Municipal Watershed Mapping Data Dictionary

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MUNICIPALITY OF ANCHORAGE
WATERSHED MANAGEMENT PROGRAM

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WATERSHED FEATURES

Watershed features are distributed land features and qualities that can be grouped through their association with and importance to specific hydrographic features

WATERSHED FEATURES

A "watershed" is a hydrographic feature defined as the drainage basin of any stream whose outlet discharges to a marine or coastal wetland feature, and includes the drainage basins of all its tributaries. As defined here, a "watershed" extends from a drainage divide to a marine outlet. A drainage basin is defined as an area of the surface of the lithosphere that is occupied by a stream drainage system or contributes surface water to that system. A drainage divide is the furthest surface extent of a drainage basin and is the boundary between adjacent drainage systems.

At Anchorage, watersheds identified by the Municipality to date include Virgin Creek, Glacier Creek, McHugh Creek, Potter Creek, Little Survival Creek, Rabbit Creek, Furrow Creek, Campbell Creek, Hood Creek, Fish Creek, Chester Creek, Ship Creek, Eagle River, Fire Creek and Peters Creek. Most of these watershed streams also include well known tributary streams that lie within the watershed of the main stem.

WATERSHED MANAGEMENT UNITS

A "watershed management unit" (WMU) consists of all or part of a watershed and incorporates surface runoff tributary areas having common hydrologic and geographic characteristics. WMUs are intended to provide a means of prioritizing and focusing watershed management activities towards manageable portions of whole watersheds that have generally common qualities. The Municipality and its co-permittee, DOT&PF, identified 27 initial WMUs in Part 1 of their NPDES application to discharge storm water (*Storm Water Discharge Permit Application, Part 1*, May, 1992, p.3-3). However, these watershed management units are intended as flexible tools, and their boundaries and numbers may change as priorities and focus of the co-permittees' storm water program evolves.

HYDROGRAPHIC FEATURES AND ATTRIBUTES

Hydrographic features are surface and sub-surface water bearing and conveyance features. Within the Municipality's hydrographic classification, these include both natural and human-constructed features. Major classes include:

- Snow and Ice Features
- Ground Water Features
- Marine Features
- Wetland Features
- Lake Features
- Watercourse Features

Watercourse features include two important subclasses as well, "Streams" and "Drainageways".

Detailed definitions of these features and their identifying characteristics are discussed in the Municipality's Watershed Management document WMP APg97002, "Classification System for Municipal Hydrologic Features". Municipal mapping methods and data limitations for these hydrographic features and their attributes are described in the following section.

Snow and Ice Features

Snow and ice features include naturally-occurring perennial accumulations of snow and ice, including glaciers and snowfields. This feature class also represents significant natural accumulations of snow that recur annually or periodically but that are typically melted by the end of a summer. These include, for example, regularly recurring snowdrifts and snow avalanche deposits. Some of these features have been systematically mapped by the Municipality and other agencies, though mapping products are not generally available in digital form. Snow and ice features are critical elements in the character of Anchorage surface and ground water hydrology but currently are not actively mapped by the Municipality.

GROUND WATER FEATURES

Ground water features include all spatially significant and definitive water-saturated zones beneath the earth's surface, both shallow and deep. They include aquifer and non-aquifer features. Little comprehensive mapping of these features exists for the Municipal area, though public and private efforts have locally defined the location and character of some. Though these features are critical in the function and existence of most natural Anchorage surface waters, they currently are not mapped by the Municipality.

MARINE FEATURES

Generally, within the Municipality's hydrographic classification, marine features include those standing bodies of water that are openly connected to the sea. For the Municipality of Anchorage, marine features include the Cook Inlet, Turnagain Arm, and Knik Arm and all of their major embayments.

Marine features mapped by the Municipality include:

- Marine
- Shoreline
- Tideland
- Map Shoreline

Mapping definitions and guidance for each of these features and their attributes follows.

Feature—Marine

Associated Features

- Shoreline
- Tideland
- Map Shoreline

Definition

A "Marine" feature is a large body of brackish or saline water that has unrestricted connection to the ocean and that ebbs and flows with the tide.

Functional Indication

At Anchorage "marine" features are the tidal waters encompassed by Turnagain and Knik Arms and Cook Inlet adjacent to the Municipality.

Representation Method

Municipal marine features are represented as areas lying seaward of the mean high water line (MHWL), and as shown on National Coast and Geodetic Survey charts and maps (or US Geological Survey maps where Coast and Geodetic Survey charts are not available). Where marine features border river estuaries, the marine boundary is represented by the landward-most position of the combined trace of the headland-to-headland line and the mean low water line (MLWL).

Mapping Method

Marine and Shoreline features are generally mapped simultaneously, because the boundary of a Marine feature where it is marginal to freshwaters or land is, by definition, a Shoreline feature. Municipal mapping of these features generally follows the following process:

- Acquire Coast and Geodetic Survey (or USGS) mean high water line and mean low water line digital data
- Map areas seaward of the mean high water line as "marine"
- Inspect data in relation to select baseline imagery at a scale of 1:1200 and update marine boundaries to reflect fill and other shoreline changes
- Adjust marine boundaries at river estuaries following the landward-most trace of a combined headland-to-headland line and mean low water line.

Feature—Shoreline

Definition
A "Shoreline" is the line of contact between land or bodies of freshwater and a marine body of water.

Functional Indication
A Shoreline is useful as a "hard" mapped line between land and sea even though, in reality, the boundary is often transitional.

Representation Method
At the boundary between land and sea, the Shoreline is represented as the mean high water line (MHWL) as shown on Coast and Geodetic Survey nautical charts and surveys or USGS maps. Where the Shoreline crosses river estuaries, it is represented as the landward-most position of the combined trace of the mean low water line (MLWL) and the headland-to-headland line.

Mapping Method
Mapping methods for Shoreline features are described under "Marine" features.

Feature—Tideland

Definition
A Tideland is the land that is covered and uncovered by the normal daily rise and fall of the tide. Near Anchorage this zone may include both mudflats and beaches.

Functional Indication
Location of the higher energy zone typically represented by tidelands is particularly important to the Municipality. At Anchorage tide ranges are some of the largest in the world, winter ice floes annually clog marine waters, shore currents are vigorous, and tidal zones are often covered by dangerous mudflats.

Representation Method
Tidelands are generally represented as that area between the mean high waterline and the mean low water line. At river estuaries, tidelands are represented as that area between the mean high water line and the mean low water line, excluding the river surface area at its bankfull depth.

Mapping Method
Municipal mapping of "tideland" features generally follows the following process:

- Establish a Municipal "marine" feature boundary.
- Using Coast and Geodetic Survey mean low water line digital data, identify those areas between the Municipal marine boundary and the mean low water line as "tideland"

Feature—Map Shoreline

Definition

The Municipal "map shoreline" is the boundary between land and sea at an elevation where the land is considered free from any annual or other periodic tidal inundation or impact. The "map shoreline" may be placed landward of "emerged" tidal flats, coastal marshes, or other low-lying coastal features.

Functional Indication

The "map shoreline" shows the apparent boundary at which tidal influences are no longer predominant. Its primary intended purpose is as a graphic boundary consistent for use with select ortho-imagery used in Municipal base maps and other publications.

Representation Method

A "map shoreline" is represented by a line drawn at an elevation at or above the mean higher high water line, and consistent with the presence of predominantly terrestrial vegetation.

Mapping Method

A "map shoreline" is generated through simultaneous inspection of ortho-imagery and the trace of the mean higher high water line (MHHWL) as mapped on Coast and Geodetic Survey charts and maps. However other map shoreline features may be developed on project specific bases for particular graphic applications.

WETLAND FEATURES

Wetland features include all wetland areas as defined by the U.S. Army Corps of Engineers and as administered through the Anchorage Wetlands Management Plan. Wetland boundaries are determined by special investigations and are only generally represented by Municipal maps. Anchorage wetlands are categorized by their functional quality that, in part, determines their suitability for development. Based on these qualities, Municipal wetlands are attributed as type A, B or C. For mapping definitions and methodology, refer to the Anchorage Wetlands Management Plan.

LAKE FEATURES

Lake features are those areas encompassed by either pond or lake waters. In general, lakes and ponds are inland bodies of open, standing water. Typically they are perennial features but may also form and dissipate seasonally.

Lake features mapped by the Municipality include:

- Lake
- Lake Shoreline

Mapping definitions and guidance for these features and their attributes follows.

Feature—Lake
Associated Features

- Lake Shoreline

Definition
A lake is a perennial or ephemeral inland body of open, standing water which is not actively maintained for, or constrained to, a single specific human use (e.g., wastewater treatment ponds or flood detention ponds). Thus, an inland waterbody may serve some single, important human function (e.g., water supply) but to the extent that it is maintained to serve other functions as well (e.g., provision of fish and wildlife habitat and recreation opportunities) it will be identified as a lake feature under this classification. Conversely, to the extent that a standing body of water is controlled for a single, limited human use (exclusive of contact recreation and fish and wildlife habitat), it will not be identified as a lake under this classification system.

