Supplement

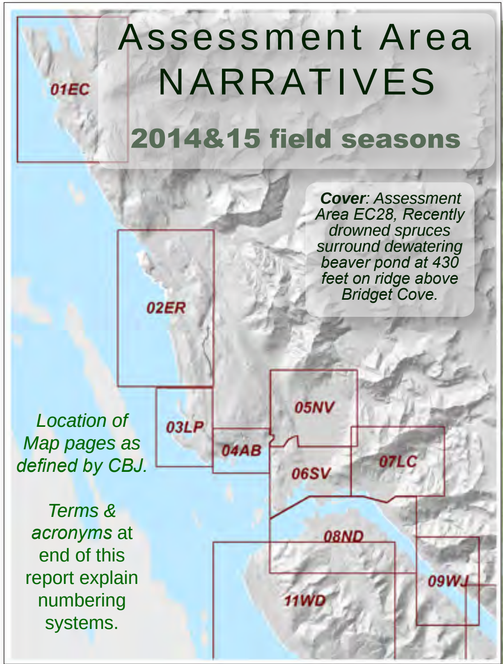
to the 2016 Juneau Wetlands Management Plan

Assessment Area NARRATIVES

Bosworth Botanical Consulting
Richard Carstensen 2016

Assessment Area NARRATIVES

2014&15 field seasons



***Cover**: Assessment Area EC28, Recently drowned spruces surround dewatering beaver pond at 430 feet on ridge above Bridget Cove.*

Location of Map pages as defined by CBJ.

Terms & acronyms at end of this report explain numbering systems.

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*"**Narratives**," in this document, refer to informal descriptions of geomorphology, hydrology, ecology and cultural significance of units assessed during the CBJ wetlands project.*

Contents

Type	Wetland definition under WESPAK
forested peatland *fw*	Nearly all the AA is moss-covered and/or with peat or muck soils to a depth of at least 4 inches, sometimes greater if not rocky. More tall (>3 ft) woody cover than herbaceous. Trees often hemlock or cedar. Often with skunk cabbage (at least in seasonal channels), blueberries. Little or no open water. Includes shrub fringes of open peatlands and fens. Not in active floodplain.
open peatland *op*	Nearly all the AA is moss-covered. Peat depth usually >16 inches except where bedrock near surface. Tree cover is <5% and cover of tall (>3 ft) shrubs is <30%. Shore pine, Labrador tea, crowberry often occur. Often with small (<25 sq ft) scattered stair-step pools with acidic, stained water. Some examples are flat bogs, floating bogs, and sloping muskeg.
fen/ farsh *fm*	Often with extensive surface water, at least seasonally. Usually with more emergent than tall (>3 ft) woody plant cover. Often sedges, deer cabbage, marsh marigold, horsetail, burreed, pond lily. If ground is moss-covered, the moss often is mostly obscured by sedges or other herbaceous plants. Soils often muck or peat, seldom coarse unless created by excavation. Often beaver-created, or at base of steep slopes, or in depressions or adjoining larger water bodies.
floodplain wetland *fl*	At least once annually, surface water in a channel that flows through or adjoins the AA causes the width of surface water in the AA (perpendicular to the channel) to more than double. The increased width is due mainly to that channel inflow, not to hillslope seepage or runoff. Soils are silt or coarser (little or no organic soil or peat). Vegetation can be woody or herbaceous: often alder, willow, devil's club.
uplift meadow *um*	Within a few miles of tidewater or a glacier, but nontidal, and mostly within 100 miles of Glacier Bay National Park. Little or no persistent surface water except in channels, which may be strongly downcut. Mostly sweetgale and/or herbaceous vegetation, e.g., silverweed, iris, Lyngbye's sedge. Tree cover usually <30%. Peat depth usually <16 inches. Resulted from uplift following isostatic rebound as a glacier receded within recent centuries.
beaver influenced *bi*	Active or recent beaver activity has altered the water regime and vegetation. These wetlands are typically episodic, with periods of flood-induced tree mortality alternating with periods of de-watering and vegetation recovery.
tidal wetland *td*	Inundated by tide at least once annually and dominated by emergent herbaceous or woody plants. The level of surface water fluctuates every ~6 hours on a daily basis in response to tides. Does not include areas of beachgrass (*Leymus* or *Elymus mollis,* also called ryegrass) unless they are inundated at that frequency. Does not include areas that are entirely eelgrass or seaweeds.

Introduction

This report is provided as an informal supplement to official documents summarizing the 2016 Juneau Wetlands Management Plan (JWMP), conducted by Bosworth Botanical Consulting in 2014 and 2015. Its purpose is to gather into one easily navigated document a description, maps, and on-site photography for every wetland mapped and assessed during the JWMP.[1] **Our definition of "narrative," and its history in this project, is explained on page 15.**

Most of the following introductory material, site descriptions and narratives are by Richard Carstensen—field member and cartographer for Bosworth Botanical Consulting. Narratives by other team members are in quotes, preceded by initials: **KB**, Koren Bosworth; **CP** Catherine Pohl; **AA**, Andrew Allison; **RA**, Rachel Allison. All other text is by **RC**.

Mapping; methods and criteria

Priority Areas (PAs) Mapped by CBJ, these are 72 tracts where surveys were conducted, ranked 1 (highest priority) through 4 (lowest priority). To identify individual PA units, we added 2 digits after the rank. For example, 1.17 is the 17th CBJ unit of highest rank (1).

Field procedure In 2014 and 2015, our team traversed a broad array of wetlands from Echo Cove to Douglas Island in probably the most geographically wide-ranging survey ever conducted within the road-accessible portion of the City and Borough of Juneau. It also served to inaugurate the WESPAK-SE assessment procedure, a new standard for rapid wetland survey and analysis for Southeast Alaska.

On a typical field day, our team drove together to a predicted Assessment Area, but then split up to accomplish two tasks.[2] One member traversed the unit, attempting to see, photograph and characterize the full range of habitat variation, then filled out the WESPAK-SE field form. Others walked the unit boundaries with GPS, following the contact of wetland and upland. In this work, presence and quantity of skunk cabbage (LYAM: ***Ly**schiton* ***am**ericanum*[3]) was the most reliable indicator, followed by soil 'sponginess,' hydrologic indicators, and a suite of subtler vegetative cues that collectively contribute to surveyors' 'wetland-gestalt.'

The Juneau Wetlands Management Plan Update For readers unfamiliar with the 2016 JWMP project, our final reports explain the study's purpose, scope, history, methods, analysis and results. See *2016 Juneau Wetland Management Plan, Volumes 1 & 2*, available from CBJ's Community Development Department.

Beyond those formal objectives of the 2014-2015 JWMP, the Bosworth Botanical field team had an unprecedented opportunity to experience and document Juneau's diverse watersheds—in particular the 345 assessed wetland units. This supplement shares those observations with researchers, naturalists, developers, land managers, and everyone seeking to better understand Juneau's wetlands.

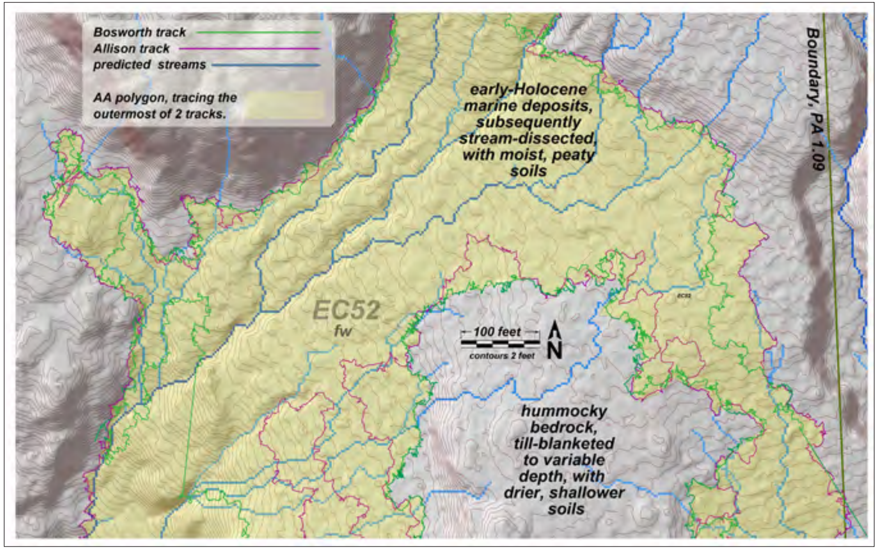
According to our protocol, wetland-upland boundaries were ground-truthed with high-resolution GPS. In contrast, wetland-to-wetland boundaries (*i.e.* different categories in question F1, WESPAK-SE field form) are less critical jurisdictionally, as well as more amenable to tracing in GIS, especially given the high-resolution imagery[4] and LiDAR provided to us by the City for this project. For example, we determined early in summer, 2014, that the contact between open peatland (<5% cover of conifers >20 ft tall) and forested wetland (>5% conifer cover), when hand-drawn from color infrared 6-inch pixel imagery, agreed closely with our 'trimbled'

1 Some of the specified JWMP deliverables included here will also be delivered in other formats (folders with original .jpgs, etc).

2 Team members communicated by handheld radio. Cell phones used early in the project too often proved unreliable in areas beyond effective reception.

3 Appendix 1 lists 4-letter acronyms for common plant species. First 2 letters of genus followed by first 2 letters of species.

4 Contracted from the aerial survey company Watershed Sciences Inc. Subsequent to their contract with CBJ, WSI merged with Aerometrics to form a new company called Quantum Spatial: *http://quantumspatial.com/*



Creation of unit EC52 On a few occasions this summer, a unit, or portion thereof, was accidentally trimbled twice by different surveyors. The entire landscape mapped on left lies beneath conifer canopy. Our predicted AA was crude—essentially just a placeholder to assure a ground-truther went there.

