. SVAP scores can then be used as a preliminary and qualitative evaluation of conditions. Low scores likely indicate more quantitative assessments of geomorphic, hydrological, and biological features of the stream corridor are needed to determine what stressors are causing the problems identified. Narrative elements of the SVAP should be included as applicable, and sketched in the "Site Diagram" section



[2] Note, NRCS recommends numerous videos and publications to assist in identification of bankfull discharge indicators, available at www.stream.fs.fed.us. See e.g. Harrelson, C., L. Rawlins, and J.P. Potyondy (1994). Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA General Technical Report (RM–245): 61.

[3] Bankfull discharge is expressed as the momentary maximum of instantaneous peak flows rather than the mean daily discharge. Because site visits are often not made during a bankfull event, physical indicators (floodplains, depositional features, breaks in slope, changes in vegetation) must often be relied upon. See Principles and Bankfull Discharge Indicators in Appendix F.

included in CNMI-SVAP Form Part 3. Typical physical assessment terms such as “pool,” “riffle,” and “run” are depicted in the figure at right and should be noted in qualitative descriptions of the site. Sketches and photographs are also encouraged.



Example of a pool segment on Rota, CNMI

If there are several stream types (reaches) within the property, multiple stream visual assessments should be completed, one for each reach. Details regarding specific cross sections may be included in narrative descriptions, but are not required. Additional figures supporting further narrative assessment are included in the appendices.

Scoring Elements of the Stream Visual Assessment Protocol

The SVAP field work ideally should be completed during base flows or low-flow conditions when habitat feature limitations are likely to be most visible. Each assessment element is scored with a value of one to four on the data sheet, with four having the highest quality. Some of the elements from SVAP2, for example, salinity, may not be relevant to the stream being assessed, and thus, should not be scored but should be included in narrative sections if these indicators are observed. Score only those elements appropriate to the ecological setting of the stream. Observations of trash, livestock, or human waste should be scored in all reach assessments.

Background information is provided for each assessment element, as well as a description of what to look for. Using Part 2 of the Stream Visual Assessment Protocol Summary Sheet (CNMI-SVAP Form Part 2), record the score that best fits the observations made in the assessment reach. Base observations on the descriptions in the matrix provided for each element assessed. Assign a score that applies to the conditions observed in the assessment reach. Again, evaluate conditions on both sides of the stream, and note left bank and right bank conditions while looking downstream. Segment conditions should be sketched in the “Site Assessment Diagram” portion of the form (CNMI-SVAP Form Part 3).

The complete assessment is recorded on the summary sheet, which consists of two principal sections: Preliminary Watershed Assessment and Field Assessment. Section 1 records basic information about the watershed and reach such as drainage area, location, and land uses. Space is provided for a description of the reach, which may be useful to locate the reach or illustrate problem areas. On the worksheet, indicate tributaries, presence of drainage ditches, and irrigation ditches; note springs and ponds that drain to the stream; include road crossings, and note whether they are fords, culverts, or bridges, and note any other noticeable features in and around the site.

Section 2 is used to record stream data (page 1) and qualitative scores for up to 8 assessment elements (page 2). Score an element by comparing the observations to the descriptions provided. If matching descriptions is difficult, try to compare what is being observed to the conditions at reference sites for the area. Again, some of the elements may not be applicable to the site and, therefore, should not be included in the assessment. The overall assessment score is determined by adding the values for each element and dividing by the number of elements assessed. For example, if the scores add up to 19 and 7 assessment elements were used, the overall assessment value would be 2.7, which is classified as FAIR. This value provides a numerical score of the environmental condition of the stream reach. This value can be used as a general statement about the state of the environment of the stream or (over time) as an indicator of trends in condition. The following section provides additional narratives to guide quantification of assessment components.

Part II Page 1 – Qualitative Stream Data

The elements below describe qualitative stream data that assessors are encouraged to collect to document easily observable or measurable stream conditions that can help establish baseline stream conditions and show change in stream systems over time. Observations that are relevant to stream characteristics that do not fall under the category types below are encouraged to be logged in the “notes” section of your data sheet.

1. Stream ID Elements

Enter the date, season, weather conditions, and stream name on the top of the Part II data sheet for data tracking purposes. Fill in data for each assessment reach (*an assessment reach for this protocol is, at minimum, a length of stream equal to 3 times the bankfull channel width*) as you move up or down the stream system. Include stream type, segment length, average width and depth as you continue completing the data sheet. This data can help establish baseline stream information and enable comparisons of the SVAP data sheets collected over time.

2. YSI Measurements / Turbidity

The grayed boxes on Part II, Page 1 require measurement tools such as a GPS or YSI meter. Elevation can be measured easily if a GPS unit is being used to track your path, and can be helpful for describing stream hydrology. If you are using a YSI meter, gather and record turbidity, salinity, dissolved oxygen, and temperature measurements. Given the challenges for measuring these parameters without a YSI, other indicators are used to quantitatively score water clarity in Part II Page 2.

3. Surface Water Flow

Using a float is a quick and simple method to measure approximate water flow in very small streams. Drop a leaf in the water flow of the stream you want to measure, and time how long the leaf takes to travel a standard distance (typically seconds per meter). A 25-foot to 100-foot section is recommended to get a more accurate flow reading. With this flow data and width measurements, it is possible to estimate water volumes in the stream system.

While it is not required for the completion of the SVAP, it is worth noting that based on the measured flow, it is possible to compute the stream velocity (ft/s) by dividing the length of the section (ft) by the time (s) it took the float to move through the section.

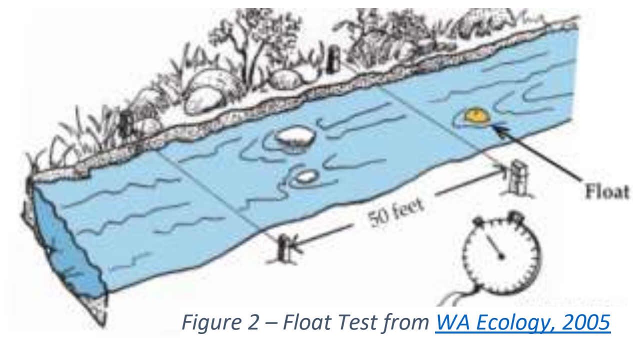


Figure 2 – Float Test from WA Ecology, 2005

4. Water Appearance / Color / Odor

Water that has slight nutrient enrichment may support communities of algae, which provide a greenish color to the water. Tannins may also leach into water from decaying plant material, which may turn the water brown or orange. Visible sheens may indicate oil contamination. Similarly, foul odors may indicate livestock or wastewater control opportunities as well as anaerobic wetland conditions (fleeting "rotten egg" smell). These properties are important to note on your data sheet if they are observed.

5. Streambed Material / Embeddedness

Indicate the dominant stream bed material and if it is "loose" or "cemented" in the fields provided to help describe the stream system you are assessing. This data can be collected to indicate the likelihood of system shifts in terms of erosion and channel movement over time.

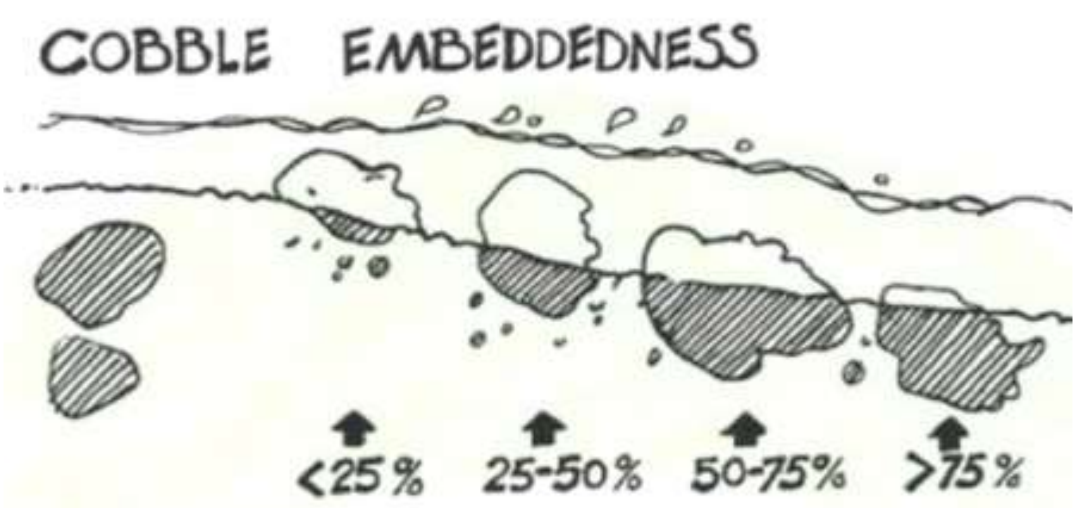


Figure 3 – Embeddedness illustration courtesy of WVDEP.

Part II Page 2 – Quantitative Stream Data

The second page of the field data sheet (Part II) allows for quantitative scoring of stream indictors in order to establish a rapid quantitative assessment of a stream system. Remember to fill in the columns you can and leave those you can't complete blank and try to be consistent with your assessments and measurements.