Lake features may include expanded parts of rivers, reservoirs behind permanent dams, and basins seasonally inundated by intermittent stream flows. Lakes, as defined here, include natural lakes, run-of the river lakes or impoundments, abandoned "gravel pit" lakes or other constructed lakes, reservoirs, and bog ponds.

Note that under this definition lakes are not classified by size. Small inland waters more commonly referred to as ponds may be identified as "lake" features. However, a lake, by definition, is characterized by open water. Thus, standing water that exists solely amongst vegetation (e.g., as in a swamp, marsh or mire) does not comprise a "lake".

Functional Indication
Lakes are important surface water resources that support aquatic and other wildlife, provide flood detention for storm water runoff, and provide recreational and aesthetic value. A lake's character is the cumulative result of the complex interactions of climate and terrain, surrounding land practices, and the nature of the ground and surface waters entering it. Thus lake attributes are important indicators of the nature of these contributing watershed systems.

Feature—Lake Shoreline

Definition
A lake shoreline is the boundary between lake water and land.

Functional Indication

Representation Method
For most lakes the water level is relatively constant and the shoreline can be reasonably represented by a line tracing the elevation of the average lake level. However for ephemeral lakes or reservoirs the lake level can change dramatically during each year. Therefore for Municipal maps, a lake shoreline is represented by the line tracing the lake border at the mean annual high water level of the lake.

Watercourse Features

A "watercourse" is a natural channel produced wholly or in part by the flow of water, or an artificial channel constructed for the conveyance of surface water. In short, a watercourse represents almost any surface water conveyance feature. By this definition, a mountainside rill, a drainage ditch, and a natural stream course are all "watercourses". Clearly there are important distinctions between these features. To help recognize these differences, the Municipality has further categorized watercourses as either "drainageway" or "stream" features.

Mapping definitions for stream and drainageway features and their attributes follows.

Feature—Stream

Associated Features

- Flood Zone
- Source
- Outlet
- EndMap
- Control
- Reach

Definition

A stream is a watercourse perennially or intermittently conveying waters not solely the result of drainage construction or storm water runoff. If the stream feature is not piped, it has banks and a bed. A stream also maintains its identity as a watercourse even though it may periodically break up and disappear along its alignment.

Functional Indication

Streams are important water resources that support aquatic and other wildlife, provide flood passage and detention for storm water runoff and stream icings, and provide recreational and aesthetic value.

Representation Method

Municipal stream features are represented by a series of connected straight line segments—each of which are equal to or less than 10 meters in length—mapped along the approximate centerline of the stream as observed in selected ortho-imagery or as located in land or FEMA-administered floodplain surveys. The stream centerline is that line formed by all points located midway between the stream's banks at the bankfull elevation

Feature—Flood Zone

Definition

"Food zones" are those areas that are inundated by stream flood waters of specified return periods. Municipal "flood zone" types (representative of inundation from different flood return periods) are as defined and approved by the Federal Emergency Management Agency (FEMA).

Functional Indication

Flood zones identify those areas that periodically receive overbank flood flows and that are subject to the range of effects commonly associated with stream flooding. Maps of these areas provide indication of the potential for increased downstream channel erosion and flood wave impact. They may also provide important indication of flood flow detention and flood wave attenuation available to different stream reaches.

Representation Method

All Municipal flood zones are represented by map areas developed, approved, administered and distributed under FEMA.

Feature—Stream Source
Associated Attributes

- Stream Source Type

Definition
A *stream source* is the beginning point of flow in a feature mapped as a stream by the Municipality. In many instances headwater flows are contributed from numerous seeps rather than from one discrete source. In Municipal stream mapping, a source location is the upstream-most point at which sufficient indicators are present to allow reasonable identification of a feature as a discrete stream, as defined by Municipal criteria.

Functional Indication
A source feature is a geographic pointing device used to indicate the point at which the Municipality locates the beginning of a stream feature. Although in Municipal mapping a stream "source" is represented by a point to delineate the beginning of a stream as a discrete feature, the vicinity of a stream source is often a critical watershed management zone.

Representation Method
A stream "source" is represented by an end point on the stream centerline.

Attribute—Stream Source Type

Definition
"Stream source type" identifies the nature of incipient surface flow at the headwaters of a stream feature. Types of stream headwater sources include:

- Stream
- Spring
- Lake
- Wetland
- Snow Field
- Constructed Drainageway
- Natural Drainageway
- Unknown

Streams receiving source water from other stream features have a "stream" source type. Streams receiving source water from outlet flows from lakes or wetlands have "lake" or "wetland" sources respectively. Streams receiving source water originating from prolonged snowmelt (i.e., from a "snow and ice feature") have a "snow field" source. Streams receiving source water from constructed drainageways (including sustained ground water flows from storm drain systems) or from natural drainageways have "constructed" or "natural" drainageway sources respectively.

Functional Indication
Types of headwater sources of stream flow have important implications for management of stream hydrology and water quality. This information helps identify watershed features and areas that play critical roles in maintenance of stream resources.

Feature—Stream Outlet

Definition
A “stream outlet is the discharge point of a Municipally mapped stream. It is the downstream-most point of any individual stream feature.

Functional Indication
An outlet feature is used to indicate the point at which the Municipality locates the lower end of a discrete stream feature.

Representation Method
A stream’s “outlet” is represented by an end point on the centerline of the stream. Except where the stream directly infiltrates to ground water, this end point is an intersection point with the centerline representation of another stream or with a boundary of a marine, lake or wetland feature. Note that where one stream discharges to another stream, the representational location of the stream outlet, then, will incorrectly represent the actual ground location of the outlet of the tributary stream by half the width of the receiving stream.

Feature—Endmap

Definition

An “endmap” feature is the end extent of Municipal mapping. For a stream feature, it is an upstream or downstream end point of Municipal stream mapping.

Functional Indication

An “endmap” feature is used to indicate the upstream or downstream extent of Municipal stream mapping where Municipal mapping has not been completed from stream source to stream outlet. Endmap features indicate an expected significant continuation of a stream feature either upstream or downstream of the endmap point.

Representation Method

An “endmap” feature is represented by a point along the centerline of a stream.

Feature—Stream Control

Definition

A "stream control" is any permanently placed device that is either intended to, or in fact does, divert, direct, detain or otherwise control the flow of a stream. The Municipality recognizes three basic types of stream controls:

- dams or weirs
- stream crossing structures
- erosion control structures.

Stream crossing structures include highway and trail bridges, culvert crossings, utility crossings and other crossing structures. Erosion control structures include any devices placed within or near the stream channel with the intent to reduce or re-direct local stream flow energy and associated erosional forces.

Even though they clearly control stream processes and flows, significant lengths of pipe or engineered channels conveying stream flows are not classified as "stream controls". Instead, these channel qualities are mapped as attributes of discrete geographic segments ("subreaches") of a stream.

Functional Indication

Any structure placed in or near streams can play a significant role in the development of channel patterns and qualities both up and down stream from the structure and can alter the height of flood waves. Structures can also have a significant impact on development of stream icings, and on local erosion and deposition.

Representation Method

Stream controls are represented as points located along the centerline of a stream feature.

Feature—Reach

Associated Features

- Subreach

Associated Attribute

- Reach Slope

Definition

A "reach" is a stream segment having common adjacent watershed qualities that in part control the streams local character. A reach has generally similar "ultimate controls"—factors related to geology, landform, land cover and climate that play important roles in the stream's form and function. In this sense, adjacent riparian terrain characteristics and geology are relatively constant along a reach, as is slope. Drainage basins contributing local storm water flows directly to a reach have unique surface hydrology and pollutant generation characteristics, related to the land cover and land use qualities of the basins.

However, though these ultimate controls are often relatively constant over an individual reach, "proximate controls"—very localized channel and in-stream characteristics that affect or reflect a stream's form and function—may vary significantly along a reach. In Municipal stream mapping, unique groupings of these latter characteristics are delineated by segmentation of each reach into one or more "subreaches" (discussed in a following section).

Functional Indication

Reaches provide practicably sized stream segments that can be integrated at larger scales to expedite Municipal watershed management of whole streams. They provide a means of aggregating local variations in in-stream characteristics into stream segments that have otherwise similar watershed characteristics. Reaches, then, play a crucial role in allowing combined assessment of impacts of both watershed and stream (that is, ultimate and proximal) factors on opportunities for uses of streams. For more discussion of stream segmentation and its use in watershed management, see Bauer and Ralph, 1999 ("*Aquatic Habitat Indicators and Their Application to Water Quality Objectives Within the Clean Water Act*").

Representation Method

Reaches are represented as arc segments along a stream centerline.

Mapping Method

Reaches are selected through a two step process. Candidate stream segments are first identified based on inspection for generally common riparian terrain; stream slope; and qualities in adjacent outfall basins (specifically for characteristics of street type, land use, land cover, landform, and slope). Candidate stream segments are then further arbitrarily segmented to achieve manageable length and easily identifiable end points. Reach identification is performed initially using stereo models of aerial photography or other imagery, and available maps and digital and other spatial data sets.