Duplication gives a measure of between-observer repeatability. In this example there was good agreement between Bosworth (green) and Allison (purple)—especially at slope breaks—where their tracks were only a few feet apart. Elsewhere, they diverged by as much as 60 feet.

Note that track divergences do not suggest one of our surveyors was more conservative or inclusive than the other. In some places Bosworth mapped wetlands outside Allison's line; elsewhere, Allison's line reached out farther.

This map demonstrates how fuzzy wetland boundaries can be in some situations. Areas with greatest track divergence are in dense tangles of blueberry and menziesia where only a couple skunk cabbages might be visible from any one position. Additional cues, such as softness of the ground underfoot, are likewise less diagnostic in understories of 8-foot-tall menziesia.

boundaries—the downloaded tracks created by walking these edges.[5]

Office routine We usually corrected Trimble tracks 24 hours after acquisition, because earlier post-processing often delivered 'jaggy,' unsatisfactory lines, particularly when the Whitehorse Station was unavailable. Unit boundary tracks were overlaid on the JWMP ArcMap project for comparison with aerial imagery, or hillshade such as this example for EC52. The yellow AA-unit polygon in this example was drawn with the polygon trace tool, by right-clicking on the track and selecting *snap to feature>midpoints*.

WESPAK **forested wetland** (3,961 acres) and **floodplain wetland** (48 acres) were mapped exclusively by ground-truthing. The 4 remaining ***non***-forested types—open peatland, fen/marsh, uplift meadow and tidal marsh, collectively about a third of our 2014-&-15 acreage—were reliably mapped in GIS where they contacted another wetland type. Where they contacted "upland" they too were GPSed, except for the tidal wetland type.

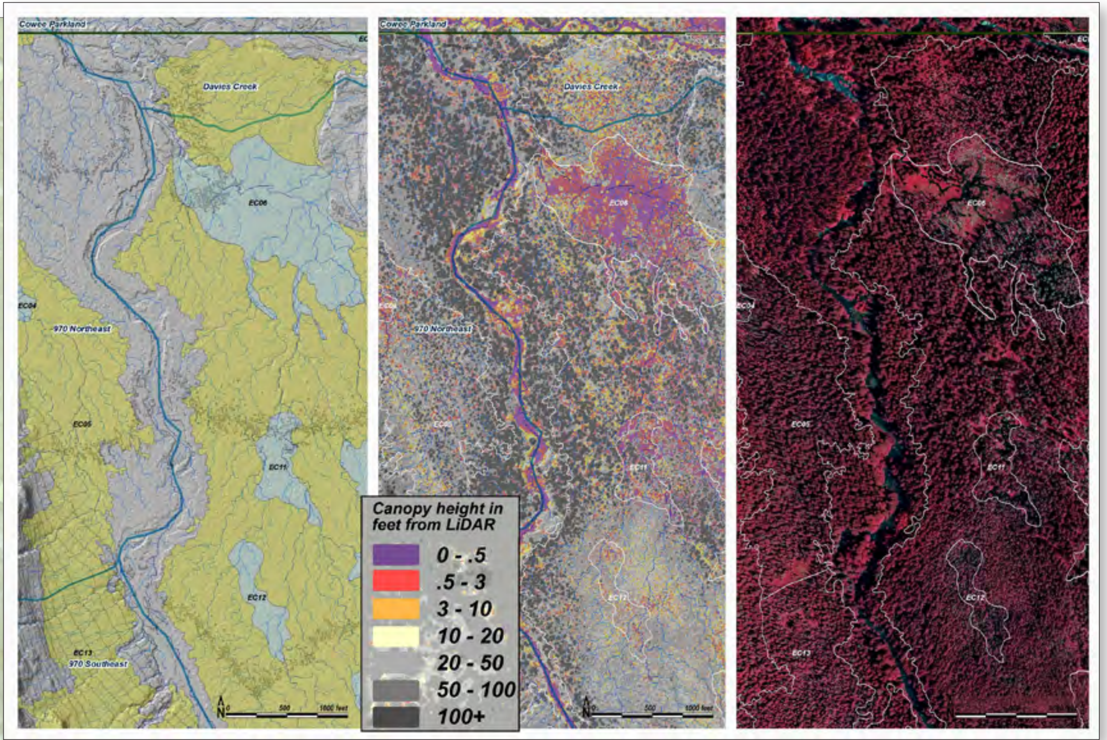
According to the Corps of Engineers, the upper limit of **tidal wetlands** is extreme high water—20.8 feet above sea level in the Juneau-area. We isolated a 20.8 contour from the 2013 DEM,[6]

5 As of 2016, it's difficult to imagine how wetland-upland boundaries beneath forest canopy could be mapped with confidence from imagery or LiDAR alone. The WSI data library has given us a level of landscape and habitat understanding unforseeable as recently as 3 years ago. But in the forest, wetland boundaries are 'fuzzy' and permeable. Away from slope breaks, where skunk cabbages are dispersed and brush is thick, our suite of wetland-boundary cues weaken or even conflict. Ideally, these wetland transitions would not be shown on maps as crisp, 'either-or' polygons, but as *gradients*, with wettest places darkest, fading to paler over those arguable boundaries. In any case, LiDAR—or similar remote sensing tools—are unlikely to soon replace boots-on-the-ground.

6 DEM = digital elevation model, derived from the LiDAR bare-earth returns.

text continues after sidebar

Cartographic resources



Products of the CBJ mapping contract with WSI included a bare-earth surface model (hillshade, left panel), forest structure information from the LiDAR point cloud ('normveg,' center) and high resolution air photography (right panel)

The 3-panel collage is an example for Cowee Creek valley. I prepared these composites every morning for field use by our wetland assessors and boundary mappers who uploaded them to tablets and smartphones.

- **Left panel**: ***Hillshade*** with modeled streams and 10-foot contours—both generated from LiDAR-based DEM (digital elevation model). On more moderate terrain we sometimes used 2-foot contours.

- **Center**: ***Normalized Vegetation***, or height of trees, shrubs and herbaceous vegetation above “bare earth.” This is one of many LiDAR derivatives, colored here by height class, in this case corresponding to thresholds on WESPAK field and office form questions. Notice that areas of darkest grey (tallest) tree crowns were usually excluded from forested wetland units, at least when closely packed. In contrast, areas liberally sprinkled with purple, red and orange (forb, shrub and subcanopy strata, respectively) signify brushy gaps in small or even large-tree forest, and these often turned out to be forested wetland.

- **Right panel**: ***Color infrared*** output from the 6-inch pixel orthophotography. We usually prefer this to true color imagery because it's easier to distinguish conifer from deciduous forest; brighter pinks in this example are riparian alder. Wetland unit outlines shown here are actually the final, surveyed boundaries. Prior to those visits, we used the pre-field predicted outlines, shown in our May 6, 2014 report, titled *2014 Field Plan* (Bosworth, Carstensen & Pohl, 2014a). Preloading these predicted unit outlines into our Trimbles and other GPS devices ensured that a surveyor would visit all of the places we anticipated wetlands might occur.

used in most cases as upper limit of tidal units.[7] Seaward limits were GPSed, walking lowest vascular vegetation.

Similarly, we used a DEM-generated 32-foot contour to identify terrain flooded at peak of the Little Ice Age (map, page 13). Examination of marine landforms on the hillshade imagery confirmed our earlier estimate that landward intrusion reached to about that level throughout the CBJ. All of our mapped **uplift meadow wetlands** occurred below the 32-foot contour.

Raster and vector resources delivered by Watershed Sciences Inc. to CBJ under a separate contract included 6-inch pixel imagery, acquired in 2 missions in spring and early summer of 2013, and many derivations of a LiDAR survey from the same period. Midway through the 2014 field season, CBJ staff developed and shared with us a provisional streams model from the LiDAR DEM. Our use of these resources, both in prefield planning and post field mapping and interpretation, has been described elsewhere. Examples are interspersed among the following AA unit narratives.

Attribute table As the 2014 field season unfolded, we ultimately added 20 fields to the ArcMap master table,[8] fortifying our descriptions of geography, topography, geology and vegetation structure. From this table, individual records have been copied into each of the unit descriptions in this report.

● **YYYYMMDD**: The date of our assessment. Many sites were visited on multiple days, and generally the latest, 'concluding' date is chosen. *Year>month>day* is most useful date format for tables. It makes sorting and analysis easier.

7 Exceptions included "tidal" sloughs far inland from the salt chuck at Amalga Harbor, where vegetation below the 20.8-foot line was completely intolerant of salinity, and tidal fluctuation was preempted by bedrock control at chuck mouth. Here, we changed our predicted tidal AA units to fen/marsh, in consideration of rich sedge and other herbaceous cover.

8 In *ArcMap*, the database associated with a shapefile is called the "attribute table." Spatially linked to each AA unit "polygon," this *.dbf* table is the core document of the JWMPU project. It can be exported to *Excel* for non-spatial forms of analysis by collaborators lacking *ArcMap*, or copied record-by-record into formats such as the bulleted parameters preceding each of the following narratives.

type	#AAs	%total	acres	%acres
fw	160	46%	3961	76%
op	104	30%	773	15%
um	23	7%	182	3%
fm	24	7%	63	1%
td	13	4%	58	1%
fl	8	2%	48	1%
bi	13	4%	118	2%
	345		**5204**	

Acreages of our mapped wetland types.

● **phase**: Twelve bi-monthly reporting phases spanning the 2014-&-15 field seasons.

● **observer**: **aa**—Andrew Allison; **kb**—Koren Bosworth; **cp**—Catherine Pohl; **ra**—Rachel Allison; **rc**—Richard Carstensen; **all**—most or all of our team saw the unit at various times.