1. Aquatic Plant Growth

Streams with heavy loads of nutrients have thick coatings of algae attached to the rocks and other submerged objects. Floating algal mats, surface scum, or microbial sheen (fern hydrite) are indicators of a eutrophic stream. Note the level of plant/algal growth on the datasheet.

2. Channel Condition

Changes in the channel may affect the way a stream naturally does its work, such as the transport of sediment and water, and the development and maintenance of habitat for fish, aquatic insects, and aquatic plants. Some modifications to the stream channels have more impact on stream health than others. And some stream types are more sensitive to management stress than others. For example, riprap along the sides and bottom of the Segment can affect a stream more than channelization. Active downcutting and excessive lateral cutting are serious impairments to stream function. Both conditions are indicative of an unstable stream channel. Usually, this instability must be addressed before committing time and money toward improving other stream problems. Extensive bank-armoring of channels to stop lateral cutting usually leads to more problems (especially downstream). To score this element, pick the condition that best characterizes the segment and document the score on the data sheet.

3. Channel Flow Alteration

Water withdrawals from the stream have potential to affect habitat conditions and change the biological and geomorphological conditions of the stream. Temporary diversions are those that are not meant to last (e g small rock diversions for taro that would blow out during a normal storm event). Intermittent withdrawals are those that are occasional or periodic. Any flow alterations outside of the segment should not be counted in this element; instead, note distant diversions/inputs in the "Overview" sheet. If temporary or intermittent, the score should reflect also the amount of water being taken, scoring higher within the range if minimal water is being diverted. Also note if there are inputs, such as stormwater outfalls or culverts in the segment. Record score on the data sheet.

4. Bank Stability

This element is the potential for soil erosion from the upper and lower stream banks into the stream. The bank consists of the sides of the channel, between which the flow is confined. Some bank erosion is normal in a healthy stream. Excessive bank erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in hydrology, sediment load, or isolation from the flood plain. High and steep banks are more susceptible to erosion or collapse. A healthy riparian corridor with a vegetated flood plain contributes to bank stability.

The type of vegetation along the banks is important. For example, most trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while pioneer species (such as guinea grass) do not. Mulch can also act as a stabilizer (e.g. ironwood twigs). Hardened banks (e g riprap) are also stable. Soil type at the surface and below the surface also influences bank stability. Look for signs of erosion, unvegetated stretches, exposed tree roots, or scalloped edges. Evidence of construction, vehicular, or animal paths near banks or grazing area leading directly to the water's edge suggest conditions that may lead to the collapse of banks Take into account the six key factors that influence stability:

1. Bank Height
2. Bank Angle
3. Bank Composition
4. Root Depth
5. Root Density
6. Surface Protection

Estimate the size or area of the bank that is bare and unstable, relative to the total bank area. Total bank area includes the slope and area immediately adjacent that if unstable would erode into the stream. This element will be difficult to score during high water. Calculate the ratio of eroded-disturbed bank /total area, yielding a percent stable bank value.

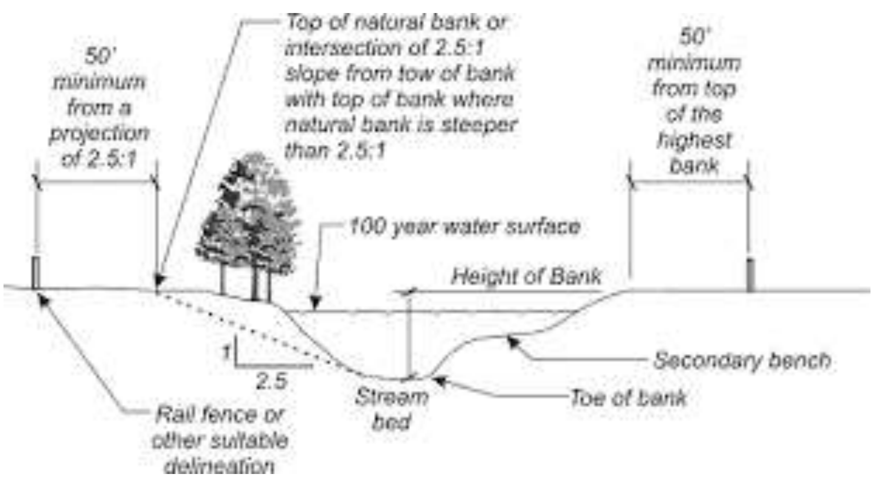


Figure 4 – Measurement of banks and buffers, courtesy of [Santa Clara City Code 20-30.040, CA]

5. Canopy / Shade

This element is the measurement of shade across the active channel. Shading of the stream is important because it keeps water cool and limits the growth of less preferred types of algal. Cool water has a greater oxygen holding capacity than does warm water. When streamside trees are removed, the stream is exposed to the warming effects of the sun, which can change plant and animal species composition and abundance. For instance, alien fish such as tilapia are more adaptable to high water temperatures than some native species. Review your numbers under the Characterization Section on Average % canopy/shade, and determine if the canopy is open, closed, or in-between.

6. Riparian Width/Condition

“Riparian area” is the width of the natural vegetation zone from the edge of the active channel (or normal water line) out onto the flood plain. For this element, the word natural vegetation means plants native to the site or introduced species that function like them.

In most cases, this zone:

- Reduces the amount of pollutants that reach the stream in surface runoff.
- Helps control erosion.
- Provides a microclimate that keeps the water cool for stream biota.
- Provides fish habitat in the form of undercut banks with the "ceiling" held together by roots of woody vegetation.
- Provides organic material for stream biota that, among other functions, is the base of the food chain in lower order streams.
- Provides habitat for terrestrial insects, and habitat and travel corridors for terrestrial animals
- Dissipates energy during flood events.
- Often provides the only refuge areas for fish during out-of-bank flows (behind trees, stumps, and logs).

In CNMI, much like in Hawai’i, we often find highly incised stream channels with steep-sloped riparian areas in their "natural" condition. This means that the stream is in the evolutionary stage of headcutting. It will typically have a gradient greater than 3%, and should not be scored lower because it is not yet in the stage of having floodplains or terraces. The type, timing, intensity, and extent of activity in riparian zones are critical in determining the impact on these areas.

Narrow riparian zones and/or riparian zones that have roads, agricultural activities residential or commercial structures, or significant areas of bare soils reduce stream functions. The filtering function of riparian zones can be compromised by concentrated flows. Look for evidence of concentrated flows through the riparian zone.

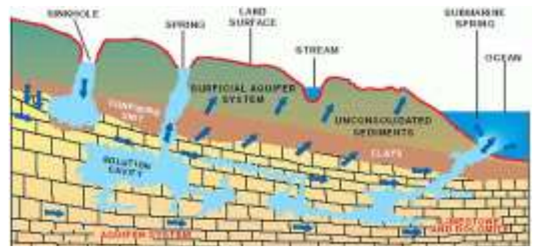
Compare the width of the riparian zone to the active channel width. In this case, observe how much of the flood plain is covered by riparian vegetation. The vegetation must be natural, take particular note of pioneer, invasive species. These do not provide good cover or stability to the banks and can wash away after storm events. Vegetation should consist of all of the structural components (aquatic plants, sedges or rushes, grasses, forbs, shrubs, understory trees, and overstory trees) appropriate for the area.

Examine both sides of the stream (looking downstream) and note on the "Channel cross section" diagram which side of the stream has problems. Check for evidence of concentrated flows through the riparian zone that are not adequately buffered before entering the riparian zone. Pick the condition that best characterizes the Segment and document the score on the data sheet.

7. Flow Type and Habitat Available for Native Species

This assessment element measures availability of physical habitat for native Hawaiian stream organisms. The potential for the maintenance of a healthy aquatic plant and animal community and its ability to recover from disturbance is dependent on the variety and abundance of suitable habitat and flow available.

Observe the number of different habitat and flow types within each Segment and document the score on the datasheet. If there is flow, there will be at least one type of habitat available. Each flow type must be present in appreciable amounts to score. If a specific flow type composes a significant portion of the assessed area, assessors may consider completing one SVAP form for the entirety of this reach.



Due to the karst-limestone geology characteristic of Saipan, Tinian, and Rota, seeps, springs, and sinkholes are commonly observed.

Flow types are described as follows:

(1) Seeps / Springs / Sinkholes (SSS)— Areas in the riparian area where there is groundwater input (cooling the water and providing habitat to native aquatic invertebrates). These features should be mapped and assessed as individual reach units.

(2) Pools (P0)— Areas characterized by smooth undisturbed surface, generally slow current,, and typically deep (deep enough to provide protective cover for fish. Included in this habitat would be deep "plunge" pools at the base of a cascade or waterfall.

(3) Runs (RU) — Areas characterized by moving water, but no broken water surface or whitewater.

(4) Riffles (RI) — Areas characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches). Generally, flow is fast and shallow.

(5) Cascades (CA) — Waterfalls, or basically steep riffles (greater than 3% gradient).

Chose a high score within the range if there are multiple numbers of each flow type within the reach, or if the substrate is more compatible to native species. Decide on a score in the higher range if there are numerous pools, runs or riffles versus one of each. The range of scores allows best professional judgement to suit each unique situation.