Attribute—Reach Slope

Class attribute for *Reach* feature

Definition

"Reach slope" represents the ratio ($\Delta E/L$) of the difference, ΔE, in water surface elevations between the end points of a reach, and the length of the stream reach, L. In general it is intended to be an approximation of the slope of the stream water surface. However, at the reach scale, local stream grade breaks, cascades and small impoundments—not uncommon on smaller Anchorage streams—are accumulated into an estimate of stream slope generally appropriate for the larger reach feature. "Reach slope", then, may significantly over- or under-estimate local stream slopes along the reach.

Functional Indication

Water surface slope is a major determinant in channel morphology and hydrology. It is directly related to bed load and grain size and inversely related to stream discharge. Many stream classification systems use slope as a primary factor in grouping stream features.

Representation Method

Reach stream slope is represented by the ratio of elevation differences approximated from topographic maps or measured in field surveys, and stream reach lengths measured from mapped stream centerlines. Slope values are reported as unitless ratios (e.g., feet/feet).

Mapping Method

Reach stream slope is calculated from elevation differences estimated from topographic maps, and reach stream lengths measured from mapped centerlines. More accurate slope estimating techniques are employed only in measurement of stream water surface slopes at the subreach or smaller scale.

Feature—Subreach
Associated Attributes

Class Attributes
- Flow Type
- Routing Type

Channel Attributes
- Profile Type
- Maximum Bankfull Depth
- Mean Bankfull Depth
- Bankfull Width
- Width/Depth Ratio
- Floodprone Width
- Entrenchment
- Sinuosity
- Bed Material
- Bank Material
- Roughness Coefficient, n
- CEM Class
- Modification

Habitat Attributes
- Undercut Bank
- Canopy
- Invertebrate Habitat
- Fish Habitat

Definition
A "subreach" is a stream segment having generally common local channel and habitat characteristics. Because in Municipal stream mapping each subreach is a component of a reach, the "ultimate controls" (watershed characteristics) are the same for all subreaches within a given reach. Subreaches are distinguished by the unique character of each subreach's "proximal" (channel and in-stream) qualities. These quality attributes of subreaches are described in detail in the following sections of this document.

Functional Indication
Where reaches allow delineation and integration of watershed impacts on streams across whole stream systems, subreaches allow a similar delineation and integration of channel and in-stream qualities along a reach. Thus a subreach allows analysis at a much greater level of detail, and in terms of the qualities and functionality of the stream itself. Subreach information (integrated through the use of reaches) helps establish and monitor relationships between in-stream qualities and watershed qualities. Understanding and integrating these cause and effect relationships between watershed and stream is an essential element in effective watershed management.

Representation Method
Subreaches are represented as arc segments along a stream centerline. Within the Municipal mapping system every stream subreach is a subset of one and only one stream reach, and every reach is composed of one or more subreaches.

Mapping Method
Subreaches are mapped through determination of the general continuity of several channel and near-channel characteristics. These primary characteristics include “profile type”, channel “modification” and “CEM class”, and adjacent riparian terrain. “Profile type” designates the general character of the existing stream profile geometry (described in terms of distinctive longitudinal channel and bedform patterns such as pool/riffle, step/pool, etc.). “Channel modification” reflects the degree to which the existing stream channel has been altered, directed or otherwise channelized by human activities. The “CEM class” represents the general erosional and depositional stage in the evolution of a stream and, at Anchorage, is often reflected in the degree of human modification to the stream. Adjacent riparian terrain is assessed in terms of the quality of local relief and slope, geology, and the “upland” or “lowland” nature of adjacent stream banks. The general continuity of these characteristics are distinguished in the field by trained mappers as they proceed upstream from the beginning of a reach. The end of a subreach is marked by a substantial change in any one of the core qualities or by the end of the reach.

Attribute—Flow Type

Class Attribute for *Subreach* feature

Definition

"Flow type" classes a stream as having "perennial" or "intermittent" flow.

A "perennial" flow type is defined as a stream flow occurring throughout the year, except for extended periods of drought or cold. The source is not a criteria for identification of a perennial flow—confirmation of a continual flow alone is a sufficient condition for determination of perennial flow.

An "intermittent" flow type is defined as stream flow that is not perennial but still conveys flow from sources other than recent storm runoff. Intermittent flow occurs when:

- stream flow exceeds a duration solely attributable to a response to direct runoff OR
- the source of flow is sustained over a reasonable period of time AND
- the flow is not solely the result of drainage construction, or snow removal or snow disposal activities.

The character of the source(s) must imply the ability to sustain flow over a period of time. Examples of these types of sources include groundwater, wetlands, snow fields, and lakes and other impoundments.

Note that under the Municipality's classification system there is no such thing as an "ephemeral" stream. Ephemeral flows are defined as surface runoff resulting from a single storm event only, and therefore do not meet the basic criteria of a Municipal stream feature.

Functional Indication

Flow periodicity has important implications for the functional capabilities of streams.

Representation Method

Each subreach is assigned an attribute value for flow type of either "intermittent" or "perennial".

Mapping Method

Flow periodicity of a stream is initially mapped through inspection of stereo aerial photography and other available mapping and data, and later confirmed through field reconnaissance performed by trained observers. Mappers must apply criteria as described under the Municipality's hydrographic classification system.

Attribute—Routing Type
Class attribute for *Subreach* feature

Definition
"Routing type" generally defines the position of a subreach as part of a continuous unique stream feature. Routing types include "source", "stem", "continuity", and "outlet". A "source" subreach identifies a subreach that includes a stream "source" feature at one endpoint. Conversely, an "outlet" subreach identifies a subreach that includes a stream "outlet" feature at one endpoint. (Where the same subreach includes both the stream source and outlet endpoints, the subreach is designated as an "outlet" routing type.) Where the same stream feature both enters and exits a mapped wetland or lake feature or a spatially intermittent stream segment, the continuity of the stream network across the wetland, lake or intermittent segment is represented by a subreach identified as a "continuity" routing type.

Functional Indication
Routing type characteristics allow analysts and map users to rapidly identify and flag beginnings and end segments of streams. In the case of the "continuity" routing type, the network integrity of unique stream features is maintained for modeling purposes while allowing the easy recognition of important stillwater and wetland features along stream routes.

Representation Method
Routing type is assigned as a "source", "stem", "continuity" or "outlet" attribute value to a subreach feature.

Mapping Method
Routing type attributes are assigned by inspection of completed stream network maps by trained mappers.

Attribute—Profile Type
Class attribute for *Subreach* feature

Definition
A "profile type" represents a general longitudinal pattern in streambed morphology and hydraulic character. It is reflected in common sets of streambed geometric characteristics that vary longitudinally along a stream in generally predictable patterns. Longitudinal channel patterns and stream flow characteristics representative of individual profile types are those present or observable at base flows (flows less than bankfull). Profile types recognized in Municipal stream mapping include:

1. Pool/Riffle
2. Estuarine
3. Run
4. Braided
5. Step Pool
6. Cascade
7. Bog
8. Multi-channel
9. Flat
10. Piped
11. Continuity

These types are defined as follows.

Pool/Riffle: a "pool/riffle" profile stream segment has a meandering single-channel streambed morphology characterized by a uniformly repetitive sequence of deep, flow cross sections (pools) and shallow flow cross sections (riffles). Pool and riffle bed structures are well-defined, relatively large scale features with pronounced differences in stream flow velocities and turbulence between adjoining structures. The riffles typically have coarser bedload grain sizes than the pools.

Estuarine: an "estuarine" profile type is assigned to stream segments that are significantly influenced by the ebb and flow of the tide. At Anchorage, where sediment-filled fiords and emerged tidal flats are common near the marine shore, this often implies a relatively homogenous, evenly graded and sinuous channel morphology.

Run: a "run" is represented by a single-channel, relatively uniform and evenly-graded streambed morphology that carries a continuously shallow and moderately turbulent flow. In Anchorage, runs are often typified by low sinuosity channel patterns. Well-defined pool structures are generally absent, and, where present, have very small residual depth. For smaller streams having this profile type, flows may be too small to readily create any pool structures in local bed materials, particularly where streams have been channelized and armored.

Braided: a "braided" stream segment displays rapidly shifting, highly interconnected multiple-channel bed structure, reflected by an unstable longitudinal pattern of rapids and irregularly spaced, small scour pools. A braided profile type is distinguished by the intimate interconnectedness of the multiple channels and their highly unstable nature.

Step Pool: a "step pool" profile displays an irregular pattern of rapids and short drops closely interspaced with small, distinctive plunge, scour and eddy pools. The number and regularity of the small pool features preceeded by distinct vertical drops or "steps" clearly distinguish this profile type from runs.

Cascade: a "cascade" profile is characterized by predominant and very turbulent rapids, chutes and falls, and less frequent scour and plunge pools. Flow is typically very turbulent and fast and is the hallmark of this profile type.

Bog: a "bog" stream profile type is represented by single-channel, low-gradient streams having relatively smooth and featureless beds broken by infrequent and irregularly spaced riffle structures. These stream profiles are also characterized by low width to depth ratios and generally laminar flow. Channel patterns are moderately to very sinuous. Streams with these profiles typically occupy peatlands and often display substantial undercut in peat banks below the bankfull elevation.