● **AA**: Abbreviation for Assessment Area. *Eg*; AB01 = Auke Bay #1. Units were numbered in the order assessed.[9]

● **wettype**: One of 7 wetland categories permitted under WESPAK. Six are also permissable as answers to question #1 on the field form: ***fw***—forested peatland; ***op***—open peatland;

9 Due to unit deletions, mergings, etc, there are gaps in the AA numbers. For example, on the following table, there is no NV28.

fm—fen/marsh; ***fl***—floodplain wetland; ***up*** uplift meadow; ***td***—tidal marsh. A 7th category is ***bi***—beaver-influenced, which we map as such but assign to either *fw* or *fm* in question #1.

See *Changes to wetland* types, below, for explanation of types used initially that were later collapsed into the 7 types above.

Table

aa09

YYYYMM	ph	obser	num2	AAname	aat	acres	elev	aspect	slope	roughness	d_ra	land	watershed	latitud	longit	PCN	parts	n	photodate
20140604	2	kb	NV12	Trailsidecrowberry	op	1.79	380	n	8	smooth	d2	am	Montana Creek	58.430	-134.6	4B2901420050	100		20140604
20140604	2	kb	NV13	Trailsideplateau	fw	22.41	330	ne	10	dissected	d5	am	Montana Creek	58.434	-134.6	4B2901420050	50		20140604
20140603	2	kb aa	NV14	Plateaumatrix	fw	73.4	380	w	17	dissected	d5	am	Montana Creek	58.431	-134.6	4B2901420050	30		20140603
20140625	4	aa	NV15	Laketwocreek	fw	9.13	180	s	16	dissected	d5	am	Lake Two Creek	58.397	-134.6	4B2701080130	60		20140625
20140530	2	cp rc	NV16	McGinnisLYAM	fw	1.88	310	flat	2	smooth	d4	al	Montana Creek	58.440	-134.6	4B2901420050	100		20140530
20140604	2	aa ra	NV17	McGinnisNW	fl	4.07	380	flat	4	smooth	d4	al	Montana Creek	58.449	-134.6	4B2901420050	80		20140529
20140530	2	rc cp	NV18	Dividedwarfshrub	op	3.03	400	s	8	smooth	d2	am	Montana Creek	58.446	-134.6	4B2901420050	100		20140530
20140529	2	all	NV19	Dividematrix	fw	110.57	450	s	10	dissected	d5	am	Montana Creek	58.446	-134.6	4B2901420050	20		20140529
20140529	2	kb cp	NV20	Dividegrandchild	op	2	350	sse	7	smooth	d2	am	Montana Creek	58.444	-134.6	4B2901420050	100		20140529
20140529	2	rc aa	NV21	Dividecentral	fw	1.94	430	sse	12	smooth	d6	am	Montana Creek	58.446	-134.6	4B2901420050	50		20140529
20140529	2	kb cp	NV22	Dividepondline	op	1.17	510	sw	19	smooth	d2	am	Montana Creek	58.448	-134.6	4B2901420050	100		20140529
20140529	2	aa rc	NV23	Dividescrubconifer	fw	2.23	630	ssw	22	pit-mound	d6	am	Montana Creek	58.449	-134.6	4B2901420050	70		20140529
20140529	2	aa rc	NV24	Dividepanorama	op	1.04	650	sse	17	smooth	d2	am	Montana Creek	58.450	-134.6	4B2901420050	100		20140529
20140624	4	aa	NV25	ORVtrailhead	fw	13.83	160	se	10	pit-mound	d6	am	Lake Creek	58.395	-134.6	4B2801030131	60		20140624
20140530	2	aa cp	NV26	McGinnistoeslope	fw	27.81	410	wnw	20	dissected	d5	am	Montana Creek	58.445	-134.6	4B2901420050	30		20140530
20140530	2	cp rc	NV27	Dividescrubhalo	fw	4.41	400	s	7	smooth	d4	am	Montana Creek	58.446	-134.6	4B2901420050	50		20140530
20140603	2	rc kb	NV29	LittleMcGinnisactive	fl	1.04	300	flat	2	pit-mound	d6	al	Montana Creek	58.438	-134.6	4B2901420050	50		20140603
20140603	2	rc	NV30	LittleMcGin-inactive	fw	10.1	310	w	4	pit mound	d4	al	Montana Creek	58.438	-134.6	4B2901420050	50		20140603
20140603	2	rc	NV31	Plateausphagnum	op	2.15	370	ene	7	smooth	d2	am	Montana Creek	58.434	-134.6	4B2901420050	80		20140603
20140603	2	rc	NV32	Plateaurichfen	fm	1.97	380	wsw	9	dissected	d3	am	Montana Creek	58.434	-134.6	4B2901420050	80		20140603
20140603	2	rc	NV33	Plateaualder	fw	2.83	400	wsw	23	dissected	d7	am	Montana Creek	58.434	-134.6	4B2901420050	40		20140603
20140603	2	rc	NV34	Plateaudwarfshrub	op	7.39	360	nw	3	dissected	d2	am	Montana Creek	58.434	-134.6	4B2901420050	80		20140603
20140604	2	kb	NV35	Trailsidedomebog	op	1.1	380	n	9	smooth	d2	am	Montana Creek	58.430	-134.6	4B2901420050	100		20140604

● **acres**: Calculated automatically from polygon metrics in ArcMap.

● **elevation**: The unit's elevational midpoint from 10-foot LiDAR-generated contours. (Highest and lowest elevations of the unit, necessary for slope calculation, are usually reported at the end of each narrative.)

● **aspect**: The 16 slope directions—cardinal and intervening. Listed clockwise from true north, they are; *n; nne; ne; ene; e; ese; se; sse; s; ssw; sw; wsw; w; wnw; nw; nnw.* Units of <1% slope are listed as *flat*.

● **slope**: Calculated in ArcMap. Elevational relief from 10-foot contours, divided by total distance across unit from highest to lowest point. Expressed as *percent*-slope (rise-over-run) rather than degrees—averaged over the unit. Within larger units, slope varies considerably. Units <1% slope are listed as "0." Span over which this slope is measured doesn't always assume hydrologic connectivity; i.e. water entering at the top may emerge elsewhere; not necessarily at bottom of the measured transect. Intent is to show slope steepness upon which wetland vegetation has colonized, rather than to compute steepness of streams, which can be many, and variable within the unit.

● **roughness**: Categories pertinent to wetland structure, function, hydrology, and successional trend. Only the dominant category is listed, as interpreted from the LiDAR-derived hillshade image and personal knowledge. For example, a unit dissected by stream gullies may also be 'lumpy' from generations of tree mortality. If the 1-meter-pixel hillshade shows obvious stream gullies, the unit is described as dissected, and any subtler 'overlayment' of pillows-&-cradles from biological activity ('lumpiness') is disregarded.

smooth *Almost no features on hillshade throughout majority of AA. Found beneath many peatlands and tidal or uplifted wetlands. May occur on slopes, but on steeper slopes the probability of dissection increases.*

dissected *Transected by incised streams—gully clearly visible on hillshade. Commonly found on unconsolidated ancient marine (am) surfaces as described in* landform*, below.*

pit-mound *From millennia of treefall, uprooting, etc—biologically-driven topography, also called "pillow&cradle" by some foresters.*

rugged-mild *Bedrock-controlled undulations—greater relief on hillshade than pit-mound 'pimples,' but easy to hike through (apart from consideration of brush density: see d-ranking).*

rugged-med *Bedrock-controlled, intermediate roughness.*

rugged-high *Bedrock-controlled, extreme relief—entails considerable scrambling by our surveyors. Common in 'uplands' but rare among Juneau wetlands.*

● **d-ranking**: Ten-class system (d1 through d10), explained in Appendix 2, *Bushwacker's difficulty ranking*. Very rough estimate of average d-value. Obviously, within-unit range in difficulty may be great. The larger and more diverse the unit, the less useful this 'average' becomes as a measure of understory conditions. Our unit 'narrative' sometimes contains more information about the ranges in d-value.

● **landform**: Five categories of bedrock- and surficial geologic landform are useful in characterizing wetlands of the CBJ. The commonest wetland substrate above tidal and near-tidal elevations (*ie* 32 feet+) is ancient marine terraces and more steeply sloping raised beaches from the early Holocene (9,000—14,000 years BP). Because fine sediments abound in these ancient deposits, they're often too poorly drained to support productive 'upland' forests, resulting in either forested wetland (*fw*) or open peatland (*op*).

As for the upper limit of early Holocene marine intrusion, USFS geologist Jim Baichtal has recommended a 600-foot contour for scientists at Héen Latinee. Highest dated shell in the Juneau area was from about 700 feet above sea level. A sidebar associated with our narrative for EC18 notes evidence for a tiny pocket beach at 706 feet.