8. Litter/Trash/Waste Presence

The presence of litter, trash and fish or animal carcasses are obvious signs of stream degradation. Assess the presence in both the wetted area and riparian zone. Outflow pipes, encroaching piggeries, and the presence of other waste should be noted and geolocated if possible. Note the condition and score on the datasheet

Restoration Recommendations Evaluation

After conducting a SVAP, enhancement opportunities or management recommendations may be identified. The following ideas are a few examples for improving the various stream elements. It is important to have interdisciplinary input from experts in geomorphology, engineering, plant ecology and fish and wildlife biology. Applying adaptive management principles to achieve identified restoration objectives is recommended. See *Salafsky et al., Adaptive Management: A Tool for Conservation Practitioners*, and *U.S. Forest Service NSAEC Guidance for Stream Restoration and Rehabilitation, 2016* for additional information.

Figure 5 – Adaptive management cycle.

1. Turbidity — Improve water quality by reducing sediment loads into the stream, by revegetating banks, reducing inputs from fields, or other means.

2. Plant growth — Improve water quality by reducing nutrient loading in the stream (e.g. nitrates and phosphates). Improve canopy cover to encourage compatible species of algal growth.

3. Channel Condition — Evaluate ways to reconnect or enhance the connectivity of the stream channel to its floodplain, where applicable.

4. Channel Flow Alteration — Evaluate ways to restore altered sites, producing changes in hydrology (e.g. bioengineering, removing diversions).

5. Percent Embeddedness — Reduce fine sediment input from the upper watershed and/or eroding streambanks.

6. Bank Stability — Improve bank stability with a wide riparian buffer, better channel conditions and bioengineering methods. Note that if there is major, contiguous erosion occurring around a bend, it may be a system-wide problem that needs to be addressed, compared with small eroding spots that may be treated on site.

7. Canopy/Shade — Enhance canopy over the stream to keep water temperature cool with plantings and management.

8. Riparian Condition — Improve conditions with plantings and management for a wide riparian buffer.

9. Habitat Available for Native Species — Evaluate ways to improve habitat conditions for native flora and fauna (e.g. flow, water depth, roughness of the channel)

10. Litter/trash/human or animal waste — Identify source(s) and clean up litter/trash in the stream and stream riparian areas and set up regular trash pickup.

Recommended Next Steps

Stream Classification and Reference Sites

NRCS guidance notes that healthy streams will look and function differently depending on its location or ecological setting. Thus, accurately classifying the type of stream in an area of interest is important to assessing the current condition, or health, of that particular stream. Stream classification is a way to account for the effects of natural variation in streams and helps avoid comparing the conditions of streams of different classes. A stream's classification provides a point of reference for subsequent assessments that may occur at the site. Ideally, a separate SVAP modification should be developed for each stream class, but realistically, this is not possible. Therefore, NRCS recommends that States identify only as many stream classes as are necessary to account for natural variation in streams caused by the prevailing environmental influences of their region. Some important factors to consider are major land resource areas (MLRA) or ecoregion, drainage area, and gradient. Ecoregions are geographic areas in which ecosystems are expected to be similar. Drainage area is the size of the area of a watershed (catchment or basin).

SVAP2 Guidance recommends that enough up-front work should be done by State Offices in tailoring the protocol to permit field offices to use it without further modification. This includes refining and evaluating the protocol, modifying the element criteria and scoring to reflect local conditions, and delineating the geographic boundaries for its intended use. To reach this objective, it is important to identify and assess reference sites to represent the range of conditions that potential exist for a particular class of stream. Least impaired reference sites represent the best conditions attainable, and most impaired reference sites the worst. Accessible, least impaired reference sites are important not only because they define a benchmark for attainable conditions, but they also serve as demonstration areas for field staff to observe the characteristics of the region's best streams that would result in the highest possible SVAP2 scores. NRCS instructs that reference sites should represent an entire stream class and thus may be located in another county or State. Therefore, it helps if they can be identified at a State or higher level and with the help of State agencies that may have already established reference sites that represent a full range of human perturbations for a given class of stream.

Implementation, Training, and Outreach

- Training is needed to reduce SVAP variability. *(See Hannaford et al., 1997).*
- Develop CNMI bio-assessment protocols to support further water quality assessment and valuation. The SVAP provides a basic level of stream health evaluation, known as a "first level" protocol in a four-part assessment hierarchy; Tier 2 is the NRCS Water Quality Indicators Guide, Tier 3 is the NRCS Stream Ecological Assessment Field Handbook, and Tier 4 is the intensive bio-assessment protocol used by State water quality agencies. Because CNMI does not have established bio-assessment protocols, future development of localized assessment hierarchy protocols is recommended to support assessment, valuation, and management efforts. Consideration of Hawaii's 2002 Stream Bioassessment Protocol, Version 3, is recommended.
- Build capacity in natural resource management staff to support implementation of stream valuation to support protection and restoration objections.

CNMI-SVAP Form

Part 1 – Stream Visual Assessment Overview Data Sheet

CNMI-SVAP
OVERVIEW DATA SHEET

1. Preliminary Assessment

Date: ____________________ Evaluator(s) ____

Stream Name: ____ Island: _______________________ Village: _________________

Location - Latitude: ____________ Longitude: _______________________ Land Ownership Status (Public / Private): __________________

A. Watershed Description

Stream Order _____________ Connected to ocean at least 1x/year? _________ Drainage Area ___________ Total length _________ miles

Watershed management structures (#): dams ___ water controls __irrigation diversions __ other (describe) ______________________________

Land use within watershed (%): cropland ___ grazing/pasture ___ forest ___ urban ___ industrial ___ other (specify) _____________________

Stream Hydrology: ____ Intermittent, months of year wetted: ___________ OR ____ Perennial, months of year at baseflow: __________

B. Stream / Reach Description

Stream Gage Location / Discharge: ___________ / ___________ ft^3/s

Applicable Reference Stream: ___________ R eference Stream Location: ___________

Fish and other animal species (known to exist in stream from CNMI stream assessment and/or personal contact with experts):

Endangered / Threatened / Proposed / Candidate / Sensitive Species Present:

Other Comments:

List data sources referenced: ____

Part 2 – Stream Visual Assessment Scoring Sheets

Page 1 – Qualitative Data

SCORING DATA SHEET (Part II)						
Date		**Season**		**Relative Flow Status** circle one: high / normal / low		
Stream Name & Reach ID		**Weather**				
Segment (eg. #, headstake, GPS ID)						
Stream Type eg. pool, riffle, run, fall						
Segment Length (circle one: ft or m						
Average Width DHWL & Wetted circle one: ft or m						
Average Depth circle one: ft or m						
Elevation circle one: ft or m						
Temperature circle one: C or F						
Dissolved Oxygen specify units:						
Conductivity/Salinity specify units:						
Surface Water Flow eg. standing, slow, fast or circle one: sec/ft or sec/m						
Water Apperance/Color eg. clear, oily sheen, brown, orange, green						
Water Odor eg. sewage, fishy, sulphur						
Streambed Material/ Embeddedness eg. bedrock, gravel, silt / loose, cemented						
Flora/Fauna eg. identified species and characteristcs						
Notes						

Page 2 – Quantitative Data

Score Each Applicable Element from 1 to 4 - Use "Scoring Sheet for the Elements" Guidance					
1. Aquatic Plant Growth					
2. Channel Condition					
3. Channel Flow Alteration					
4. Bank Stability					
5. Canopy					
6. Vegetation Strata					
7. Riparian Condition					
8. Contamination Circle all applicable sources:	-Trash/Litter -Road/Surface Runoff -UXO -Marine Debris -Human Waste/TP -Farm Runoff -Illicit Discharge/Pipe -Other:	-Trash/Litter -Road/Surface Runoff -UXO -Marine Debris -Human Waste/TP -Farm Runoff -Illicit Discharge/Pipe -Other:	-Trash/Litter -Road/Surface Runoff -UXO -Marine Debris -Human Waste/TP -Farm Runoff -Illicit Discharge/Pipe -Other:	-Trash/Litter -Road/Surface Runoff -UXO -Marine Debris -Human Waste/TP -Farm Runoff -Illicit Discharge/Pipe -Other:	-Trash/Litter -Road/Surface Runoff -UXO -Marine Debris -Human Waste/TP -Farm Runoff -Illicit Discharge/Pipe -Other:
Total Score					
Average Score					
Rating > than 3.5 = Very High 3-3.5 = High 2-3 = Fair < 2 = Low					
Notes (eg. restoration opportunities, artifacts, overall stream summary)					

Part 3 – Stream Visual Assessment Site Diagram

Site Diagram: Indicate approximate scale, major features, resource concerns, etc. Provide notes related to each element scored on back of site diagram, as needed.

Part III: Sketch Stream Cross Section(s):

Appendices

Classification techniques discussed in the SVAP and described in more detail in the appendices included herein do not come without flaws. One of the reasons why there are so many classification techniques and not one universal technique is because none of them are applicable to every stream. Most of the classification techniques listed were developed for a certain region and can only accurately classify a stream located in a similar climate amongst similar vegetation and at a similar elevation. For example, Montgomery and Buffington's method, which is not included in the appended information, focuses on larger mountain systems with steep gradients. Leopold and Wolman's method also leaves a very broad description of the system. Describing a river as braided, meandering, or straight has its advantages but it does not give any other information. Also, river systems typically only continue with one of these descriptions for a brief time and therefore can only be classified for short reaches. Many rivers exhibit all three of these characteristics at some point. Many of these methods also require costly and sometimes inaccurate data measurement from field technicians. Using GIS data can solve this problem. Unfortunately, there are still a number of biological variables that cannot be determined with GIS.