Multi-channel: a "multi-channel" profile type is characterized by active but relatively stable multiple channels. This profile type is characteristic of some low gradient streams where they cross peatlands but may also be observed at some low-gradient delta landforms.

Flat: a "flat" profile type characterizes single-channel, low-gradient streams having relatively smooth and featureless longitudinal bed structures, or bed structures deeply submerged at base flow. "Flat" profile types display very slow, generally laminar flow. Little or no riffle bedforms are present though short rapids or drops may be present where local structures or debris impound the stream flow. "Flat" profiles have a distinctively higher width/depth ratio than "bog" profile types.

Piped: a "piped" profile includes all significant lengths of streams that are completely enclosed in human-placed conduit.

Continuity: a "continuity" profile type identifies topographic fall lines, lines of ground interflow or segments of surface water that are not stream features but that represent an approximate line of hydraulic continuity between two segments of the same stream. "Continuity" profile types exist, for example, between the two points where a stream enters and exits a lake, or the two points a stream enters and exits a segment of permeable surface sediments and flows as interflow.

Functional Indication

In combination with geologic parameters, profile characteristics are important indicators of a stream's channel dynamics and stability, the nature of its hydraulics, and the presence and quality of opportunities for aquatic wildlife habitat. Field identification of profile character provides one of the primary criteria for segmenting stream reaches into subreaches.

Municipal stream profile types are <u>not</u> intended to provide a stand-alone basis for comprehensive stream classification. They do, however, provide a generalized characterization of a range of stream qualities that may, in conjunction with other stream data, be useful in applying any of a number of existing stream classification systems. Along with riparian terrain, channel modification, and CEM class, the profile characteristic is a primary element used in field delineation of endpoints of discrete subreaches.

Representation Method

Qualitative field inspection for specific criteria is used to establish presence of individual profile types. Profile types are assigned as attribute codes to stream subreaches.

Mapping Method

Profile types are determined in the field by trained and qualified investigators. Initial "desktop" identification and aerial photo inspection of reaches in part limits the variability in, and provides preliminary indications of, profile types anticipated for a given reach. Field delineation is performed by in-stream traverse of each reach, starting at the reach's downstream endpoint and progressing upstream. The defining criteria described above and knowledge of the range in these characteristics in Anchorage streams are applied to identify segments of the reach having generally common profile characteristics. During field mapping, criteria used to distinguish profile types are applied to those stream patterns that are observed, or anticipated to be observed, at base flows (flows at less than bankfull stage).

Attribute—Maximum Bankfull Depth

Class attribute for *Subreach* feature

Definition

The maximum bankfull depth (in feet) of a stream is the maximum difference in elevation between the stream bed surface and the bankfull stage. The bankfull stage for a given stream segment is the elevation of the stream flood having an average return interval of 1.5 years.

Functional Indication

Knowledge of existing relationships between normal flood flow character and channel geometry has important applications in stream and watershed management activities as well as in responsible planning for engineering design and land development. Measurement of a few simple relationships allows us to make reasonable estimates of a stream's probable response to changing conditions based on relatively easily obtained information. This is possible because "normal" (most frequent) flood flows play a well-understood and central role in determining channel patterns and geometry, and in establishing and maintaining characteristic features and habitat qualities of a stream. Understanding these relationships allows us to use easily measured channel geometry information along with other stream data to predict flow characteristics (discharge, velocity, etc.) and to relate those projected parameters to norms for similar watersheds and streams. Based on these characterizations we can also predict functional response of a stream feature to existing or changed environmental conditions (e.g., to predict stream icing or erosion potential, channel stability, etc.) and thus generate information useful in planning and development decisions.

Representation Method

Maximum bankfull depth is a representative attribute value (in feet) assigned to a whole subreach. The value for the subreach is estimated from field measurement(s) made at one or more representative cross sections located along the subreach. Bankfull depth measurements are not made on "estuarine", "piped" or "continuity" profile types.

Mapping Method

Trained investigators measure bankfull depth information following field delineation of each subreach. One or more representative sections along the subreach are selected for bankfull depth measurement. All measurements are made from the stream thalweg (deepest channel position) at a riffle section (or similar hydraulic section) at a point 1/3rd of the length of the riffle above the lip of the riffle. In all cases measurements must be made at flows less than bankfull and at "straight" stream segments (i.e., at points of inflection in the stream thread where the lateral flow component is minimum).

At each cross section, establish the elevation of the bankfull stage through inspection of indicators. Indicators may include positions of: recent or active in-stream depositional features including small flood-carried debris; break in slope in stream banks or other erosional features; seasonal and specialized vegetative growth; exposed root structures; staining; and others. Bankfull stage must be located through the evidence of a preponderance of indicators as observed at multiple sections, and not by a single indicator, or indicators observed at only a single section.

Having established the elevation of the bankfull stage, measure maximum bankfull depth using an appropriate method. For smaller streams, position a wading rod at the thalweg (deepest channel location) along the cross section. Where the thalweg is less than 20 feet from the nearest bank, fix a tape at the bank at the bankfull stage elevation, tightly stretch it, and level it against the wading rod, referencing the tape to a carpenters bubble attached to the free end of the tape. After leveling the tape, use the wading rod to measure the depth (to the nearest tenth of a foot) from the channel bottom to the tape elevation to establish the maximum bankfull depth. For streams having widths greater than 20 feet, use an infrared or other suitable electronic distance-measuring device, transmitting to targets first leveled using a p-gun stationed at the bankfull stage. Alternatively, where stream water level across the width of the channel is not influenced by bed structure or lateral flow components, establish the difference (Δe) between the water level and bankfull stage at a point close to the bank using the wading rod and a stretched and leveled tape. Then calculate the maximum bankfull depth by measuring the maximum water depth at the thalweg location and summing the measured water depth and Δe. Average bankfull depth measurements made at all representative cross sections and record the average value to the nearest tenth of a foot.

Attribute—Mean Bankfull Depth

Class attribute for *Subreach* feature

Definition

The mean bankfull depth (in feet) of a stream is the mean difference in elevation between the stream bed surface and the bankfull stage. The bankfull stage for a given stream segment is the elevation of the stream flood having an average return interval of 1.5 years.

Functional Indication

Knowledge of existing relationships between normal flood flow character and channel geometry has important applications in stream and watershed management activities as well as in responsible planning for engineering design and land development. Measurement of a few simple relationships allows us to make reasonable estimates of a stream's probable response to changing conditions based on relatively easily obtained information. This is possible because "normal" (most frequent) flood flows play a well-understood and central role in determining channel patterns and geometry, and in establishing and maintaining characteristic features and habitat qualities of a stream. Understanding these relationships allows us to use easily measured channel geometry information along with other stream data to predict flow characteristics (discharge, velocity, etc.) and to relate those projected parameters to norms for similar watersheds and streams. Based on these characterizations we can also predict functional response of a stream feature to existing or changed environmental conditions (e.g., to predict stream icing or erosion potential, channel stability, etc.) and thus generate information useful in planning and development decisions.

Representation Method

Mean bankfull depth is a representative attribute value (in feet) assigned to a whole subreach. The value assigned the subreach is derived from field measurement(s) made at one or more representative cross sections located along the subreach. Bankfull depth measurements are not made on "estuarine", "piped" or "continuity" profile types.

Mapping Method

Trained investigators measure bankfull depth information following field delineation of each subreach. One or more representative sections along the subreach are selected for bankfull depth measurements. All measurements are made across a riffle section (or similar hydraulic section) at a point 1/3rd of the length of the riffle upstream from its lip. In all cases measurements must be made at flows less than bankfull and at "straight" stream segments (i.e., at approximate points of inflection in the stream thread where the lateral flow component is minimum).

At each cross section, establish the elevation of the bankfull stage through inspection of indicators using methods described earlier for estimation of the maximum bankfull depth.

Having established the elevation of the bankfull stage, measure bankfull depths (to the nearest tenth of a foot) at three or more locations (including the thalweg as one location) across the full width of each representative cross section using methods as described for maximum bankfull depth estimations. For each of the representative cross sections assessed, average the bankfull depth measurements made at each point along its section. Sum and average the averages calculated for each of the measured cross sections and record this value to the nearest tenth of a foot.

Attribute—Bankfull Width

Class attribute for *Subreach* feature

Definition

The "bankfull width" is the bank to bank width (in feet) of a target stream channel feature measured at the elevation of the bankfull stage. The bankfull stage for a given stream segment is the elevation of the stream flood having an average return interval of 1.5 years.

Functional Indication

Knowledge of existing relationships between normal flood flow character and channel geometry has important applications in stream and watershed management activities as well as in responsible planning for engineering design and land development. Measurement of a few simple relationships allows us to make reasonable estimates of a stream's probable response to changing conditions based on relatively easily obtained information. This is possible because "normal" (most frequent) flood flows play a well-understood and central role in determining channel patterns and geometry, and in establishing and maintaining characteristic features and habitat qualities of a stream. Understanding these relationships allows us to use easily measured channel geometry information along with other stream data to predict flow characteristics (discharge, velocity, etc.) and to relate those projected parameters to norms for similar watersheds and streams. Based on these characterizations we can also predict functional response of a stream feature to existing or changed environmental conditions (e.g., to predict stream icing or erosion potential, channel stability, etc.) and thus generate information useful in planning and development decisions.