Current rate of glacial rebound in the CBJ ranges from 0.5- to 0.8 inches per year (Larsen *et al*, 2005). Below about 32 feet above sea level ("0 feet," or Mean Lower Low Water), wetlands on level surfaces were recently tidal, thus classified *nm* for "neoglacial marine" landforms.[10] Compared to ancient wetlands above that elevation, they often have shallower peat.

am *Ancient marine (uplifted), smooth or pimpled on hillshade, from 32 to 700 ft+.*

nm *Neoglacial marine (uplifted), smooth or pimpled on hillshade, from 20.8 ft (EHW) to 32 feet elevation*

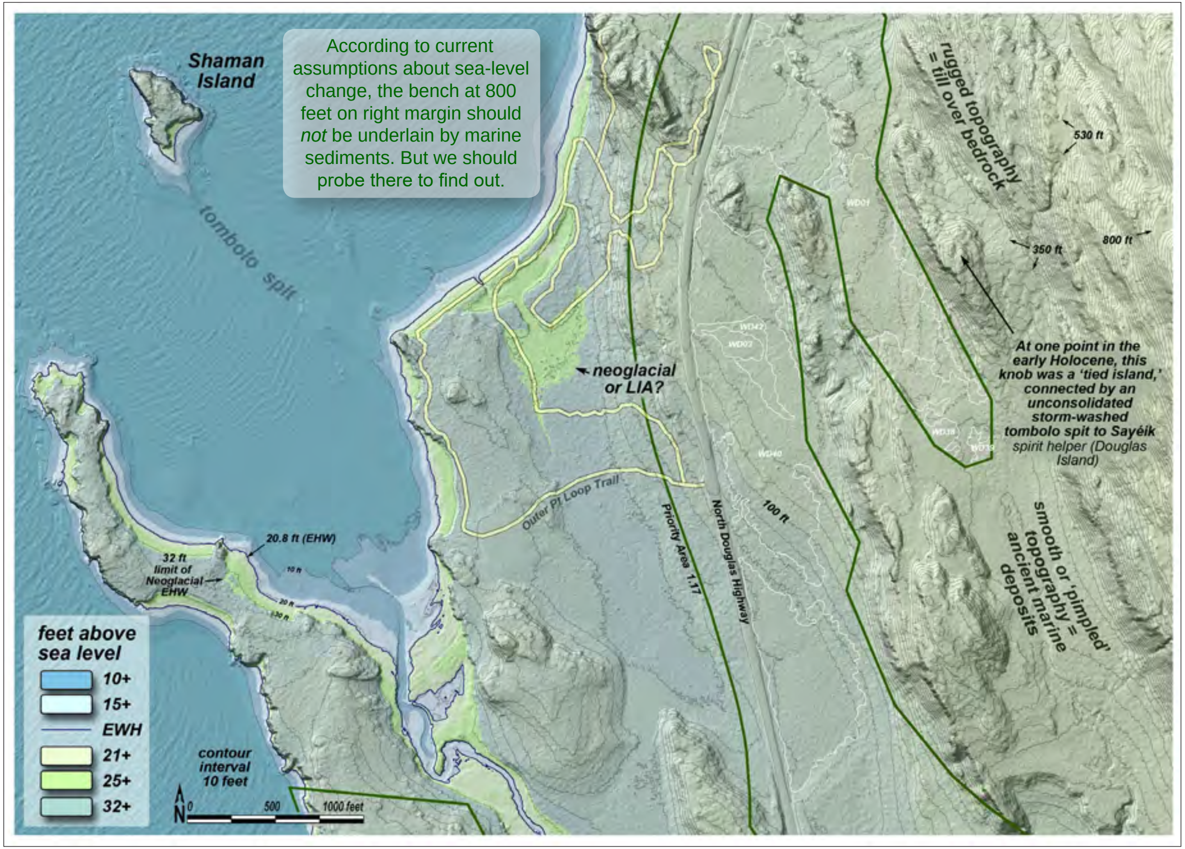
al *Alluvial. Generally well drained, but in some broad, raised floodplains like Cowee, finer sediments lead to large units classified* fw *under WESPAK, and rarely (100 acres total),* fl *for "floodplain wetlands" in the demonstrably annual flood zone.*

td *Tidal (active, <20.8 ft) Within the Priority Areas assigned to us by CBJ, tidal wetlands are relatively uncommon (102 acres total)*

tb *Till (glacial) and/or bedrock. Second most common landform underlying our mapped wetlands. Often found intermixed with am (ancient marine). Only the more widespread of the two is listed, as suggested by examination of hillshade and contours.*

● **subshed**: When the JWMP project began, the most detailed existing "watersheds" layer was HUC-12, by the US Geological Survey (HUC = hydrologic unit code). This was not fine enough to meaningfully define distinct versus connected basins. As described in Appendix 7, we created

10 "Neoglacial" and "Little Ice Age" (LIA) are sometimes used interchangeably. The neoglacial period began about 3000 years ago, concluding the Thermal Optimum. In the CBJ, we know little about the neoglacial's pulses of glacial advance or associated isostatic changes in relative sea level; more is known in Glacier Bay. The Little Ice Age was the most recent and *probably* strongest glacial pulse in the Juneau area. Its timing and extent are well documented.



Westernmost Douglas Island. Thanks to this hillshade, we can detect even small pockets of ancient marine deposits, perched up to 700 feet above today's sea level. Beneath the 50%-opaque hillshade, a digital elevation model (DEM) has been color-coded for significant elevation breaks. Brightest green, for example, shows the zone between current Extreme High Water (EHW) at 21 feet, and highest extent of Neoglacial marine intrusion, at 32 feet. We also use this hillshade to classify surface roughness into 6 different categories.

102 "subsheds" (i.e., sub-units of HUC-12) as a framework for Assessment Area mapping.

- **lat-long fields**: Latitude and longitude of the unit's polygon centroid, calculated in ArcMap. Decimal-degrees format.

- **PCN**: Parcel Code Number, from CBJ's parcels layer.

- **%seen**: Not a required metric under WESPAK. A very rough estimate of % of unit seen by our field team. Depends on both size and vegetation cover. Even a large open peatland may be 100%

“seen” by our mappers and assessors. But forested wetlands larger than a few acres with dense understory may be less than 50% “seen.”

● **photodate**: Sometimes date of selected image differs from ‘concluding’ date of assessment.

Changes to *AAtype*, unit size & spacing

Wetland type Paul Adamus, author of the WESPAK-SE assessment protocol (Adamus, 2013), joined us in the field for our first week of surveys—May 7-11, 2014—and again in late June for protocol review. In those first weeks of 2014, we applied 2 wetland types that were collapsed during the June review back into the 7 types listed in question F1 of the WESPAK field form. The discontinued types—*scrub conifer, sc,* and *scrub deciduous, sd*—are described on page 3 of our Phase-2 report, May 19—June 5.

At the time these wetland types were merged, project managers decided to retain those AA units as mapped, but not to distinguish these wetland types in future surveys—instead, wrapping them into forested wetland, *fw,* that typically encompasses or abuts them. Concluding the 2014 field season, we changed the *sc* and *sd* type to *fw*, and merged these units with the adjacent 'matrix' for purposes of analysis and score-computation.

Because the total number of units originally designated by these discontinued types is small (3 *sc* units + 3 *sd* units = 1.7% of total AA pool), changes to protocol 'midstream' should introduce little bias to summary analysis. *Appendix 4* contains pre-collapse descriptions of several AAs that were merged.

In addition, some units initially designated "floodplain," *fl*, have been changed to the more generic "forested peatland," *fw*. *Appendix 5* gives definitions for "floodplain" and related terms in hydrology and geomorphology.

Wetland size As with these wetland-**type** issues, the question of minimum AA **size** was not fully resolved until late June. Ultimately we settled on a 1-acre threshold. Even after late June, we continued to GPS units smaller than this, and often did not discover until tracing track lines back at the office that they were underqualified as AAs. We've retained these <1-acre units on some maps, but do not describe or report them as 'official' AAs. Instead of a sequential ID number, these undersized units are designated ECxx, WDxx, etc, and transfered out of the GIS layer used for most analyses.

As for AAs with discontinued wetland-type (*sc, sd*), it was decided to retain some of the early AA units of less than one acre that were reported prior to establishment of that size threshold. In some cases these wetlands extended off the Priority Area, such that their full size was more than an acre. For purposes of ecological and hydrological analysis, ownership and administrative status are irrelevant. However, after Phase 3, all AAs have at least one acre *within the PA*. Because the total number of units <1 acre is small (3 AAs <1 acre prior to June 16 comprise <1% of total AA pool), changes to protocol should introduce negligible biases into summary analyses.

Wetland spacing It took several weeks to resolve how far apart AAs of like type should be to qualify as distinct units, or whether separation should occur between DEM-definable slope breaks such as marine escarpments. Ultimately we settled upon a minimum distance of 200 feet, and eliminated slope-break as a criterion. Some AAs mapped and assessed before that decision have been retained. Again, the number of these near-neighbor, like-type units from early-2014 surveys is small. A few additional instances of like-type units <200 feet apart have resulted from post-mapping changes to wetland type (*e.g. fl* to *fw*).

Seasonally variable sites revisited

The Alaska Regional Supplement to the Corps' delineation manual addresses places with seasonally and interannually variable wetness:

If the original site visit was made during the dry season or a drier-than-normal *year, it may be necessary to revisit the site during the wet season or in a normal year and check again for hydrology indicators.*

After a drier-than-normal May, 2014, our field trips took place during 3 months of exceptionally high summer precipitation, followed by fairly average autumn rainfall. (*Appendix 3*). So one would not anticipate pronounced changes to "hydrology indicators" at sites we visited after May. However, as we finished our field season in early October, during visits to the Methodist Camp and Amalga Meadows, we saw standing water in places where earlier soil pits and probing found little moisture.

These uplifting, formerly tidal surfaces are changing more rapidly than other landforms we assessed in 2014. Our last GPS mapping of the season was therefore in the Amalga area, where we significantly expanded previously reported wetlands in the uplift meadow (*um*) and fen-marsh (*fm*) classifications. Further discussion of seasonally variable groundwater in uplift meadows is in the overview section for Eagle River (02ER) map page.

These return visits did not result in any newly created AAs.