Similarly, although Rosgen's method is currently the most widely used, it doesn't go without criticism. *Simon et al.* takes a critical look at the Rosgen method of classification and addresses what could be considered a number of critical flaws, particularly as it relates to Rosgen's analysis of bankfull dimensions (Simorn, 2007). When considering sediments for classification, Rosgen suggests that particle counts should be considered from one bankfull level to the opposite bankfull level. Simon et al. suggests that this mixes two different alluvial materials requiring different forces and processes while depositing at different times. Classification related to this issue can be seen when trying to describe two channels classified as C. One channel can have gravel bed and silt-clay banks, while the other containing a sand bed and sandbanks. These two channels could have the same median diameters of particle size. Thus, the following information is intended to be informative and assist with terminology in applying the CNMI-SVAP and should not be considered required elements of SVAP narratives.

The appendices that follow start with a glossary of key terms and then provide summaries of classification techniques and relevant ecological indicators to support application of the CNMI-SVAP.

Appendix A – Glossary

Active floodplain: The land between the active channel at the bankfull elevation and the terraces that are flooded by stream water on a periodic basis. This is not synonymous with the FEMA flood zone designation.

Aggradation: The rising of a streambed due to sediment deposition.

Alluvial and/or Alluvium: Clay, silt, sand, gravel, or similar detrital material deposited by running water.

Back water pools: A pool type formed by an eddy along channel margins downstream from obstructions such as bars, rootwads, or boulders, or resulting from backflooding upstream from an obstructional blockage. Backwater pools are sometimes separated from the channel by sand or gravel bars.

Bankfull: The water level, or stage, at which a stream, river or lake is at the top of its banks and any further rise would result in water moving into the flood plain. It may be identified by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

Bankfull Bench: A flat or shallowly sloped area above bankfull that slows high velocity flows during flows above bankfull.

Bankfull Depth: The average depth measured at Bankfull Discharge.

Bankfull Discharge: The dominant channel forming flow with a recurrence interval seldom outside the 1 to 2-year range.

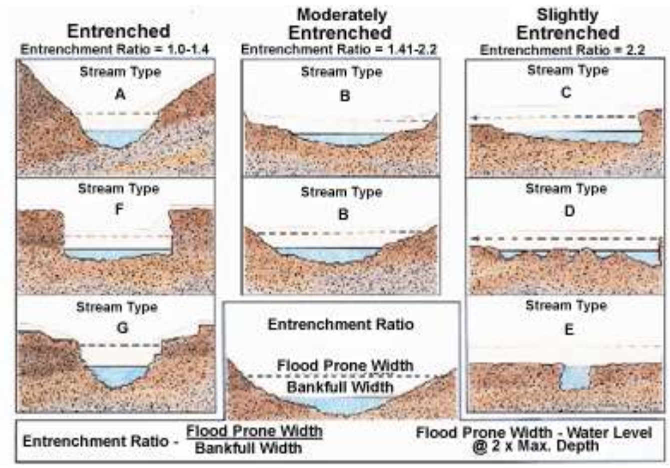
Bankfull Width: Channel width at Bankfull Discharge.

Baseflow: Also called drought flow, groundwater recession flow, low flow, low-water flow, low-water discharge and sustained or fair-weather runoff) is the portion of streamflow that comes from "the sum of deep subsurface flow and delayed shallow subsurface flow".

Drainage Area: The horizontal projection of the area upstream from a specific location that has a common outlet at the site for its surface runoff from precipitation that normally drains by gravity into a stream.

Embeddedness: The extent to which rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, fewer living spaces are available to macroinvertebrates and fish for shelter, spawning and egg incubation.

Entrenchment ratio. The vertical containment of the river described as the ratio of the flood-prone width to the bankfull width (Rosgen, 1996).



Flood-prone width: The width across the flood plain, measured at a section perpendicular to the streamflow, at a water-surface elevation corresponding to twice the maximum depth of the bankfull channel (Rosgen, 1996).

Manning's roughness coefficient (n): A dimensionless measure of the frictional resistance to flow, or roughness, of a stream channel.

Maximum bankfull depth: The maximum depth of the bankfull channel measured at a section perpendicular to streamflow.

Mean annual precipitation: The basin average value for annual precipitation.

Mean bankfull depth: The mean depth of the bankfull channel measured at a section perpendicular to streamflow.

Percent of basin covered by forest: That portion of the drainage area of a stream shown in green on a 7.5-minute U.S. Geological Survey topographic map, divided by the total drainage area, and multiplied by 100.

Reach: A reach is a length of stream with relatively consistent gradient and channel form.

Recurrence interval: The average interval, in years, between exceedances of a particular annual peak discharge.

Rosgen classification: A system of describing river channels based on channel geometry, stream plan-view patterns, and streambed material (Rosgen, 1996). See Appendix D.

Stream bank / river bank: Terrain alongside the bed of a river, creek, or stream consisting of the sides of the channel, between which flow is confined.

Stream classification: The process of assigning a numeric order to links in a stream network based on the number of tributaries.

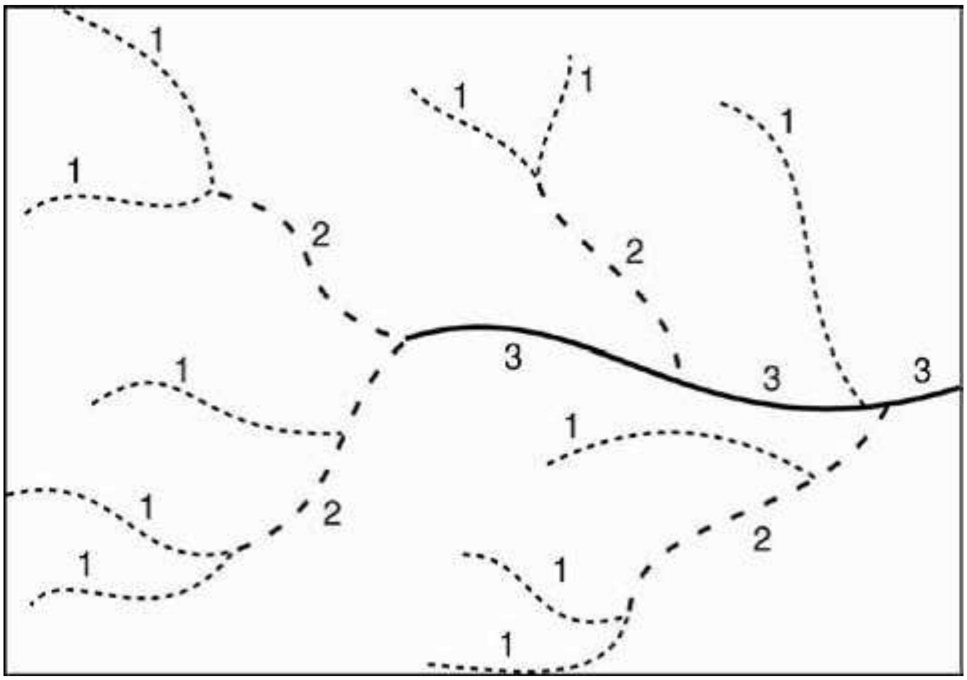
Sinuosity: The ratio of the measured channel distance divided by the straight-line distance of the valley from the beginning of the channel reach to the end of the channel reach.

Thalweg: The lowest point in a stream channel.

Width/depth ratio: The ratio of bankfull width to mean bankfull depth measured at a section perpendicular to streamflow.

Appendix B - Stream Classification Tools – Strahler's Stream Order Classification

One of the first methods developed for stream classification was developed by Strahler in 1952. This method simply describes the order of streams. This method starts with the smallest tributaries are considered 1st order. When two of these tributaries meet, the resulting tributary is considered 2nd order. When two 2nd order streams meet, the result is a 3rd order and so on (Strahler, 1952). Although this type of classification is fairly vague, it is an important indicator of stream size and drainage (Ward et al., 2008). Long 1st and 2nd order streams are often characteristic of manmade or severely altered natural channels. As CNMI has not adopted stream order assignments, applying this methodology can support initial classification of stream orders for the purposes of CNMI-SVAP application.

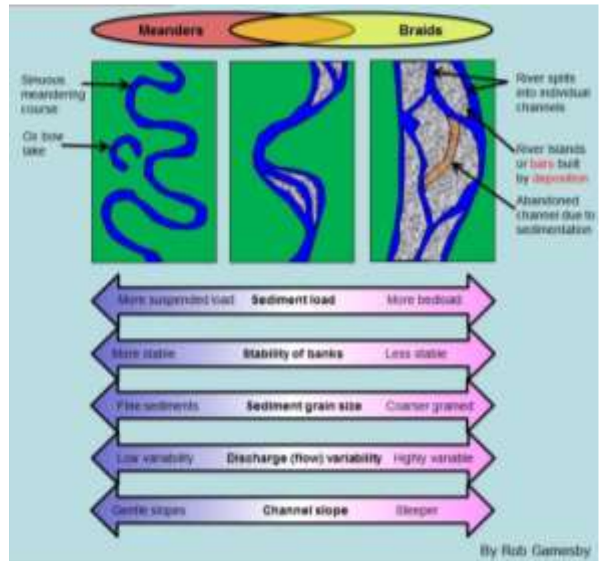


Stahler Stream Order Classification Diagram

Appendix C - Stream Classification Tools – Channel Evolution Model

Leopold and Wolman's "Channel Evolution Model" method, developed in 1952, describes streams as braided, meandering, or straight. The method looks at specific reaches of the system as opposed to the whole system due to the river system often changing from straight, to meandering, to braided, etc. This early method was developed in order to attempt to "understand the mechanisms by which these laws operate in a river" (Leopold et al., 1952).