Representation Method

Bankfull width is a representative attribute value assigned to whole subreach features. Bankfull width is derived from averaging one or more field measurements of the width (in feet) of representative cross sections of a subreach. Bankfull width measurements are not made on "estuarine", "piped" or "continuity" profile types.

Mapping Method

Bankfull width is measured in the field with a steel or plastic tape, or with calibrated electronic distance-measuring devices. The procedure is as follows. After completing subreach field reconnaissance, one or more representative cross sections are selected for measurement. All measured sections are located at one-third the length of a riffle upstream from its lip, at the front lip of a step, or at a turbulent, shallow flow section for other profile types. Bankfull width measurements are made across the entire width of all channels for "braided" profile types. Bankfull measurements are made only on the primary—typically largest—channel of "multi-channel" profile types.

At each cross section to be measured, determine the vertical location of the normal bankfull stage by visual inspection of field indicators (see "maximum bankfull depth" for methodology). Measure the width between the two stream banks at the elevation of the bankfull stage using an appropriate method. For bankfull widths up to 20 feet, use a tape stretched between the banks. Fix the tape at one bank at the bankfull stage elevation, tightly stretch and level it, referencing it to a carpenters bubble attached to the free end of the tape, and read the resulting width. For widths greater than 20 feet, use an infrared or other suitable electronic distance-measuring device, transmitting to targets first leveled using a p-gun referenced from the bankfull stage. Average measurements made at all representative sections and the record the average value.

Attribute—Width/Depth Ratio

Class attribute for *Subreach* feature

Definition

The width/depth ratio is the ratio for a given stream cross section of bankfull width to the mean bankfull depth (bankfull width divided by mean bankfull depth). Bankfull width and mean bankfull depth are defined in previous sections.

Functional Indication

The width/depth ratio is a good indicator of the potential erosive energy and stability of a channel. Generally, the higher the ratio (i.e., the wider the stream relative to its depth), the greater the potential for lateral (bank) erosion.

Representation Method

Width/depth ratios are representative unitless attribute values assigned to whole subreach features. These values are derived from other parameters measured and calculated for specific, representative stream cross sections. Width/depth ratios are not estimated for "estuarine", "piped" or "continuity" profile types.

Mapping Method

Width/depth ratios are directly calculated as the ratio of the valid reported values of bankfull width and mean bankfull depth for each subreach.

Attribute—Floodprone Width

Class attribute for *Subreach* feature

Definition

The floodprone width is the width between confining banks at an elevation of two times the maximum bankfull depth, measured from the thalweg of a riffle cross section.

Functional Indication

The floodprone width is an indicator of the lateral extent of flooding during low frequency (larger) flood events. Rosgen (1996, *Applied River Morphology*) equates the bankfull depth upon which this term is based with the stage of an approximate 50-year recurrence interval flood event for most streams.

Representation Method

The floodprone width is a representative attribute value (in feet) assigned to whole subreach features. Floodprone width is derived from values calculated or measured at specific, representative stream cross sections. Floodprone width estimates are not made for “estuarine”, “piped” or “continuity” profile types.

Mapping Method

Floodprone width is measured or estimated in the field with a steel or plastic tape, or with calibrated electronic distance-measuring devices. The procedure is as follows. After completing subreach field reconnaissance, one or more representative cross sections are selected for measurement. All measured sections are located at one-third the length of a riffle upstream from its lip, at the front lip of a step, or at a turbulent, shallow flow section for other profile types. Floodprone width measurements are made across the entire width of all channels for “braided” profile types. Floodprone width measurements are made only on the primary—typically largest—channel of “multi-channel” profile types.

At each cross section to be measured, determine the vertical location of the normal bankfull stage by visual inspection of field indicators and measure the maximum bankfull depth (see “maximum bankfull depth” for methodology). Establish the “floodprone elevation” on a high bank at a height of two times (2x) the maximum bankfull depth above the stream thalweg. The floodprone width is the distance between stream banks at this elevation.

Measure the floodprone width between the stream banks at the floodprone elevation using an appropriate method. For floodprone widths up to 20 feet, use a tape stretched between the banks, applying methods similar to those employed in measuring bankfull widths. For widths greater than 20 feet, use an infrared or other suitable electronic distance-measuring device, transmitting to targets first leveled using a p-gun referenced from the floodprone elevation. Average measurements made at all representative sections and record the average value. For all floodprone width values greater than three times (3x) the bankfull width, enter a value equal to three times the bankfull width and flag the result as a large value estimate.

Attribute—Entrenchment

Class attribute for *Subreach* feature

Definition

Entrenchment is the ratio of floodprone width to bankfull width (i.e., floodprone width divided by bankfull width). Bankfull width and floodprone width are defined in previous sections.

Functional Indication

Entrenchment is a measure of the vertical containment of a stream relative to its valley bottom, and is a good indicator of potential for increased bank erosion. Deeply entrenched streams experience a much higher rate of increase in water depth than in surface width with increasing flood stage. That is, rising flood waters remain deep and contained. The higher rate of increase in depth during flooding along these stream reaches represents a substantially higher bank erosion potential than for those streams with smaller entrenchment ratios and correspondingly lower rates of increase in flood stage.

Representation Method

Entrenchment is a representative unitless attribute value assigned to whole subreach features. Entrenchment is derived from values measured and calculated for specific, representative stream cross sections. Entrenchment estimates are not made for “estuarine”, “piped” or “continuity” profile types.

Mapping Method

Entrenchment ratios are directly calculated as the ratio of the valid values of floodprone width and bankfull width recorded for each subreach.

Attribute—Sinuosity

Class attribute for *Subreach* feature

Definition

Sinousity is the ratio of the stream length to its valley length, or the ratio of channel slope to valley slope. Stream length is defined as the length of the centerline of the stream where the centerline is that line connecting the midpoints of all surface water cross sections measured at the bankfull flood stage. Valley length is the down-valley length measured along the meander belt axis (or along the centerline of the floodplain).

Functional Indication

Sinuosity is an aspect of meander geometry and is directly dependent upon local geology and local and system-wide stream energy relationships. Sinuosity, when assessed in context with local norms and conditions, can be a generally useful parameter in analyzing and estimating stream stability characteristics.

Representation Method

Sinuosity is a representative unitless attribute value assigned to whole reach or subreach features. Sinuosity is derived from values obtained from: (1) existing mapping and topographic information sources, (2) field estimates, or (3) field measurements. The type of sinuosity representation is recorded in metadata tables. Sinuosity estimates are not made for “estuarine”, “piped” or “continuity” profile types.

Mapping Method

Sinuosity values for reaches or subreaches are determined in one of three ways:

(1) Map Measurement

Sinuosity estimates can be calculated using existing mapped information. In this method, measure the length of a target stream segment using an existing topographic map source. Using the same mapping, establish and measure the length of the meander belt axis. Calculate sinuosity based on these measured values. Record sinuosity value and mapping source, scale, and accuracy. Sinuosity values estimated using this method may underestimate the actual sinuosity of smaller streams.

(2) Field Estimate

Estimates of sinuosity may be made in the field by trained investigators using graphic field guides. In this method, after a reach or subreach has been delineated in the field, categorize the stream segment’s sinuosity based on a visual estimate of relative sinuosity. To incresase reproduceability, carry and use graphic guides that assign sinuosity categories for a range of channel patterns typical of Anchorage streams. Assign sinuosity categories as: (1) less than or equal to 1.2 ($S \leq 1.2$), (2) greater than 1.2 and less than 1.4 ($1.2 < S < 1.4$), or (3) equal to or greater than 1.5 ($S \geq 1.5$). Record estimated sinuosity.

(3) Field Measurement

Sinuosity may also be derived from basic measurements made in the field and from selected topographic mapping. In this method, directly measure the stream centerline length and measure valley length from existing topographic mapping. Make centerline measurements by measuring a series of straight line arcs along the approximate position of the stream centerline such that the positional error of any arc from the true stream centerline nowhere exceeds a distance of the larger of 20% of the stream's bankfull width or 0.5 feet. Calculate sinuosity using the measured centerline length and existing topographic data. Record the calculated sinuosity values, and associated topographic mapping sources.

Attribute—Bed Material

Class attribute for *Subreach* feature

Definition

Bed material is sediment that is present at and near the bottom surface of the stream channel and may be mobilized by normal flood flow events (return periods of less than 5 years). It may also include larger particles not readily mobilized by normal flood flows (stream pavement materials and armor) where these materials are the predominant or only channel sediments present.

Functional Indication

Bed material directly reflects flow characteristics, and affects channel stability and aquatic habitat availability and quality.