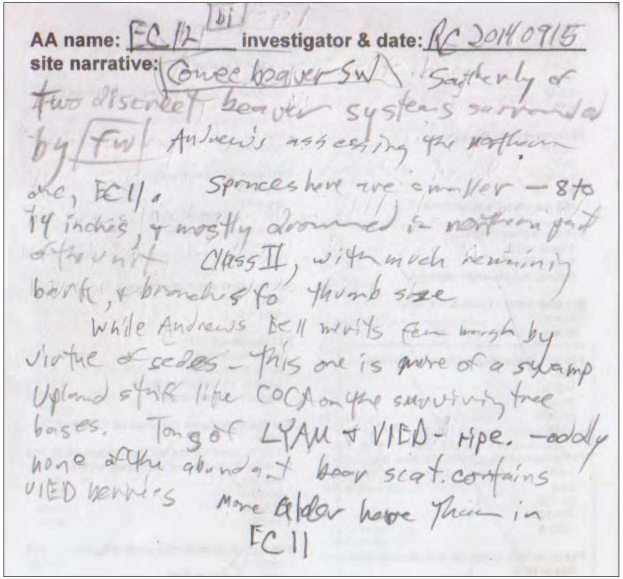
Narratives

The "narratives" for each Assessment Area are informal natural- and cultural-history descriptions. Early in our field work, "narratives" or qualitative unit summaries were a required part of the field form. By early June, 2014, project managers in consultation with Adamus and Naglich determined that these descriptive passages should be replaced in progress (phase) reports by standardized statements under each AA name explaining WESPAK criteria by which the unit was judged.

Our team therefore collected fewer unit-summary remarks in the field after early June, 2014. Part of the purpose of this report is to assemble those informal 'narratives,' especially recording those aspects of the field experience that 'slip through the cracks' in a multiple-choice field form. For units lacking on-site narratives, a short "hindsight-narrative" has been assembled based upon what can be determined from imagery and LiDAR products (often considerable), plus conversation between Carstensen and team members who surveyed the unit borders, or completed the on-site field form.

The goal of each narrative is to describe, from a naturalist's perspective, the geology, ecology, and cultural significance of the wetland unit. We don't attempt to be comprehensive but we do strive to convey the uniqueness (in a few cases, lack thereof) of every unit we examined on the ground and later in GIS.

Some aspects of unit evaluation are better performed in *ArcMap* than in the field. Slope steepness, aspect, and surface


AA name: EC12 bi investigator & date: RC 20140915
site narrative: Cowee beaver SW. Southerly of two discreet beaver systems surrounded by FW. Andrews assessing the northern one, EC11. Spruces here are smaller — 8 to 14 inches, & mostly drowned in northern part of the unit. Class II, with much remaining bark, & branches to thumb size. While Andrews EC11 merits fen-marsh by virtue of sedges - this one is more of a swamp. Upland stuff like COCA on the surviving tree bases. Tons of LYAM & VIED - ripe. - oddly none of the abundant bear scat contains VIED berries. More alder here than in EC11

Example of Assessment Area "narrative" for EC12, Sept 15, 2014.

This is how the “trimblers” spend most of their day. That's about d5 bushwacking between Catherine Pohl and the camera (*Appendix 4* explains d-ranking scale).

This kind of brush density characterizes the **majority** of most *fw* (forested wetland) units that we traversed (for assessment) and circumnavigated (for boundary-mapping). The images we’ve selected *instead* are samplings from the more scenic and/or ecologically interesting parts of each unit.

roughness, for example, are more accurately measured from hillshade imagery and fine LiDAR-derived contours than in the unit itself, where visibility is typically limited by brush. Such values are mostly captured in the attribute-table exports preceding each narrative.

Documentary photos

Our contract specified delivery of one photograph per AA. In many cases we have dozens, including multi-shot panoramas. The choice of photograph to include in this report is sometimes difficult. Within-unit habitat diversity, expecially in the larger units, is often so great that a single “representative” photo would be meaningless. We’ve tried instead to picture, collectively, the full diversity of Juneau’s wetlands. Thus, a photo may be chosen because it depicts wetland attributes not otherwise shown in our collection—rather than to “typify” that particular unit. Image quality also factors into our selections; attractive photos sometimes trump mediocre images that may better show 'average' conditions within the overall unit.

Because even the widest angle lens can’t encompass the defining features of most habitats except at the micro-scale, we take panoramas. Our selections favor these panos, unless a single, conventional photo better illustrates the unit. Viewers should be aware that panoramas spanning as much as 180° may induce distortions of alignment, especially where they incorporate linear human features such as roads or powerlines.[11]

A caveat concerning the photos: Forested wetlands comprise 76% of 5,204 wetland acres mapped in this project. Inside those forested wetlands, *dense brush* is the rule. Our Trimble-carriers often spent more than half of their day in d5+ brush tangles (*Appendix 2: Bushwacker’s difficulty ranking*). The camera typically comes out as we *leave* those denser habitats, and a more inviting vista beckons.

In this regard, our photographic archives—and perhaps *especially* the selections in this report—should not be considered “documentary” in the sense of representational. They might best be called “highlights” of the 2014 field season. Photos accompanying the following narratives are mine (RC), unless otherwise credited.

11 See caption accompanying the panorama for ER24

Additional terminology

The following informal narratives employ vocabulary that's not always in the communal lexicon. **Terms and acronyms** in *Appendix 6* explain geographic unit names and abbreviations specific to the JWMP (Juneau Wetlands Management Plan) project. In addition, the following explanations may provide some guidance.

4-letter plant codes are used for commonest wetland plants in the following narratives. For example, LYAM, for skunk cabbage, derives from the first 2 letters of genus, ***Ly**sichiton* and the first 2 letters of species, ***am**ericanum*. For less universal species, we use common names in the narratives. Where only one species of a genus occurs locally, we forego the full name (spruce, as opposed to Sitka spruce). *Appendix-1* has a table for common & botanical names plus 4-letter code for those species and common species-associations we don't wish to write over and over again.

Decay class A standard 5-class forester's ranking. Stage of decay in snags and down logs is important to fish and wildlife habitat, and to interpretation of successional status and trend. Stages I, II and III can be either standing or down. By stage IV the tree has invariably fallen:
I Needles shed but retains fine twigs; usually died <1 yr ago.
II fine twigs shed but retains fingersized branches and bark.
III only coarsest branches, most bark sluffed, usually falls over in this stage but is firm enough to be self-supporting over a span.
IV conforms completely to ground undulations but wood too hard to kick in, mostly moss-covered.
V sometimes barely detectable, can kick the wood in with your boot.

Geologic terms Bedrock and surficial landforms are key to understanding the hydrology and successional status of Juneau wetlands. For background, and a complete glossary, see Carstensen and Connor (2013) *Reading Southeast Alaska's Landscape*.

Bushwacker's difficulty rating An important field in our attribute table, fully explained in *Appendix-2*. Controls not only the degree of pleasure/pain experienced by wetland ground-truthers but also interacts with many other wetland functions and values.

Unit map-pairs

A pair of maps is provided for every AA described. Several AA units are often mapped together when they are best understood collectively. The left-side maps are on a hillshade base, with 10-foot contours and a modeled streams layer. Where scale permits, Priority Area (PA) and subshed boundaries are shown. On the right side of each map-pair is a June, 2013 true-color air photo for the same area, with only thin white unit boundary lines overlain, for minimal interference with vegetative information.

On the left-side hillshade maps, AAs are color-coded by wetland type according to this key. The first 6 types correspond to choices on question F1 of the WESPAK field form. The last type, *beaver-influenced,* is not on that list, but is a permissible AA mapping unit in our GIS project.

A third, context map shows red-circled location of mapped units within the encompassing CBJ map page.

Navigating this document

The overall trend of wetland descriptions is from from NW to SE, according to the 11 numbered map pages (we conducted no field surveys on map

The 230-foot escarpment

One landform we encountered repeatedly throughout the CBJ could not have been plotted or measured before receipt of the 2013 high-resolution, LiDAR-based hillshade. Especially prominent on the Douglas side of Gastineau Channel is a long, 10 to 40-foot-high escarpment carved by waves during a still-stand of the sea at an as-yet unknown time in the early Holocene. The base of this escarpment is usually at 230 to 240 feet in Gastineau Channel, where it can be detected from Fish Creek around to Nevada Creek. An escarpment at this level also occcurs in the Bay Creek subshed near Auke Bay School, and above Bridget Cove 'out-the-road.' It often divides our wetlands into disjunct units.

On the more exposed marine terraces of western ('back') Douglas Island, there's no consistent escarpment at this level. Instead we often see a 'staircase' of risers, at variable heights, both lower and higher. Perhaps on this stormier side of the island, a single major gale could create an escarpment, whereas in protected waters, a series of storms over a longer period were required?

page 10).[1] Each of the 10 map-page sections begins with a geographic overview, including a coarse-scale map showing all AAs on that "page." Although the map pages are a convention we inherited from CBJ cartographers—laid out simply for partitioning convenience—it so happens that each features unique geology, hydrology, disturbance regime, successional history, prevalence of certain wetland types, ownership patterns, development history, and significance to Juneau's future.

After each map-page intro is a page for each of its AA units. These descriptions include a photo taken within the unit, a standard array of physical and biological parameters determined from field observation and GIS analysis, and a "narrative."

Inserted throughout, on separate pages, are the unit map-pairs, *usually* placed immediately following the appropriate 'narrative page.' But AA units were assigned numbers in the order assessed, so adjacent units are not always numbered sequentially. To locate the map-pair for a given AA, scan the *table of contents,* or open *bookmarks* (left-side column in the pdf version). Both are hyperlinked; clicking jumps you to the map.

 These are useful buttons to dock on your Acrobat Reader header (*tools>customize toolbars*) The **back-arrow** returns you to the previous page—for example when jumping from a map back to the unit's site description. The **binocular** button opens a contextual word search. The **magnifier** allows precision (marquis) zooming, especially helpful with high-res maps;[2] instead of multiple clicks, drag a box over the area of interest, then back-arrow to return to full-page view.

1 In 2015, we did conduct "off-site" assessments on map page 10, southeast Douglas Island.

2 Unit boundary lines are intentionally thin on the air-photo (right) side of the map pairs. This choice was made in order to have minimal disruption of the view of forest canopies and other wetland detail. Because the *pdf* version of this document has 300 dpi resolution, difficulties in viewing some of the more complex unit-arrays can be resolved by zooming in with the marquis-magnifier.