Leopold and Wolman describe braided rivers as channels that flow around alluvial islands developed in the system. This can include two or more channels. Braided channels are typically seen as wider, shallower and steeper than undivided channels of similar flow (Leopold et al, 1952). Velocity, cross sectional area, and roughness can all be factors resulting in the development of a braided channel. Leopold and Wolman performed a study in the lab by developing a braided channel by depositing a central bar consisting of coarse particles that could not be transported under current conditions. The coarse material acted as a catalyst for a subsequent island that developed and was maintained naturally by the system, thus creating a braided channel.



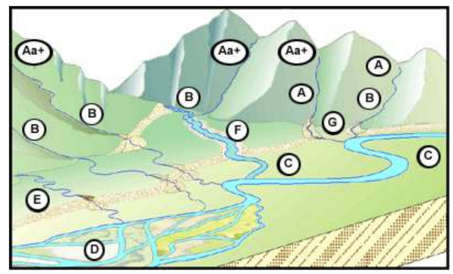
Meandering channels are different than braided channels in that they typically exhibit a single channel that is characterized by multiple turns or curves through the floodplain as it flows downstream. Sediment is deposited on the outside banks of the floodplain often leading to erosion. Meandering reaches are the most common classification of the three discussed by Leopold and Wolman.

Straight channels are classified in the Leopold Wolman method but are often rare in a natural setting. Straight natural reaches are most often shorter than ten times the width of the channel. Straight reaches longer than this is often altered by man. Studies by Leopold and Wolman indicate that straight reaches also exhibit pools and riffles as do meandering channels. Further studies by Leopold and Wolman also indicate that although the banks of "straight channels" may be linear, the flow within the banks often exhibit a sort of meandering quality.

Appendix D - Stream Classification Tools – Rosgen Stream Classification System

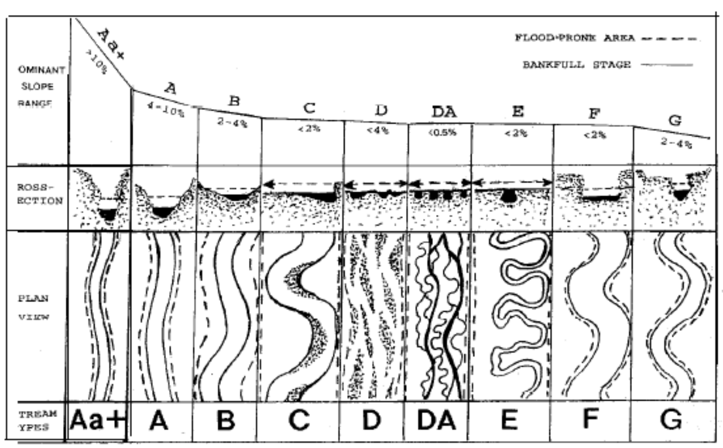
For the purpose of easily classifying rivers, Rosgen has broken the process into four levels. A river starts by being classified using Level I. The river is then further classified in Level II, by describing the river in the next sub-genre of classification. The river is then further classified in Levels III and IV. Each level deals with a different topic of characterization. Level I begins with geomorphic characterization. Level II deals with morphological descriptions. Level III characterizes the streams state. Finally, Level IV addresses validation of process characteristics (Rosgen, 1994). For the purpose of clarity, Rosgen primarily describes Level I and II in detail, and only briefly describes Level III and IV. For the purposes of assessing "stream types" for the CNMI-SVAP, the focus here is mainly on Level I and II. These descriptions are included to support initial channel assessment and inclusion of relevant terminology. Rosgen classification is not intended to be applied in full during the SVAP assessment or analysis.

Level I provides a broad geomorphic characterization to start the classification process. Landform and fluvial characteristics are described and combine channel relief, shape, and dimension profiles (Rosgen, 1994). There are 8 categories that a stream can be classified as in Rosgen's method. Streams are broadly classified as A, B, C, D, DA, E, F, or G. These categories are used to describe a variety of characteristics.



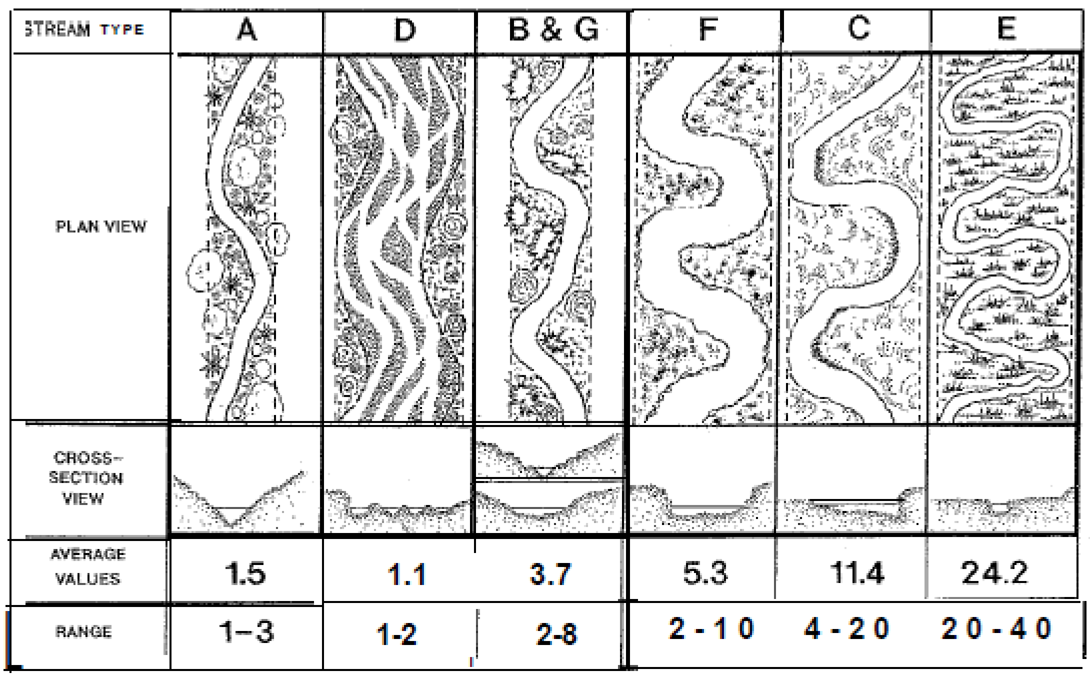
Different "Level I" stream types tend to occur in different landscape settings.

The first distinguishable characteristics in Level I are the longitudinal profiles used to represent slope. The slopes start with Aa+ being very steep at >10% gradually decreasing to DA at <0.5% and then increasing in slope to 4% at G. Slope can be related to bed features and can be described as pools, riffles, rapids, cascades, and steps (Rosgen, 1994). Riffle/pool streams are represented with CE, and F streams. Rapids are found in B and G streams, while steps and cascades are found in A and Aa+ streams. See figure below for details.



Cross section morphology is also described in Level I of Rosgen's method. The cross sections differ greatly in the 9 categories ranging from deep and narrow to wide and shallow. The cross section morphology also describes the flood plain ranging from well-developed flood plains to virtually no flood plain.

Finally, Level I discusses plan view morphology. The nine categories describe the sinuosity of the river system in question. River A types represent relatively straight streams, B represents low sinuosity, C represents meandering streams, E represents high meandering, and D/DA represent complex braided systems (Rosgen, 1994). This form of classification often uses the meander width ratio to describe the sinuosity. Plan view morphology is also very important for proper river restoration. Rosgen's method can be used for "describing the most probable state of channel pattern in stream restoration work," (Rosgen, 1994). See figure below for plan view morphology.



Level I Stream Classification

The Level I stream classification serves four primary functions:

1. provide for the initial integration of basin characteristics, valley types, and landforms with stream system morphology.
2. provide a consistent initial framework for organizing river information and communicating the aspects of river morphology. Mapping of physiographic attributes at Level I can quickly determine location and approximate percentage of river types within a watershed and/or valley type.
3. assist in the setting of priorities for conducting more detailed assessments and/or companion inventories.
4. correlate similar general level inventories such as fisheries habitat, river boating categories, and riparian habitat with companion river inventories.

The advantage of a broad, general classification is that it allows for a rapid initial delineation of stream types and illustrates the distribution of these types that would be encountered within a given study area. The Level I classification and delineation process provides a general characterization of valley types (addressed in the second part of this module), and identifies the corresponding major stream types, A through G, discussed here. Illustrations of the Level I stream types are shown in the accompanying figure; clicking on each stream type will also bring up a brief text description of that type in this text window.