Representation Method

Categorical bed material types are used to represent the range of the predominant particle sizes of observed bed materials. Bed material categories include:

(1) clay/silt (particles $\leq$ 100μ diameter)
(2) silt/sand (100μ $\leq$ particles $\leq$ 420μ diameter)
(3) sand/gravel (420μ $\leq$ particles $\leq$ 25mm diameter)
(4) gravel/cobble (25mm $\leq$ particles $\leq$ 150mm diameter)
(5) cobble/boulder (particles $\geq$ 150mm diameter)
(6) peat/root (predominantly fine-grained organic-rich sediment)
(7) bedrock/cemented (indurated rock, concrete or other strongly cemented material)

Categorical types, identified through visual observation, are assigned as attribute codes to stream subreaches. Bed materials are not identified for "continuity" or "piped" stream reaches.

Mapping Method

Bed material type is estimated through field inspection of a subreach. Following delineation of a subreach, inspect representative riffles or similar shallow, turbulent stream profile features. Estimate bed material category for these representative sections using graphical field guides of typical particle size distributions. Record the predominant bed material category.

Attribute—Bank Material

Class attribute for *Subreach* feature

Definition

Bank material is the native, "in-place" geologic or human-placed material that is exposed in a stream bank section between the top of the stream channel and the bankfull stage. Bank material does not include active stream channel sediments.

Functional Indication

Information about bank material is useful in analyzing channel stability and potential for erosion and in-stream sediment production.

Representation Method

Categorical material types are used to represent the range of the predominant particle sizes of observed bank materials. Bank material categories include:

(1) clay/silt (particles $\leq$ 100μ diameter)
(2) silt/sand (100μ $\leq$ particles $\leq$ 420μ diameter)
(3) sand/gravel (420μ $\leq$ particles $\leq$ 25mm diameter)
(4) gravel/cobble (25mm $\leq$ particles $\leq$ 150mm diameter)
(5) cobble/boulder (particles $\geq$ 150mm diameter)
(6) peat/root (predominantly organic material)
(7) bedrock/cemented (indurated rock, concrete or other strongly cemented material or armor)

Categorical types are assigned as attribute codes to stream subreaches. Bed materials are not identified for "continuity" or "piped" stream reaches.

Mapping Method

Bank material type is estimated through field inspection of a subreach. Following delineation of a subreach, inspect bank sections at representative riffles or similar shallow, turbulent stream profile features. Observed sections must include only in-place materials (materials not deposited or positioned by active stream processes). Estimate the bank material category for these sections using graphical field guides of typical particle size distributions. Record the predominant bank material category.

Attribute—Roughness Coefficient (Manning's n)
Class attribute for *Subreach* feature

Definition
Roughness, n, in this use is the coefficient reflecting channel characteristics as a factor in the resistance the channel offers to flow at bankfull stage. The flow resistance of different bed forms and qualities can be expressed by Manning's equation:

$$V = (1/n)R^{2/3}S^{1/2}$$

or $V = 1.486(1/n)R^{2/3}S^{1/2}$ in english units

and V = average flow velocity
R = hydraulic radius ($\approx$D, stream depth, for width $\geq$ 20D)
S = energy slope
n = Manning's roughness coefficent

Functional Indication
Manning's n is a necessary factor in estimating the overall effects that a channel's characteristics have on stream flow.

Representation Method
Roughness is a representative unitless attribute value assigned to whole reach or subreach features. Roughness is derived from values obtained from: (1) field estimates, or (2) field measurements. The type of roughness representation is recorded in metadata tables. Roughness estimates are not made for "continuity" profile types.

Mapping Method
Rougness values for reaches or subreaches are determined in one of two ways:

(1) Field Estimate
Estimates of roughness may be made in the field by trained investigators using tables and guides available in the technical literature. Once a reach or subreach has been delineated in the field and a bankfull cross section established, estimate the most probable stream roughness using tabulated values (e.g., Barnes, 1967, *Roughness Characteristics of Natural Channels*; Table 2.5.1 in Chow et. al., 1988, *Applied Hydrology*, Table 12.2.1 in Maidment, 1992, *Handbook of Hydrology*; and others). Adjust the initial n estimate using adjustment factors recommended in Aldridge and Garrett (1973, *Roughness Coefficients for Stream Channels in Arizona*) and as summarized in USDA (1998, *Stream Corridor Restoration: Principles, Processes, and Practices*). Record the estimated Manning's n value.

(2) Field Measurement

Roughness may also be derived from basic measurements made in the field. In this method, for the target subreach or reach select and measure appropriate cross sections, velocity profiles and energy grades at several stream discharges to provide basic data for use in calculating n (see Maidment, 1992). Record the derived Manning's n value.

Attribute—CEM Class

Class attribute for *Subreach* feature

Definition

A "CEM class" identifies the degree of departure of a stream from a dynamic equilibrium condition expected for a given climate, terrain, stream size, and geology (bank and channel material). "CEM" is an acronym for "channel evolution model". Channel evolution models are classification schemes useful in predicting and interpreting the sequence and character of lateral and vertical adjustments of stream channel forms. This attribute identifies the current stage in a predictable evolutionary sequence of stream forms for a stream undergoing adjustment to channel and watershed disturbances. Disturbances triggering the sequence may include near- or in-stream factors, watershed factors, or both, and may be either natural or human-initiated.

Functional Indication

A CEM classification essentially provides some insight into a stream's stability. A stream not in equilibrium with its surrounding terrain and climate will adjust its channel characteristics to establish a new dynamically stable state that is in equilibrium with the new conditions. Changes are generally sequential and predictably responsive to changes in specific watershed and channel factors. This predictability, based on observations of the current stream's "evolutionary" stage and an understanding of other channel and watershed factors, provides a powerful diagnostic tool, useful in planning and prioritizing watershed management activities. However the CEM classes defined here are not intended to supplant detailed classification approaches or intensive project-level investigations. They are intended to provide planning-level characterizations of the overall stability of stream segments in context with general stream evolutionary patterns.

Representation Method

A stream's "CEM class" is represented here by assignment to one of four stream evolutionary stages (broadly based on channel evolution models cited and described in *Stream Corridor Restoration: Principles, Processes and Practices*, 1998, U.S. Department of Agriculture, chap. 7, p.34-39). These four stability stages include:

(1) Dynamic equilibrium
(2) Degrading
(3) Widening and Aggrading
(4) Aggrading

A *"dynamic equilibrium"* condition is a relatively stable endpoint configuration of stream channel and pattern that reflects current local conditions and that has usually been developed by transformation through a predictable sequence of erosional and depositional channel forms. However in this classification, a dynamic equilibrium state may also reflect a generally stable condition artificially superimposed by relatively permanent human modifications made to stream configuration or armoring. For example, a ditched and armored stream reach may be considered "dynamically stable" due to the human controls applied within the conveyance even though it may not otherwise be in equilibrium with local natural conditions, either along the stream segment itself or up or downstream. (Note that in this example the stream reach would also likely be classed as "highly modified" which recognizes the channel control imposed by the human modifications.)

At the *"degrading"* stage prominent vertical erosion processes occur along a stream bed. Where flows are sufficient, tributaries are rejuvenated (oversteepened), with bed erosion processes proceeding upstream. Lateral erosion and widening may occur as well, but at this stage eroded materials are rapidly removed, maintaining steep banks and a continuing vertical degradation of the stream bed. Note that for this stage to exist stream flows must maintain sufficient energy to erode and transport local geologic materials or else the stream will evolve to a widening and aggrading form.

A *"widening and aggrading"* stream segment displays lateral bank erosion, often associated with stream bed aggradation, as the prominent formative stream process. Early in this stage, widening streams may display conspicuous slump blocks, ravelling, scallops, reworking of failed material and other bank retreat forms, depending on local geologic materials and stream size. As this stage progresses these features become more subdued. While banks are always actively eroding and generally less stable than those at a stream's equilibrium condition, at the same time overall bank angles at this stage are usually more flattened than those for a degrading stream.

In a widening stream segment, width/depth ratios are also commonly high. High width/depth ratios typically reflect poor sediment transport capacity, and are often associated with channel aggradation as well as bank retreat. In Anchorage, the presence of a widening and aggrading stream stage is often tied to over-widened stream channels resulting from stream ditching, or to aggradation due to local dams and obstructions. Both can lead to increased bank erosion until the stream can reestablish a deeper channel form capable of transporting its sediment load. In fact, the final stages of widening streams often display the beginning of a meandering thalweg or step-pool structures, as bank retreat allows accommodation of these more stable channel forms. Thus, in the final stages of a widening stream form, the stream is transitional to a dynamically stable channel type.

The *"aggrading"* stream evolution class, as used in this classification, is reserved for major and active alluvial depositional landforms including deltas and fluvial fan features.

Mapping Method

CEM classes are determined in the field by trained and qualified investigators. Field delineation is performed by in-stream traverse of each reach, starting at the reach's downstream endpoint and progressing upstream. The defining criteria described above and knowledge of the range in these characteristics in Anchorage streams are applied to identify segments of the reach having generally common characteristics for this parameter.

Attribute—Channel Modification

Class attribute for *Subreach* feature

Definition

Channel modification is the degree to which human activities and structures have directly modified a stream channel, or the extent to which human activities or structures immediately control or influence stream processes and patterns at a range of normal flows (bankfull stage). Channel modification focuses on effects of those human activities and structures that are located at the stream channel or within the immediate riparian zone. It does not recognize effects of human activities or controls located within the larger watershed (e.g., storm water hydrograph changes, sedimentation, etc.). These latter impacts are reflected in other channel characteristics (notably CEM classification), or the causes of these effects are mapped and reported directly as impact factors.