Appendices

1 Plant species cited in narratives

A few common plants are mentioned so frequently in the narratives that we abbreviate them with standard 4-letter codes: first 2 letters of genus followed by first 2 letters of species. This is an especially useful convention for lists of commonly-associated species that appear again and again. Botanists and field workers prefer these 4-letter codes for concise communication.

Two important plant associations are listed so frequently that we urge readers to commit their codes to memory:

PISI-OPHO/LYAM (Sitka spruce—devil's club over skunk cabbage).

TSHE-MEFE/LYAM (western hemlock and rusty menziesia over skunk cabbage.)

Because these very different forest types are lumped under *fw* (forested wetland) in our mapping, we've tried to note their occurrance and relative abundance in our unit narratives. Further discussion of upland-bottomland distinctions is in Appendix 5.

code	*botanical name*	common name
PISI	*Picea sitchensis*	Sitka spruce
TSHE	*Tsuga heterophylla*	western hemlock
TSME	*Tsuga mertensiana*	mountain hemlock
PICO	*Pinus contorta*	shore pine
ALRU	*Alnus rubra*	red alder
ALSI	*Alnus sinuata*	Sitka alder
MAFU	*Malus fusca*	Oregon crabapple
VA*spp*	*Vaccinium spp*	blueberry, *multiple species*
MEFE	*Menziesia ferruginea*	rusty menziesia
OPHO	*Oplopanax horridum*	devil's club
VIED	*Viburnum edule*	highbush cranberry
LYAM	*Lysichitum americanum*	skunk cabbage
COCA	*Cornus canadensis*	ground dogwood
EMNI	*Empetrum nigrum*	crowberry
LEGR	*Ledum groenlandica*	bog tea
FACR	*Fauria crista-castrensis*	deer cabbage
POPA	*Potentilla palustris*	marsh fivefinger
CALY	*Carex lyngbyeii*	Lyngbye sedge
CASI	*Carex sitchesis*	Sitka sedge
ATFE	*Athyrium felix-femina*	lady fern

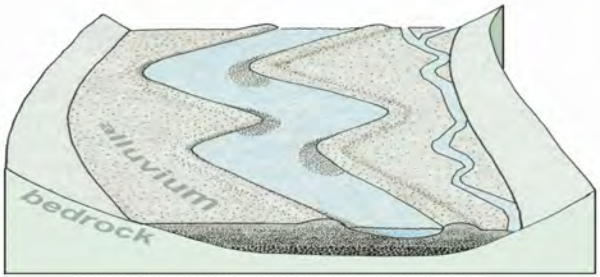
5 Alluvium, floodplain, hyporheos defined

On stream and river bottomlands, wetland classifications intersect with stream-mapping systems that are similarly keyed to needs of regulators, particularly in fisheries. Any attempt to reconcile or even cross-walk these intersecting classifications should begin with some definitions from the fields of geomorphology and hydrology. Depending upon the regulatory environment—fish habitat, flood control, etc.—terms such as *alluvium*, *floodplain* and *hyporheos* or *hyporheic zone* may be defined in slightly different ways.

Alluvium This is probably least ambiguous of the above 3 terms, and a good place to start. Alluvium is simply the material deposited by moving water of streams or rivers.[1] In some regulatory arenas alluvial features are further differentiated into fans and floodplains, but since wetlands almost never develop on universally well-drained alluvial fans,[2] we can limit this discussion to alluvial "floodplains." Since the latter term is a little slippery, call it, for now, the almost-level alluvial plain in a valley bottom resulting from millennia of deposition by migrating channels. On that plain, throughout Southeast Alaska, a mosaic of well- and poorly-drained sediments typically supports corresponding patchworks of tall spruce forest and scrubbier forested wetland or even open peatland. For those who think of "forested wetlands" as stressed environments where canopy trees rarely grow tall—a fair generalization—it can be surprizing to find skunk cabbage—usually a signal of mucky soils and drainage impediments—at the roots of vigorous conifers. An example is the stand above on Montana Creek's alluvial plain, still probably growing at more than a foot per year.

Although young (post Little Ice Age), some of these spruces are 160 feet tall. Because Montana Creek is a yazoo channel, exceptionally flood prone, this is one of the few units we mapped "*fl*"—floodplain wetland—under WESPAK criteria.

1 A related adjective, "fluvial," refers to the **processes** associated with rivers and streams and, sometimes, to the deposits (*ie*, alluvium) and landforms created by those processes. One rarely encounters what might seem a logical derivative, "fluvium," whereas it's common to see "alluvium's" adjective: "alluvial." I'll return to "fluvial" and "alluvial" at the end of this appendix, in consideration of name-choice for an additional wetland type.



2 About the closest we came to mapping a wetland on an alluvial fan in the JWMP surveys was at NV02, on Little Lake Creek, which flows into Auke Lake. A very tall-tree forest occupies the more typical fan of ('big') Lake Creek to the west; *that* forest we did *not* classify wetland.

As for what portion of our alluvial valley bottoms to designate "floodplain," here is where things get more complicated.

Floodplain For some purposes, it may be legitimate to consider the entire alluvial valley bottom a "floodplain" (once a floodplain, always a floodplain). In other situations, such as wetland delineation, assessors consider the temporal framework: in the short view, periodicity of flooding; and in the longer view, the see-saw of erosion and deposition responsible for that periodicity.

Northern Southeast Alaska has just emerged from a Little Ice Age. While glaciers are advancing, and for a period before they begin to retreat in earnest, alluvial surfaces conducting their meltwaters are *aggrading*—at the watershed scale, continually adding layers to the valley floor. (Of course, at the finer scale of cutbanks and point bars, local erosion is always taking place.) During the aggradation phase, entire valley floors may be "floodplain" by even the most restrictive definitions.

But for the past century, in most northern Southeast watersheds, aggradation has ended. Streams and rivers are cutting down (degrading) into their alluvial plains. For example, at Brotherhood Bridge on the lower Mendenhall, incision has been so rapid during the last century that a flood of 16 vertical feet would be necessary for the river to top out. So, even though flooding of the upper surface was probably annual as recently as the early 1900s, this area of the valley is no longer technically a floodplain in the language of wetland delineation. Below, I'll get to the question of what to call these superficially inactive alluvial surfaces. For now, though, let's focus more narrowly on just where to draw that line between active and inactive.

Tall-spruce wetland on Peterson Creek. *Probably* floods near-annually. LYAM laying down in early September.

Under WESPAK-SE_v1.4, a floodplain wetland is defined as follows:

> *Most of the AA floods overbank* ***at least once annually*** *from a nearby non-tidal river or stream. Soils are silts or coarser with scattered, seasonally-saturated organic layers. Vegetation is usually Sitka spruce, willow, red and Sitka alder, devil's club and skunk cabbage.*

In rainy, moss-carpeted Southeast Alaska, on the banks of smaller streams not instrumented with flow-gauges, determining whether a site floods annually is challenging. Because 3 of our field-team members have lived in Juneau for many decades, we've had opportunities to visit local streams at or shortly after flood-stage, when herbaceous vegetation is still laid-over.[3] Our estimates of what constitutes a "floodplain" are generally more encompassing than those of observers who depend upon persistent clues such as fresh sediment deposits. On Douglas Island, for example, Peterson Creek mainstem (above) *probably* overtops its banks almost every autumn, and occasionally floods during rain-on-snow events in spring, but may not carry enough suspended sediment or woody

3 Years of residency for KB, CP and RC total one century as of 2015.

debris to leave unambiguous evidence.

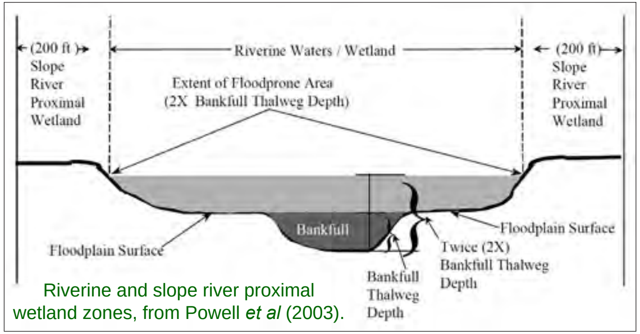
WESPAK-SE is designed for one-time visits by observers throughout Southeast Alaska who don't necessarily bring local knowledge of annual hydrologic regime. In order to apply a consistent 'threshold' to the floodplain classification, persistent evidence of overbank flooding is required. Under that definition, only a few fairly volatile streamside wetlands within CBJ's priority areas were mapped and assessed as floodplain. From north to south they are:

- 5.5 acres along Peterson Creek in Amalga Meadows
- 5 acres in 2 units along McGinnis Creek
- 10.5 acres along Montana Creek downstream from Back Loop Road.
- 27 acres along Fish Creek near Eaglecrest

In all of these examples, recent deposits of overbank flooding, or vegetation and debris cast aside by floods can be found. There are sometimes minor differences in rooted vegetation between the annual-flood and higher zones, but due to the rapidly changing nature of these near-stream environments, floral composition is usually quite similar.

In addition to the WESPAK protocol, other workers have addressed riparian wetlands in Southeast Alaska. Powell *et al* (2003) recommended a classification for "*riverine and slope river proximal wetlands.*" Jim Powell's team included many of Juneau's senior scientists in the fields of soils and hydrology: Dave D'Amore, *USFS*; Bruce Bigelow, *USGS*; Terry Brock *USFS*; Pete Huberth, *private forester,* Ralph Thompson, *COE*; and Todd Walter, *UAS/Cornell*.

The Powell team's definition for "*riverine waters/wetland*" (profile illustration, upper right) approximates that of the floodplain type under WESPAK. Framing that zone of regularly-flooded topography, Powell *et al* describe an additional, enveloping wetland zone called "*slope river proximal*." All vegetation in this zone benefits from and contributes back to the stream and its below-surface waters. Rather arbitrarily, this zone was defined as extending another 200 feet beyond the limits of riverine wetlands.[4]



Riverine and slope river proximal wetland zones, from Powell *et al* (2003).