The "Aa+" Stream Type

Stream type "Aa+" is very steep (>10%), well entrenched, has a low width/depth ratio, and is totally confined (laterally contained). The bedforms are typically a step/pool morphology with chutes, debris flows, and waterfalls. The "Aa+" stream types often occur in debris avalanche terrain, zones of deep deposition such as glacial tills and outwash terraces, or landforms that are structurally controlled or influenced by faults, joints, or other structural contact zones. Streamflow at the bankfull stage in the "Aa+" stream type is generally observed as a torrent or waterfall. The "Aa+" stream types can be associated with bedrock, and zones of deep deposition and/or be deeply incised in residual soils. The "Aa+" can often be described as high energy/high sediment supply systems due to their inherently steep channel slopes and narrow/deep channel cross-sections. "Aa+" stream types may also be found in alluvial landforms, where a change in the base level of the mainstem channel initiates a headward expansion of the tributary network through a channel rejuvenation process. Examples of rejuvenation may be observed where lower-slope position streams are deeply incised in over-steepened adjacent side-wall slopes, or older holocene terrace features that have cut their way through to the elevation of the existing mainstem river. The "Aa+" stream types are often found in valley types I, III, and VII, discussed in the next part of this module.

The "A" Stream Type

Stream type "A" is similar to the described "Aa+", in terms of associated landforms and channel characteristics. The exception being that channel slopes range from 4 to 10 percent, and streamflows at the bankfull stage are typically described as step/pools, with attendant plunge or scour pools. Normally, "A" stream types are found within valley types that due to their inherent channel steepness, exhibit a high sediment transport potential and a relatively low in-channel sediment storage capacity. Although a large number of "A" stream types occur as low-order streams, located at upper-slope positions, stream order for these stream types can range from 1st order up to 5th order or larger. Stream order referred to is that of Strahler, where the incipient crenulation of a drainage way on the landscape is order 1 and the confluence of the first two drainage ways become order 2 and so on. The influx of large organic debris can play a major role in determining the bedform and overall channel stability of "A" stream types. Landforms associated with deeply incised fanhead troughs are associated with both "Aa+" and "A" stream types. Valley types associated with the "A" stream types are I, III, and VII.

The "B" Stream Type

The "B" stream types exist primarily on moderately steep to gently sloped terrain, with the predominant landform seen as a narrow and moderately sloping basin. Many of the "B" stream types are the result of the integrated influence of structural contact zones, faults, joints, colluvial-alluvial deposits, and structurally controlled valley side-slopes which tend to result in narrow valleys that limit the development of a wide floodplain. "B" stream types are moderately entrenched, have a cross-section width/depth ratio (greater than 12), display a low channel sinuosity, and exhibit a "rapids" dominated bed morphology. Bedform morphology, which may be influenced by debris constrictions and local confinement, typically produces scour pools (pocket water) and characteristic "rapids." Streambank erosion rates are normally low as are the channel aggradation/degradation process rates. Pool-to-pool spacing is generally four to five bankfull widths, decreasing with an increase in slope gradient. Meander width ratios (belt width/bankfull width) are generally low which reflect the low rates of lateral extension. "B" stream types are usually found within valley types II, III, and VI.

The "C" Stream Type

The "C" stream types are located in narrow to wide valleys, constructed from alluvial deposition. The "C" type channels have a well-developed floodplain (slightly entrenched), are relatively sinuous with a channel slope of 2% or less and a bedform morphology indicative of a riffle/pool configuration. The shape and form of the "C" stream types are indicated by cross-sectional width/depth ratios generally greater than 12, and sinuosities exceeding 1.2. The "C" stream type exhibits a sequencing of steeps (riffles) and flats (pools), that are linked to the meander geometry of the river where the riffle/pool sequence or spacing is on the average one-half a meander wavelength or approximately 5-7 bankfull channel widths. The primary morphological features of the "C" stream type are the sinuous, low relief channel, the well-developed floodplains built by the river, and characteristic "point bars" within the active channel. The channel aggradation/degradation and lateral extension processes, notably active in "C" stream types, are inherently dependent on the natural stability of streambanks, the existing upstream watershed conditions and flow and sediment regime. Channels of the "C" stream type can be significantly altered and rapidly de-stabilized when the effects of imposed changes in bank stability, watershed condition, or flow regime are combined to cause an exceedance of a channel stability threshold. "C" stream types may be observed in valley types IV, V, VI, VIII, IX and X. They can also be found on the lower slope positions of the very low gradient valley type III.

The "D" Stream Type

The "D" stream type is uniquely configured as a multiple channel system exhibiting a braided, or bar-braided pattern with a very high channel width/depth ratio, and a channel slope generally the same as the attendant valley slope. "D" type stream channels are found in landforms and related valley types consisting of steep depositional fans, steep glacial trough valleys, glacial outwash valleys, broad alluvial mountain valleys, and deltas. While the very wide and shallow "D" stream types are not deeply incised, they can be laterally contained in narrower or confined valleys. Bank erosion rates are characteristically high and meander width ratios are very low. Sediment supply is generally unlimited and bed features are the result of a convergence/divergence process of local bed scour and sediment deposition. The multiple channel features are displayed as a series of various bar types and unvegetated islands that shift position frequently during runoff events. Adjustments in channel patterns can be initiated with either natural or imposed changes in the conditions of the encompassing landform, contributing watershed area, or the existing channel system. Aggradation and lateral extension are dominant channel adjustment processes occurring within a range of landscapes from desert to glacial outwash plains. Typically, the runoff regime is "flashy," especially in arid landscapes with highly variable extremes of stage occurring on an annual basis which generates a very high sediment supply. Braided channel patterns can be found developing in very coarse materials located in valleys with moderately steep slopes, to very wide, flat, low gradient valleys containing finer materials. The "D" stream type may develop within valley types III, V, VIII, IX, X, and XI.

The "DA" (Anastomosed) Stream Type

The "DA" or anastomosed stream type is a multiple-thread channel system with a very low stream gradient and the bankfull width of each individual channel noted as highly variable. Stream banks are often constructed with fine grained cohesive bank materials, supporting dense-rooted vegetation species, and are extremely stable. Channel slopes are very gentle, commonly found to be at or less than .0001. Lateral migration rates of the individual channels are very low except for infrequent avulsion. Relative to the "D" stream type, the "DA" stream type is considered as a stable system composed of multiple channels. Channel width/depth ratios and sinuosities may vary from very low to very high. The related valley morphology is seen as a series of broad, gently sloping wetland features developed on or within lacustrine deposits, river deltas or splays, and fine-grained alluvial deposits. The "DA" stream types make up a very small number of observed stream types, but are unique both in the process of their creation and maintenance. In certain locations operating at a "control" point within a valley, maintains the valley base level where a vertical balance exists between the rate of deposition and the rate of uplift. The geologic processes responsible for development of the anastomosed river include subsidence of sedimentary basins in tectonically active forelands, valley base level rise at the basin outlet, regional basin tilting derived from glacial-induced differential isostatic rebound, and the uplifting of sea or lake bed levels. The bedform features of the "DA" stream types are riffle/pool, similar to stream types "C" and "E." The streambanks and island surfaces between channels are well vegetated and constructed with either fine grained alluvium, or fine, cohesive depositional materials. The ratio of bedload to total sediment load is very low for these very stable stream types. The "DA" stream type normally occurs in valley types X and XI.

The "E" Stream Type

The "E" type stream channels are conceptually designated as evolutionary in terms of fluvial process and morphology. The "E" stream type represents the developmental "end-point" of channel stability and fluvial process efficiency for certain alluvial streams undergoing a natural dynamic sequence of system evolution. The "E" type system often develops inside of the wide, entrenched and meandering channels of the "F" stream types, following floodplain development on and vegetation recovery of the former "F" channel beds. The "E" stream types are slightly entrenched, exhibit very low channel width/depth ratios, and display very high channel sinuosities which result in the highest meander width ratio values of all the other stream types.

The bedform features of the "E" stream type are predominantly a consistent series of riffle/pool reaches, generating the highest number of pools per unit distance of channel, when compared to other riffle/pool stream types (C, DA, and F). "E" type stream systems generally occur in alluvial valleys that exhibit low elevational relief characteristics and physiographically range from the high elevations of alpine meadows to the low elevations of coastal plains. While the "E" stream types are considered as highly stable systems, provided the floodplain and the low channel width/depth characteristics are maintained, they are very sensitive to disturbance and can be rapidly adjusted and converted to other stream types in relatively short time periods. The "E" stream type typically develops within valley types VIII, X, and XI.