Functional Indication

Streams are natural features that seek a dynamic equilibrium in form and function through a complex interaction of a number of factors. With change in any one factor, the stream tends to modify its character in a generally predictable way in an effort to reestablish balance between all factors. Given this complex interaction, even small changes in or near the channel can have profound effects on the form and character of a stream. Channel modification information, as a general measure of near- and in-stream impact then, is a useful tool in estimating present stability of the stream. It is also helpful in predicting the future form and character of the stream as it evolves from less stable to more stable conditions. Because of its importance as an indicator, channel modification is a primary element used in delineating endpoints of discrete subreaches.

Representation Method

Channel modification is represented by a broad qualitative categorization of degree of human impacts occurring near or in a stream. Categories include:

(1) Unmodified
(2) Slightly modified
(3) Moderately modified
(4) Highly modified

An *Unmodified* stream segment has little or no human activity or structures present in or near its channel. For an unmodified stream, any human structures along the stream are minor in scale, relative to the scale of the stream segment. The total of all channel modifications in these stream segments has significantly less impact than the local climate, geology and terrain on the overall character of a given size stream channel.

A *Slightly Modified* stream segment typically includes one or more stream crossings or other permanent human structures along its length. Effects on stream character resulting from these structures are typically readily observed for short distances up and downstream. However impact of these modifications on the overall stream segment is relatively slight and highly localized.

A *Moderately Modified* stream segment is noticeably impacted over a substantial fraction of its length by the effects of one or more human structures or activities along the stream. Stream erosion or aggradation may be magnified locally. Stream forms are generally significantly different from those of an unindisturbed stream having similar size, climate, geology and terrain. Often normal erosion and stream migration processes are constrained or redirected, frequently with significant impacts on upstream and downstream channel form and process.

However, moderately modified stream segments are typically not altered or controlled continuously along their length. Modifying structures are generally localized (though effects may be present along a major fraction of the stream segment). In fact, for some moderately modified streams, effects may have been in part mitigated by re-stabilization of the stream segment at or near a new equilibrium balancing the effect of the structures. However, even in these latter cases upstream and downstream impacts may remain active and prominent. In any event, the stream's character will strongly reflect the presence of the modifying structures.

A *Highly Modified* stream segment is strongly influenced over its entire length by continuous, or very nearly continuous, human modifications. Often in Anchorage, highly modified streams are the result of channelization (including ditching, diking and revetment) and straightening of entire stream segments. Stream slopes are steepened, width/depth ratios are dramatically increased, channels are entrenched (often exposing less stable bank materials to stream erosive forces), and natural thermal balances are upset (particularly during winter months). In general, the stream processes and forms of "highly modified" stream segments reflect a significant imbalance between stream energy and channel geometry. All these changes are highly destabilizing with a resultant dramatic increase in the potential for in-stream erosion and stream icings along the stream segment itself as well as along adjacent up and downstream segments.

Mapping Method

Channel modification classification is determined in the field by trained and qualified investigators. Field delineation is performed by in-stream traverse of each reach, starting at the reach's downstream endpoint and progressing upstream. The defining criteria described above and knowledge of the range in these characteristics in Anchorage streams are applied to identify segments of the reach having generally common characteristics for this parameter.

During field mapping, criteria used to distinguish channel modification are applied to stream patterns and controlling structures and activities that are observed at or below the floodprone stage (that flood stage having an elevation of twice the bankfull depth).

Attribute—Undercut Bank

Class attribute for *Subreach* feature

Definition

Undercut bank is any stream channel area that is active at flows less than bankfull and is significantly roofed by overarching bank materials. Though dependent upon stream size, significant overarching is defined as an overhang of 0.5 feet or larger, measured perpendicular to the stream flow.

Functional Indication

Undercut bank is a potential indicator of bank stability and aquatic habitat availability and quality.

Representation Method

Undercut bank is represented by visual estimates of the percent of the total length of all stream banks (both banks of all channels) that have "significant" overarching bank materials. Observed percent values are reported as ranges:

(1) Undercut ≤10%
(2) 10% < undercut ≤ 30%
(3) 30% < undercut ≤ 50%
(4) 50% < undercut ≤ 75%
(5) 75% < undercut

Range values are assigned as attribute codes to stream subreaches. Undercut bank is not identified for "continuity" or "piped" stream reaches.

Mapping Method

During reconnaissance and delineation of a subreach, undercut is established using wading rods or other measuring devices to confirm a significant feature (minimum 0.5 foot overarch). The fraction of all banks along the subreach having significant undercut is visually estimated and the value recorded as a code for the appropriate percentage range.

Attribute—Canopy

Class attribute for *Subreach* feature

Definition

Canopy is any vegetative cover extending over all or part of the stream water surface at bankfull stage.

Functional Indication

Canopy provides shading and increases thermal stability of the stream during both winter and summer; increases bank stability via its root mass; provides an important source of nutrients and food for aquatic life; and ultimately provides a source of cover and substrate materials within the stream itself.

Representation Method

Canopy is represented by a visual estimate of the percent of the total surface area of the stream at bankfull stage that has vegetative cover. Observed percent values are reported as ranges:

(1) Canopy ≤10%
(2) 10% < canopy ≤ 30%
(3) 30% < canopy ≤ 50%
(4) 50% < canopy ≤ 75%
(5) 75% < canopy

Ranges are assigned as attribute codes to stream subreaches. Canopy is not identified for "continuity" or "piped" stream reaches.

Mapping Method

During reconnaissance and delineation of a subreach, canopy is visually estimated using a densitometer or percentage composition charts. The estimate of the percentage of canopy coverage for the entire subreach is estimated and the value recorded as a code for the appropriate percentage range.

Attribute— Invertebrate Habitat

Class attribute for *Subreach* feature

Definition

Habitat refers to any stable substrate on or in which may principally provide for insect colonization and periphyton attachment. Habitat types recognized in Municipal stream mapping include:

1. Submerged logs and large woody debris
2. Leaf packs:
3. Under-cut banks
4. Cobble and boulders
5. Fine woody debris
6. Gravel

Submerged logs and large woody debris: are defined as large pieces of dead and decaying relatively stable woody material (>6 inches in diameter) located within the bankfull channel and appearing to influence bankfull flows.

Leaf packs: are aggregates or clumps of dead and decaying submerged leafy material that may provide cover, periphyton attachment and a food source. These are typically in areas of low flow and those areas protected from flow by obstructions or depth.

Under-cut banks: Undercut bank is any stream channel area that is active at flows less than bankfull and is significantly roofed by overarching bank materials. Though dependent upon stream size, significant overarching is defined as an overhang of 0.5 feet or larger, measured perpendicular to the stream flow.

Cobble and boulders: (particles ≥ 150mm diameter) Bed material at and near the bottom surface of the stream channel that are not readily mobilized by normal flood flows.

Fine woody debris: is defined as dead and decaying woody material (<6 inches in diameter) singly or in aggregate, at least partially in the water column and that is normally not mobile during periods of increased flow.

Gravel: is defined as stream bed material with particle sizes between ≥ 25mm diameter and ≤ 150mm in diameter and not normally displaced by increased flow.

Functional Indication

The diversity, quantity and quality of habitat are a measure of potential invertebrate productivity. A stable invertebrate population is essential to maintain a viable fishery. Large and small woody material composed of fallen trees, submerged branches, tree roots, and living shrubs and trees growing in or hanging in the water provides excellent invertebrate habitat and surface area for periphyton attachment. Stream bank under cut provides cover, shade and in-stream boulders provide resting-places for fish (reduced water velocity), protection from predators, and shade in scour pools on the down stream side of the boulder. Cobble and boulders provide surface area for periphyton attachment. Overhanging and macrophyte beds offer shade and attachment for aquatic invertebrates. Riffles are sources of re-aeration and insect habitat and isolated/backwater pools offer food and protection.

Representation Method
Available habitat can range from little or none as in the case when the substrate is often disturbed covered or removed by water velocity, sediment deposition or scour to abundant. Invertebrate habitat is represented by the sum (a whole number) of the selected habitat "types" present.

Data Limitations
The sum represents the cumulative number of different types of habitat within a representative reach or sub-reach and is an indicator of presence or absence of habitat and not necessarily the quality of that habitat. The number may have been derived by reconnaissance of the entire reach or subreach or from a single representative area within either the reach or subreach. The number may be spatial/temporal distorted by stream flow and be subjected to a degree of observer bias, especially if not assessed by a trained and qualified investigator with knowledge of the target consumer(s).

Mapping Method
Habitat is determined in the field by trained and qualified investigators. Field reconnaissance is performed by observation of each reach or subreach, starting at the reach or subreach's downstream endpoint and progressing upstream. The assessment area of a reach or subreach must be equivalent to a length of five times the active channel width. The defining criteria described above and general knowledge habitat needed by a target group (dominant indigenous species) of consumers. During reconnaissance of the reach or subreach necessary observations must include habitat types, frequency and abundance with the outcome being the total number of habitat type present.