WESPAK wetland types include no analog of the slope river proximal zone. For mapping purposes, that may be of little consequence in small basins with streams on till or bedrock. (see "controlled" versus "floodplain channels" in Forest Service mapping, below). Lacking substantial alluvial deposits, hemlock-skunk cabbage wetlands ("forested peatland," *fw*) typically span these smaller channels.

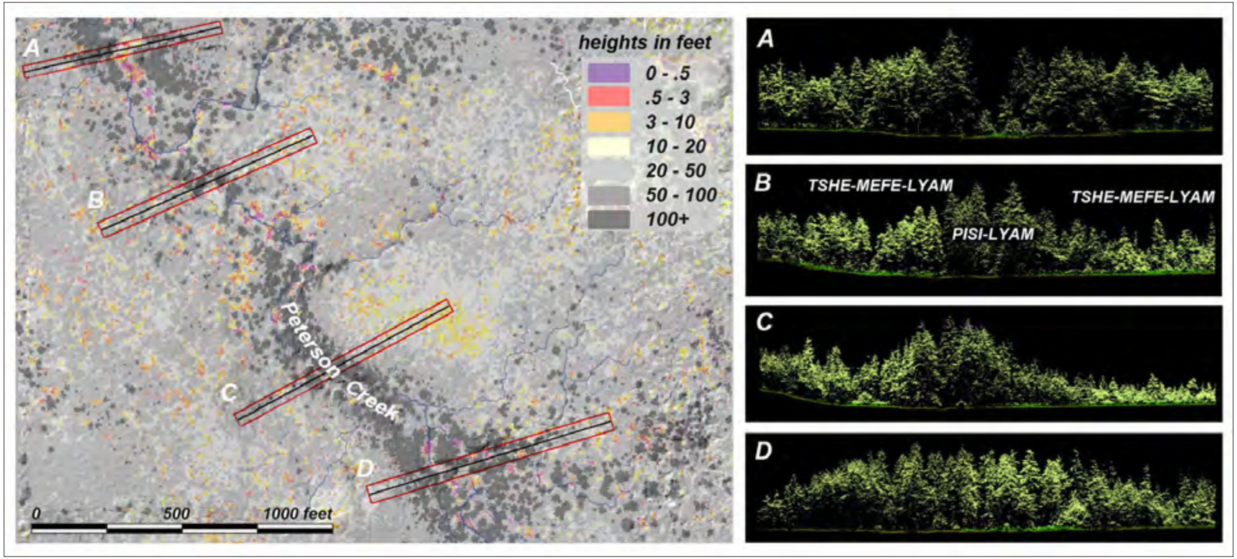
Where the wetland-type options of WESPAK become limiting are in broader alluvial basins. Examples within the CBJ priority areas include both Peterson Creeks (25-mile and West Douglas), the Montana/McGinnis system, and Jordan Creek.

But in terms of acreage, by far the most extensive bottomland forests, where we spent many days surveying, are on the half-mile-wide alluvial plain of Cowee Creek. Because Cowee and Davies have recently downcut several feet into their Little Ice

4 Powell *et al* acknowledged that "*extent of riverine wetlands is a function of valley morphology*," so obviously will vary in width. Perhaps, as with WESPAK, in designing a protocol for regulatory applications, they could not assume local, year-round knowledge on the part of observers, nor access to the high-resolution topographical mapping abilities that our field team can apply, thanks to the CBJ LiDAR resources. From these GIS layers, we could accurately map the limits of any "slope-river-proximal" zone.

Age deposits, overbank flooding is today probably restricted to a narrow band along their banks. In consequence, lacking a wetland type analogous to the "slope river proximal" of Powell *et al*, the WESPAK *fw* map units on this tall-spruce valley floor extend without distinction upslope into scrub-hemlock wetlands on the valley walls.

Wetlands are mapped as polygons. Although streams are mapped as lines in the USFS GIS database (Paustian, 2010) those linear stream features derive their classification at least in part from the enveloping landform. Even from the relatively low-resolution (30m-pixel) digital elevation models (DEMs) presently in use, most of those alluvial landforms can already be mapped at all but the finest scale. As more detailed DEMS (based on IfSAR rather than LiDAR) become available for most of Southeast Alaska, even small alluvial features such as stepped terraces and oxbow-scrolls will be mappable, as they are now for us in the CBJ.

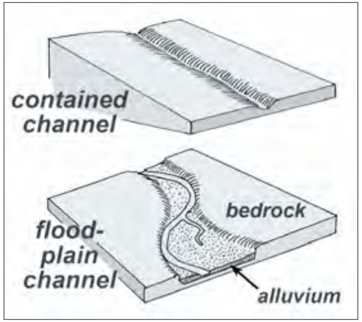


Example at Peterson Creek To compare forest structure on and off of alluvial landforms, I've drawn 4 transects through the LiDAR point cloud, about 600 yards south from road's end on Back Douglas. On the map, tree and shrub heights are color-coded with the normalized vegetation layer. Almost every tall tree (broad crowns, darkest grey, 100 feet+) *probably* experiences overbank floods regularly, if not annually. But under WESPAK, lacking evidence such as fresh sediment, we can't map a floodplain wetland here.

Still, our surveyors consistently found tall-spruce dominance (PISI) along the stream, with skunk cabbage (LYAM) on muck, and only a few woody shrubs; bushwacking is an easy d3. I've labeled this association PISI-LYAM on profile B.

Only slightly upslope, beyond influence of hyporheic water, wetlands shift dramatically to scrubby hemlock over dense menziesia tangles (~d6 bushwacking)—TSHE-MEFE-LYAM on profile B.

The 4 transects show productive young riparian spruce forest more than twice as tall as much older hemlocks in forested peatland beyond reach of stream-associated hydrology.



Bedrock-contained versus floodplain channels in the Forest Service streams classification.

In the supporting documentation for the USFS channel-type GIS layer (Paustian, 2010) there is no distinction between active versus inactive portions of floodplain landforms. From the perspective of in-stream fish habitat, the difference between regularly flooded and inactive alluvial sediments along the banks is much less important than the qualitatively different character of alluvium versus till-on-bedrock.

All of the above-listed Juneau streams—both Petersons, Montana, Jordan, Cowee, etc—are mapped as "floodplain" in USFS's *chantyp* field, irregardless of annual overbank regime. Clearly, "floodplain" has different nuances in fisheries, geomorphology and wetland ecology. WESPAK types have not been crosswalked or linked to the USFS channel-type layer because the latter is founded on landform. WESPAK classifications, in contrast, are hydrologic (Paul Adamus, *pers comm*).

If, however, we were to add a WESPAK classification for wetlands on alluvial landforms just above the reach of annual flooding, what would we call it, and how would it be delimited? In Juneau, with access to superb topographical hillshade, 2-foot contours, and stream modeling, we can easily show exactly where alluvium ends and the upland slope begins. Naming is perhaps the greater challenge.

Because "slope river proximal" of Powell *et al* is such a tongue-twister (and currently so arbitrarily defined), I've struggled with alternate labels for wetlands on alluvium. One challenge is that biologists are not accustomed to using terms from geomorphology to define habitats. They speak of "riparian" forest, for example, rather than "alluvial" forest. But riparian implies nothing more than proximity to stream or river (in some definitions even lakes!), and glosses the essential attributes of substrate and hydrologic regime.

Before proposing a name for "inactive" alluvial wetlands, let's be clear that they remain *very active*, just below the surface. Which introduces our third important concept and definition—that of the hyporheic zone.

Hyporheic zone The hyporheic zone—from the Greek, *hypo* (below) and *rheos* (flow) lies beneath and alongside a stream or river channel where surface and groundwaters intermingle.[5] In large basins like Cowee-Davies, hyporheic waters can be visualized as a slowly moving, braided network, entraining vastly more water at any point in time than carried by the visible, more swiftly flowing surface channels.

The hyporheic zone stores and redistributes nutrients from both up- and down valley, benefiting every plant association throughout the bottomlands, as well as resident and visiting terrestrial and aquatic fauna. It's the delivery system for alder-derived nitrogen, The hyporheic zone is home to the earliest stages in salmons' lives and banks the nutrients from their ultimate decomposition. Because flow is slowed to a snail's pace, longer 'residence time' permits fuller utilization of nutrients in biofilm, and a unique combination of stability and productivity (characters elsewhere at odds) in bottomland aquatic and terrestrial habitats.

Study of the hyporheic zone is a fairly new discipline, in part because it's so challenging to map. Dye tracing studies through pvc-well arrays (piezometers) are beginning to demonstrate how features such as logs, pool-step sequences, point bars and meander-bends drive exchange of stream water into and out of the hyporheic zone. The zone is almost insignificant in

5 A one-word term for the zone is *hyporheos*, but this term is less frequently encountered.

bedrock-controlled channels—just one more reason that USFS fish scientists consider "floodplain channels" (in the broadest, most inclusive definition) of highest value to salmonids in all life phases: egg-stage, in-gravel allevins, summering and overwintering fry, as well as to returning adult spawners.