The "F" Stream Type

The "F" stream types are the classic "entrenched, meandering" channels described by early day geomorphologists, and are often observed to be working towards re-establishment of a functional floodplain inside the confines of a channel that is consistently increasing its width within the valley. "F" stream types are deeply incised in valleys of relatively low elevational relief, containing highly weathered rock and/or erodible materials. The "F" stream systems are characterized by very high channel width/depth ratios at the bankfull stage, and bedform features occurring as a moderated riffle/pool sequence. "F" stream channels can develop very high bank erosion rates, lateral extension rates, significant bar deposition and accelerated channel aggradation and/or degradation while providing for very high sediment supply and storage capacities. The "F" stream types occur in low relief valley type III, and in valley types IV, V, VI, VIII, IX, and X

The "G" Stream Type

The "G" or "gully" stream type is an entrenched, narrow, and deep, step/pool channel with a low to moderate sinuosity. Channel slopes are generally steeper than .02, although "G" channels may be associated with gentler slopes where they occur as "down-cut" gullies in meadows. The "G" stream type channels are found in a variety of landtypes to include alluvial fans, debris cones, meadows, or channels within older relic channels. The "fanhead trench" which is a channel feature deeply incised in alluvial fans is typical of "G" type stream channels. With the exception of those channels containing bedrock and boulder materials, the "G" stream types have very high bank erosion rates and a high sediment supply. Exhibiting moderate to steep channel slopes, low channel width/depth ratios and high sediment supply, the "G" stream type generates high bedload and suspended sediment transport rates. Channel degradation and sideslope rejuvenation processes are typical. The valley types supporting the "G" stream types are I, III, V, VI, VII, VIII, and X. The "G" stream type can also be observed in valley types II, VI, VIII and X, under conditions of instability or disequilibrium that are often imposed by watershed changes and/or direct channel impacts.

Level II represents the morphological description of the channel. The next level of classification further describes the stream system in a more specific manner. This level breaks the channel into discreet slope ranges and introduces particle sizes of channel material. The stream types are given numbers to represent particle size diameter of the material with 1 representing bedrock, 2 is boulder, 3 is cobble, 4 is gravel, 5 is sand, and 6 is silt/clay. This generates 42 major stream types. The morphological description can only be applied to a limited length of river channel. This is due to the fact that morphology of stream systems often changes in a relatively short distance. Level II is therefore applied to only individual reaches, as opposed to being averaged over the entire basin (Rosgen, 1994).

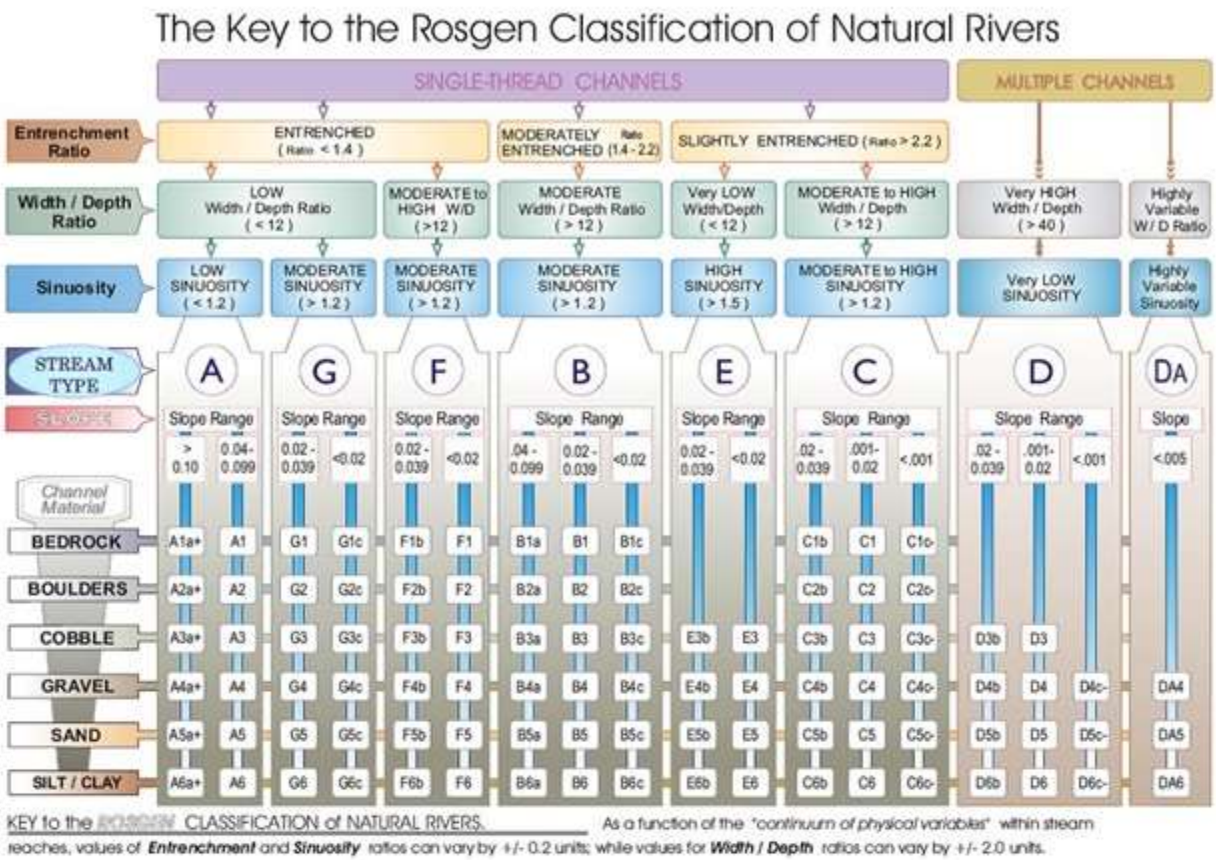
The continuum concept is also applied to Level II. As stated before, stream systems are often changing throughout its length. Some parameters change while others stay the same and therefore only one or two of the variables that define a stream classification will be outside of the presented values. "This level recognizes and describes a continuum of river morphology within and between stream types," (Rosgen, 1994). This application allows stream parameters such as slope to be sorted in sub-categories as opposed to slope. For example, if the majority of variables of a stream fit in the classification of C4 but has a slope of less than 0.001, the stream can be classified as C4c- (Rosgen, 1994).

Other variables considered at this level are entrenchment, width/depth, and sinuosity. For entrenchment, the entrenchment ratio can be defined as "the width of the flood-prone area to the bankfull surface width of the channel," (Rosgen, 1994). The entrenchment ratios are given numbers for classification where 1 to 1.4 are significantly entrenched streams, 1.41 to 2.2 can be described as moderately entrenched, and greater than 2.2 are slightly entrenched. Width/depth ratio can be described as "the ratio of bankfull channel width to mean depth," (Rosgen, 1994). A small ratio can be considered less than 12 while a moderate to high ratio is considered greater than 12. Sinuosity is defined as "the ratio of stream length to valley length," (Rosgen, 1994). Sinuosity is often linked to slope and particle size of the channel and leads into our next topic of consideration.

Level II also addresses channel materials and slope. Channel materials play important roles in sediment transport as well as the development of the form, plan, and profile of the channel (Rosgen, 1994). Channel materials are classified using the pebble count method. Water surface slope plays an important role in channel morphology. Slopes, like other variables, can delineate from the expected values of the channels classification and therefore can be addressed with the continuum concept.

Level III describes the state of streams and helps measure existing conditions in response to channel change. This level acts as a method to propose prediction methodologies and can be used to aid in restoration efforts. Important variables in order to apply Level III include riparian vegetation, depositional patterns, meander patterns, confinement features, fish habitat indices, flow regime, river size category, debris occurrence, channel stability index, and bank erodibility (Rosgen, 1994).

The last level of classification in the Rosgen method is Level IV, which describes verification. This level provides specific information on stream processes used to verify various parameters. This level helps "provide sediment, hydraulic and biological information related to specific stream types," (Rosgen, 1994). Classification at this level requires measurements and observations of sediment transport, bank erosion, channel geometry, biological data, and riparian vegetation data (Rosgen, 1994). See figure 5 for the breakdown of Rosgen's classification.