Attribute—Fish Habitat

Class attribute for *Subreach* feature

Definition

Any stable structure or physical channel attribute providing fish habitat. Habitat types recognized in Municipal stream mapping include:

12. Logs and large woody debris
13. Root mats/wads
14. Deep pools
15. Undercut banks
16. Cobble and boulders
17. Overhanging vegetation
18. Macrophyte beds
19. Riffles
20. Isolated/backwater pools

<u>Submerged logs and large woody debris:</u> are defined as large pieces of dead and decaying relatively stable woody material (>6 inches in diameter) located within the bankfull channel and appearing to influence bankfull flows.

<u>Root mat or root wad:</u> is defined as a root bole having a stump greater than 6" in diameter imbedded or firmly anchored in the streamflow and providing some flow diversion and significant cover for resident fish.

<u>Deep Pools:</u> are defined as characterized by slower, deeper water flow with a generally more quiescent surface than the adjacent riffles.

<u>Undercut bank:</u> is any stream channel area that is active at flows less than bankfull and is significantly roofed by overarching bank materials. Though dependent upon stream size, significant overarching is defined as an overhang of 0.5 feet or larger, measured perpendicular to the stream flow.

<u>Cobble and boulders:</u> (particles $\geq$ 150mm diameter) Bed material at and near the bottom surface of the stream channel that are not readily mobilized by normal flood flows.

<u>Overhanging vegetation:</u> includes living grass, shrubs and trees along the banks that over-hang, traverse or are partially in the surface water.

<u>Macrophyte beds:</u> includes rooted submerged and emergent plants and algae. Floating (not attached) plants and algae are excluded. While floating material offers some degree of shade and area for periphyton attachment they are mobile with increased flow.

Riffles: are defined cross sections of the stream bed that typically have a fast, shallow and more turbulent surface flow regime. The streambed of a riffle typically has coarse bedload grain sizes.

Isolated or backwater pools: are defined as characterized by slow flowing deeper water that normally are not within the flow regime of the channel. These pools include oxbows and portions of channels that are protected from flow changes by their location within the stream channel.

Functional Indication

Woody material composed of fallen trees, submerged branches, tree roots, and living shrubs and trees growing in or hanging in the water provides excellent habitat for fish protection, rearing, and periphyton attachment (food). Deep pools provide areas for hiding, resting and protection. Stream bank under cut provides cover for fish and is often considered a condition favorable to producing high fish biomass. In-stream boulders provide resting-places for fish (reduced water velocity), protection from predators, and shade in scour pools on the down stream side of the boulder. Cobble and boulders also provide surface area for periphyton (food) attachment. Overhanging and macrophyte beds offer shade and attachment for aquatic invertebrates. Riffles are sources of re-aeration and insect habitat and isolated/backwater pools offer food and protection.

Representation Method

Habitat is represented by the sum (a whole number) of the selected habitat "types" present.

Data Limitations

The sum represents the cumulative number of different types of habitat within a representative reach or sub-reach and is an indicator of presence or absence of habitat and not necessarily the quality of that habitat. The number may have been derived by reconnaissance of the entire reach or subreach or from a single representative area within either the reach or subreach. The number may be spatial/temporal distorted by stream flow and may be subjected to a degree of observer bias, especially if not assessed by a trained and qualified investigator with knowledge of the target consumer(s).

Mapping Method

Habitat is determined in the field by trained and qualified investigators. Field reconnaissance is performed by observing each reach or subreach, starting at the reach or subreach's downstream endpoint and progressing upstream. The assessment area of a reach or subreach must be equivalent to a length of five times the active channel width. The defining criteria described above and general knowledge habitat needed by a target group (dominant indigenous species) of consumers. During reconnaissance of the reach or subreach necessary observations must include habitat types, frequency and abundance with the outcome being the total number of habitat type present.

Coding List and Data Labels

Survey MetaData

Map Accuracy (MAP_ACURCY, same as old “map level” value, normalized)
(null value or n—unitless code, 1 to 5)
Null value (25m or worse, or unknown—xstreams coverage)
1 Photo Interpretive Mapping *(better than 25m, estimated)*
2 Reconnaissance Mapping *(better than 15m, estimated)*
3 Base Map Survey *(better than 10m, controlled survey confirmed)*
4 Low Resolution GPS Survey *(continuous controlled GPS survey)*
5 High Resolution Land Survey *(continuous controlled land survey)*

Mapping Date (open)
Month/day/year

MOA Stream

Stream ID (STREAM_ID)
AAA-nn-nn…-nn-nn.nn
Every MOA stream contains a source point or an endmap point at its upstream end
Every MOA stream contains an outlet point or an endmap point at its downstream end

Stream Name (STREAM_NAM)
Mainstem name

Watershed (WATERSHED)
Hydrographic watershed

Reach

Reach ID (RCH_SUBRCH)
AAA-nn-nn…-nn-nn.nn
Each reach is comprised of one or more subreaches

Reach Attributes:
Reach Slope (RCH_SLOPE)
(n.nnnn unitless)

Subreach

Subreach ID (RCH_SUBRCH)
AAA-nn-nn…-nn-nn.nn
Every subreach is associated with one and only one reach

Subreach Attributes:

Flow Type (FLOW_TYPE)
- Perennial
- Intermittent

Routing Type (ROUTE_TYPE)
- Source
- Stem
- Continuity
- Outlet

Profile Type (PROFILE)
- (n—unitless code, 1 to 11)
- 1 Pool/Riffle
- 2 Estuarine
- 3 Run
- 4 Braided
- 5 Step Pool
- 6 Cascade
- 7 Bog
- 8 Multi-channel
- 9 Flat
- 10 Piped
- 11 Continuity

Maximum Bankfull Depth (MAX_BF_D)
- (nn.n feet)

Mean Bankfull Depth (BF_D)
- (nn.n feet)

Bankfull Width (BF_W)
- (nnnn.n feet)

Width/Depth Ratio (BF_W:BF_D)
- (nn.n unitless)

Flood Prone Width (FLDPRONE_W)
- (nnnn.n feet)

Entrenchment (ENTRNCHMNT)
- (nn.n unitless)

Sinuosity (SINUOSITY)

Method 1
(nn.n unitless)

Method 2
(n—unitless code, 1 to 3)
1 Sinuosity ≤1.2
2 1.2 ≤ Sinuosity ≤ 1.4
3 1.4 ≤ Sinuosity

Method 3
(nn.n unitless)

Bed Material (BED_MATL)
(n—unitless code, 1 to 7)
(1) clay/silt (particles ≤ 100μ diameter)
(2) silt/sand (100μ ≤ particles ≤ 420μ diameter)
(3) sand/gravel (420μ ≤ particles ≤ 25mm diameter)
(4) gravel/cobble (25mm ≤ particles ≤ 150mm diameter)
(5) cobble/boulder (particles ≥ 150mm diameter)
(6) peat/root (predominantly fine-grained organic-rich sediment)
(7) bedrock/cemented (indurated rock, concrete or other strongly cemented material)

Bank Material (BANK_MATL)
(n—unitless code, 1 to 7)
(1) clay/silt (particles ≤ 100μ diameter)
(2) silt/sand (100μ ≤ particles ≤ 420μ diameter)
(3) sand/gravel (420μ ≤ particles ≤ 25mm diameter)
(4) gravel/cobble (25mm ≤ particles ≤ 150mm diameter)
(5) cobble/boulder (particles ≥ 150mm diameter)
(6) peat/root (predominantly fine-grained organic-rich sediment)
(7) bedrock/cemented (indurated rock, concrete or other strongly cemented material)

Roughness Coeefficient, Manning's n (MANNINGS_N)
(n.nnn, unitless)

CEM Class (CEM_CLASS)
(n—unitless code, 1 to 4)
1 Dynamic Equilibrium
2 Degrading
3 Widening and Aggrading
4 Aggrading

Channel Modification (CHNNL_MOD)
(n—unitless code, 1 to 4)

1 Unmodified
2 Slightly Modified
3 Moderately Modified
4 Highly Modified

Bank Undercut (BNK_UNDRCT)
(n—unitless code, 1 to 5)
1 ≤10%
2 10% < undercut ≤ 30%
3 30% < undercut ≤ 50%
4 50% < undercut ≤ 75%
5 >75%

Canopy (CANOPY)
(n—unitless code, 1 to 5)
1 ≤10%
2 10% < canopy ≤ 30%
3 30% < canopy ≤ 50%
4 50% < canopy ≤ 75%
5 >75%

Invertebrate Habitat (INVERT_HAB)
(n—unitless count, 1 to 6)
Reflects combined presence and quality of:

- Leaf packs
- Gravel
- Cobbles/Boulders
- Small Woody Debris
- Logs
- Undercut Banks

Fish Habitat (FISH_HAB)
(n—unitless count, 1 to 9)
Reflects combined presence and quality of:

- Large Woody Debris (>6 inch diameter)
- Deep Pools
- Boulders
- Riffles
- Root Mass
- Overhanging Vegetation
- Isolated Pools
- Undercut Banks
- Macrophyte Beds