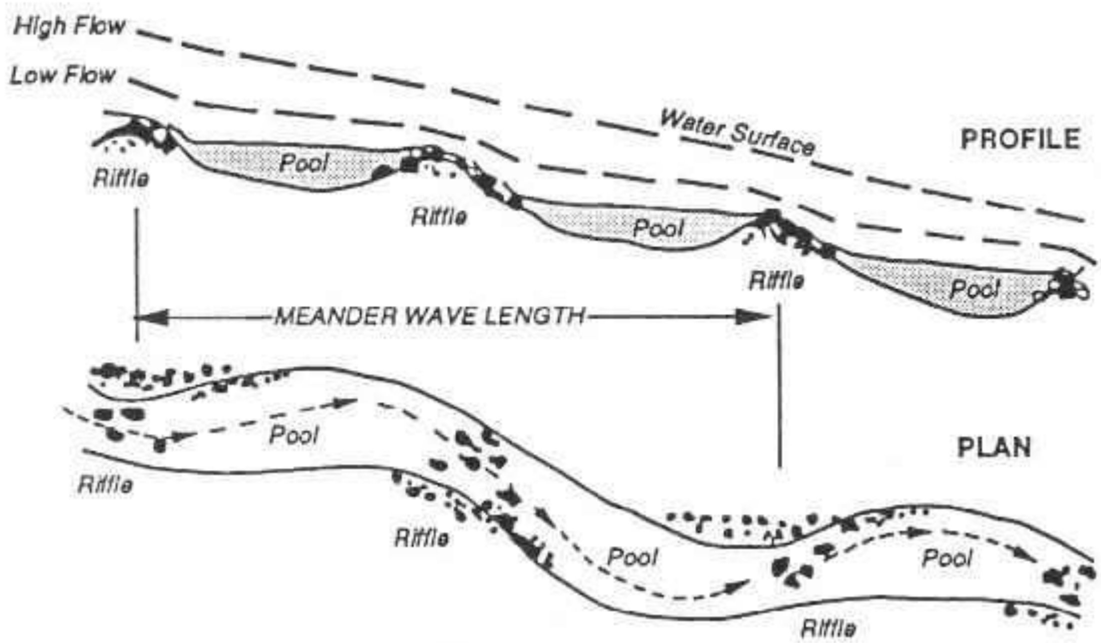


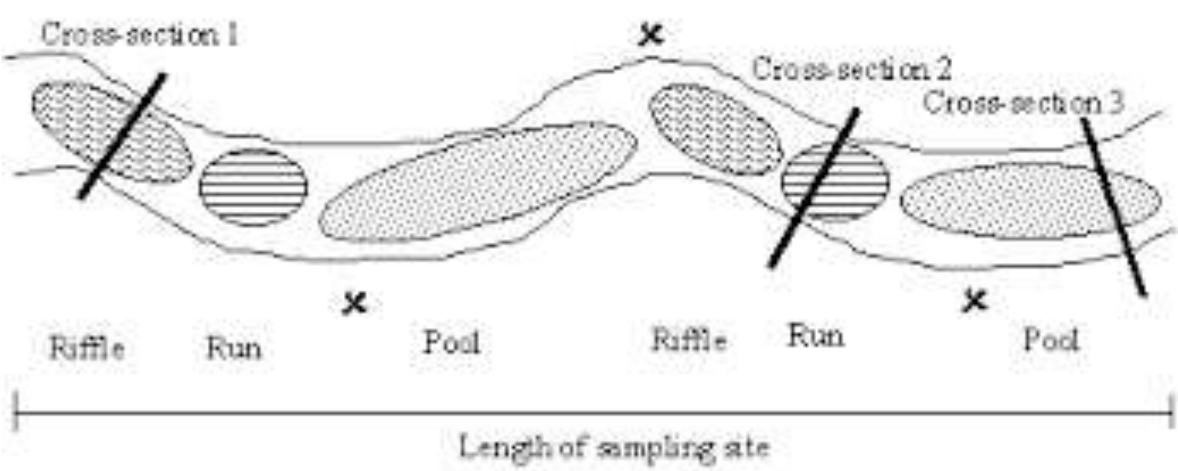
Rosgen's method is currently the most used classification system. Rosgen also discusses applying the system to restoration efforts. Historical data has shown that streams have been changing character due to imposed anthropogenic alterations in order to provide things like flood control, hydro-electric power, and allocation of water rights. These variables used to classify a river are often changed due to these alterations. Therefore, "to restore the "disturbed" river, the natural stable tendencies must be understood to predict the most probable form," (Rosgen, 1994). Stream classification aids in providing the restoration team with knowledge of how a system's variables naturally behave.

Source: USEPA Watershed Academy, Fundamentals of Rosgen Stream Classification System

Appendix E - Stream Classification Tools – Sketching Stream Features

The following images are provided to support completion of the “Site Assessment Diagram” portion of the CNMI-SVAP (Part 3). Inclusion of a stream segment profile and cross section are encouraged.





Appendix F - Stream Classification Tools – Bankfull Discharge: Principles and Indicators

"Bankfull discharge" is a frequently occurring peak flow whose stage represents the incipient point of flooding. It is often related to the elevation associated with a shift in the hydraulic geometry of the channel and is often associated with a return period of 1-2 years, with an average of 1.5 years. Bankfull discharge is expressed as the momentary maximum of instantaneous peak flows rather than the mean daily discharge. Bankfull discharge plays a fundamental role in shaping alluvial channels. Because site visits are often not made during a bankfull event, physical indicators (floodplains, depositional features, breaks in slope, changes in vegetation) must often be relied upon. Rosgen outlines four basic principles for bankfull stage indicators, and highlights common bankfull stage indicators to support field assessments as follows.

Bankfull Discharge: Basic Principles

Locating bankfull is a skill that is developed over time by field observations of different stream types in a variety of climates. However, four basic principles apply to reliable indicator selection. These are:

1. Seek indicators in the locations appropriate for specific stream types.
2. Know the recent flood and drought history of an area to avoid being misled by spurious indicators (e.g. flood debris accumulation caught in up-gradient trees following an unusual or extreme flood event).
3. Use multiple indicators whenever possible to reinforce common stage elevation observations.
4. Where possible, calibrate field-determined bankfull stage elevation and corresponding bankfull channel dimensions to known recurrence interval discharges at gage stations. This procedure, called "calibrating bankfull stage" can verify the difference between floodplain of the river and the low terrace. Where no existing gages are installed, gage installation and monitoring may be warranted to ground-truth observations.

Bankfull Discharge: Indicators

The following are common bankfull stage indicators:

1. **Floodplains.** The term bankfull elevation is often associated with the point at which the stream begins to spread out onto the floodplain. This definition can be applied to stream types C, D, DA, and E, which often have well-developed flopodplains. However, this approach does not apply to entrenched stream types (A, B, F, and G), which generally do not have floodplains. Do not confuse the low terrace with the floodplain. Terraces are abandoned floodplains that often have perennial vegetation and definite soil structure.
2. **Highest active depositional feature.** The elevation on top of the highest depositional feature (point bar or central bar) within the active channel is often associated with bankfull stage. These depositional features are especially good bankfull indicators for confined channels.
3. **Slope breaks or change in particle size distribution.** Breaks in slope of the banks or a change in the particle size distribution from coarse to fine is often associated with deposition by overland flow.
4. **Evidence of an inundation feature such as small benches.** Benches, or flat / shallowly sloped areas slow high velocity flows during high flow events, and are therefore strong indicators of bankfull width.
5. **Staining of rocks.**
6. **Exposed root hairs below an intact soil layer indicating exposure to erosive flow.**
7. **Lichens and, for some stream types and locales, certain riparian vegetation species.**

Adapted from Wildland Hydrology: River Morphology, Field Day Instructions and Forms, 2011.

References

Bjorkland, R., Pringle, C.M., and Newton, B. 2001. A Stream Visual Assessment Protocol (SVAP) for Riparian Landowners. Environmental Monitoring and Assessment. 68(2): 99-125.

de Jesús-Crespo, R. and Ramirez, A. 2011. The Use of a Stream Visual Assessment Protocol to Determine Ecosystem Integrity in an Urban Watershed in Puerto Rico. Physics and Chemistry of the Earth. 36 (12): 560-566.

Frothingham, K.M., and Bartlett, A.M. 2012. Using the Stream Visual Assessment Protocol (SVAP) as a Monitoring Tool to Assess Stream Corridor Conditions Over Time. Middle States Geographer 45:10-20.

Hannaford, M.J., Barbour, M.T., and Resh, V.H. 1997. Training Reduces Observer Variability in Visual-based Assessments of Stream Habitat. Journal of the North American Benthological Society 16(4): 853-860.

Harrelson, C., L. Rawlins, and J.P. Potyondy (1994). Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA General Technical Report (RM–245): 61.

Leopold, L. B., & Wolman, M. G. (1957). River channel patterns: braided, meandering and straight. *United States Geological Survey Professional Paper 282 - B,* 39-84.

Natural Resources Conservation Service (NRCS), 1998 (SVAP). Stream Visual Assessment Protocol. Technical Note 99-1. U.S. Dept. of Agriculture – Natural Resources Conservation Service.

Natural Resources Conservation Service (NRCS), 2001 (HI-SVAP). Hawaii Stream Visual Assessment Protocol. USDA/NRCS, Hawaii, 12pp.

Natural Resources Conservation Service (NRCS), 2009 (SVAPV2). Stream Visual Assessment Protocol Version 2. National Biology Handbook, Subpart B-Conservation Planning, 75 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology Books, Fort Collins, CO.

Salafsky, Margoluis, & Redford, 2001. Adaptive Management: A Tool for Conservation Practitioners. Available at http://www.fosonline.org/wordpress/wp-content/uploads/2010/06/AdaptiveManagementTool.pdf.

Simon, A., Doyle, M., Kondolf, M., Shields Jr., F., Rhoads, B., & Mcphillips, M. (2007). Critical evaluation of how the Rosgen Classification and associated "Natural Channel Design" methods fail to integrate and quantify fluvial processes and channel response. *Journal of the American Water Resources Association*, 1117-1131.

USDA Forest Service. 2005. Guide to Identification of Bankfull Stage in the Northeastern United States. Gen. Tech. Rep. RMRS-GTR-133-CD. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

University of Hawaii, 2002. The Hawaii Stream Bioassessment Protocol. Version 3.01. The Hawaii Stream Research Center for Conservation Research and Training. Honolulu, Hawaii.

Verry, E.S., 2005. The How and Why of Pebble Counts to Characterize Stream Channel Sediment. Ellen River Partners, Grand Rapids, Minnesota.

Yochum, S. E., 2016. Guidance for Stream Restoration and Rehabilitation. Technical Note TN-102.2. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. Available at https://www.fs.fed.us/biology/nsaec/assets/yochumusfs-nsaec-tn102-2gudncstrmrstrtnrhbltn.pdf.

Washington State Department of Ecology, 2005. Estimating Discharge and Stream Flows. Ecology Publication Number 05-10-070. Available at https://fortress.wa.gov/ecy/publications/documents/0510070.pdf.