Most studies of hyporheic flow have been on relatively small mountain streams lacking extensive lateral movements. In broad floodplains such as Cowee-Davies, that lateral distribution is assumed to be substantial. According to Rick Edwards, lead scientist at Héen Latinee:

> *" Lateral distribution of the hyporheic zone into riparian areas or across floodplains is greatly influenced by paleochannels, which are subsurface flowpaths where hydraulic conductivity is greater than in the surrounding sediments. Paleochannels can carry hyporheic water hundreds of meters away from the stream."* Edwards (2004)

Hyporheic delivery must be part of the *ongoing* reason that valley-bottom wetlands (and other habitat types) remain floristically distinct from valley-wall communities, for centuries and even millennia after channel incision has removed these surfaces from the zone of annual flooding.[6]

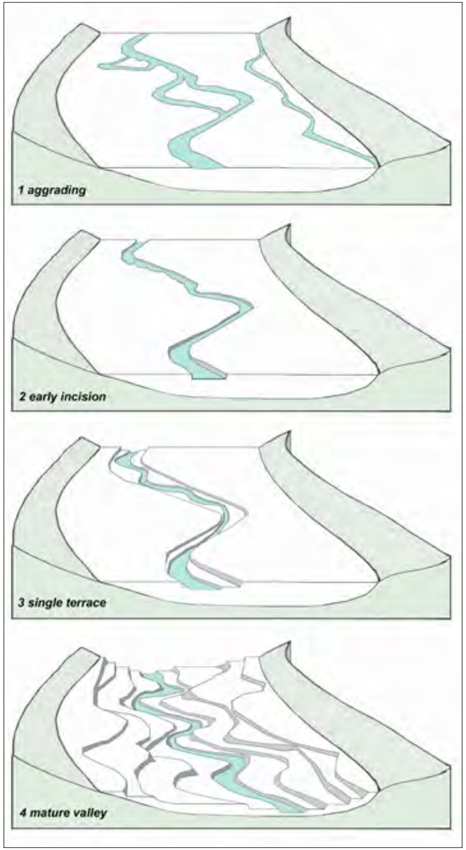
What to call it? Whether or not we ultimately add a WESPAK mapping unit to identify these unique wetland associations, we should name them in a meaningful way. I suggest a name derived from their landform, or hydrology, or both. Hydrogeomorphologists usually apply the term "fluvial terraces" to valley landforms created by stream action but no longer annually flooded:

6 In heavily developed valleys, incision can be a good thing. Fortunately for residents of Mendenhall Valley, this pattern is found downriver from the back loop bridge—or, more precisely, downriver from the band of very large terminal moraine boulders visible from that bridge. Deposited during the Little Ice Age (LIA) maximum of the mid-1700s, the moraine forms a sill, or hydrologic control. Southward, the river has down-cut through fine alluvial and tidal sediments, interlayered with root-bound organic beds of conifer forests from the Thermal Optimum. Even the annual jökulhlaups of recent years generally fail to overtop the Mendenhall's banks, once they move beyond morainal control into the roomy, degrading channel.

Yet even here, where the sheet of moving groundwater may be as deep as 15 feet below the abandoned, peak-LIA floodplain surface, the hydrology and ecology of wetlands is very different from that of non-alluvial wetlands on bedrock/till surfaces only a few feet away on the valley walls.

After a glacial episode like the Little Ice Age (LIA), streams and rivers cease aggrading and begin to excavate their former floodplains. In northern Southeast Alaska this is happening not only in currently glaciated watersheds due to ice recession, but also in valleys of Montana and Fish Creeks where glaciers existed throughout and shortly following the Last Glacial Maximum, probably persisting into the early Holocene.

In valleys like the Mendenhall and Cowee-Davies, with strong LIA legacies, incision has not proceeded much past phase 2 in these diagrams. On river bottomlands, millennia may be needed to produce the multi-stepped fluvial terraces of phase 4. Because the LIA 'reset' most CBJ valleys to phase 2, our only phase-4 terrace arrays are on ancient raised deltas, as at Fish Creek, next page.



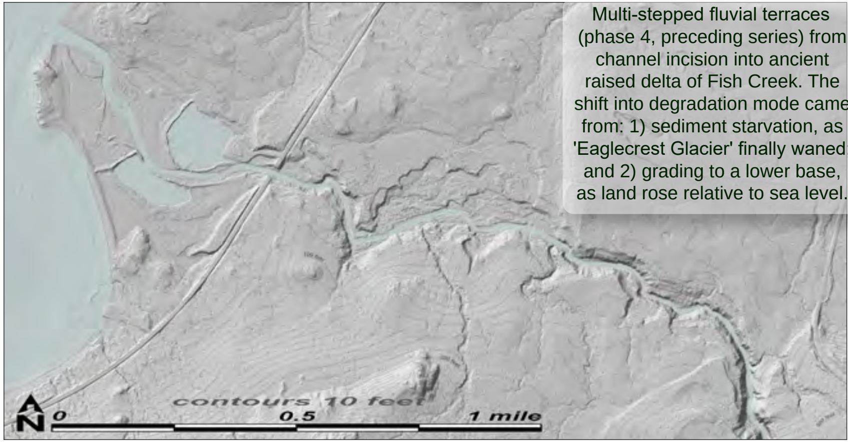
*"Elongated **fluvial terraces** flank the sides of floodplains. They consist of a relatively level strip of land, called a 'tread,' separated from a floodplain and other fluvial terraces by distinctly steeper 'risers.' Fluvial terraces are remnants of earlier floodplains created before downcutting to a new, lower floodplain, grading to a new base level* [in Juneau, caused by falling relative sea-levels], *and causing headward erosion. Terraces may also be left behind when flow declines following glaciation."* paraphrased from: en.wikipedia.org/wiki/Fluvial_terrace

But this prevailing term for higher, 'inactive' alluvial treads and risers (phase 4, preceding series) describes a landscape that's rather unusual in northern Southeast. Although stepped, linear terraces typify mature valleys in places like the Oregon Coast Ranges, where highest terraces are as old as 200,000 years (Personius, 1993), our only well-developed examples in the CBJ are on the slightly steeper slopes of ancient, raised deltas such as Fish Creek. On Prince of Wales Island, D'Amore *et al* (2011) described a simpler, 2-terrace pattern (Tonowek and Tuxekan soils), perhaps closer to phase 3 on the preceding diagram, and propose that:

"lack of evidence for soils on multiple terraces confirms that the landscape stabilized shortly after the Tuxekan terrace was abandoned."

D'Amore *et al* (2011) refer to the relatively simple landforms of Southeast valleys as "alluvial terraces." There's probably no semantic difference between "alluvial" and "fluvial" when used as adjective for a landform in this manner.

Since the common understanding of "terrace" probably assumes some degree of linearity, as in phases 3 and 4 of my preceding diagram, and since the preponderance of supra-floodplain landforms in local, CBJ valleys more closely resemble phase 2—a floor, or maybe a table, not a tread or terrace—I'm inclined, barring better suggestions, to begin calling the visually 'inactive' but hydrologically dynamic spruce-devilsclub-skunkcabbage association (PISI-OPHO-LYAM) the **alluvial forest wetland.**[7]



Multi-stepped fluvial terraces (phase 4, preceding series) from channel incision into ancient raised delta of Fish Creek. The shift into degradation mode came from: 1) sediment starvation, as 'Eaglecrest Glacier' finally waned; and 2) grading to a lower base, as land rose relative to sea level.

Although WESPAK AA map units gloss distinctions between PISI-OPHO-LYAM and the TSHE-MEFE-LYAM association on adjacent till-bedrock landforms, I've tried to capture differences in the preceding narratives by reference to the **alluvial forest wetland.** Additionally, the *landform* field of the AA attribute table typically has the entry *al*, (alluvial), rather than *am* (ancient marine), which is the predominant landform beneath hemlock forested wetland.

7 "Hyporheic forest wetland" would be equally or more appropriate, but: **1)** it has less name-recognition and about the same odds of lay-adoption as "slope river proximal." **2)** the alluvial floor is much more easily mapped on LiDAR 'bare-earth' than the lateral extent of invisible hyporheic zones.

6 Terms & acronyms

CBJ City and Borough of Juneau

JWMP Juneau Wetlands Management Plan

WESPAK-SE Wetland Ecosystem Services Protocol for Southeast Alaska

Wetland Assessment Areas (AAs) As defined by our partner Paul Adamus in the 2014 WESPAK-SE protocol (*http://southeastalaskalandtrust. org/wetland-mitigation-sponsor/wespak-se/*), these are units of fairly uniform hydrology, soils and vegetation, on which a standardized field assessment is conducted. The AA numbering system is further explained below, with *Map pages, AA numbering convention*.

Priority Areas (PAs) Defined by CBJ; 72 units within which the AA surveys are conducted, ranked 1 through 4. To identify individual Priority Area units, we added 2 digits after the rank. For example, 1.17 is Priority rank 1, unit number 17.

Map pages, AA numbering convention Names for our individual Assessment Area units are grouped geographically by Priority Area map pages, in the January, 2014 JWMP RFP # 14-132, identified by 2-letter initials. (These City map pages do not correspond with our *numbered* maps in this report.)

From northwest to southeast, the 10 CBJ map-page areas we worked in 2014 are:

EC Echo Cove
ER Eagle River
LP Lena Point
AB Auke Bay
NV North Valley
SV South Valley
LC Lemon Creek
WJ West Juneau
ND North Douglas
WD West Douglas

AA unit identification codes begin with these 2 letters followed by a 2-digit number. For example, EC44 is AA #44 within the Echo Cove (EC) map page. We numbered these units chronologically, in the order assessed, so the number sometimes bore little relationship to that of units in geographic proximity. Because this number was tied to so many other tables, maps, analyses, etc, it became 'locked in' as soon as field and office forms were completed.

An exception occurred when units were later deleted or merged. This accounts for gaps in our numbering system. For example there are no units numbered EC32 through EC36.

Subsheds Our name for small watersheds we delineated using fine LiDAR-derived contours from CBJ’s 2013 data set and a provisional streams model.

Bing (*www.bing.com/mapspreview*) Online maps, similar to Google Earth.

DEM Digital Elevation Model. One of the products of LiDAR, shows "bare earth" with vegetation removed. In contrast, the "point cloud" shows forest structure.

LiDAR Light Detection And Ranging. Airborne survey that measures distance with a laser light.

7 Subshed delineation

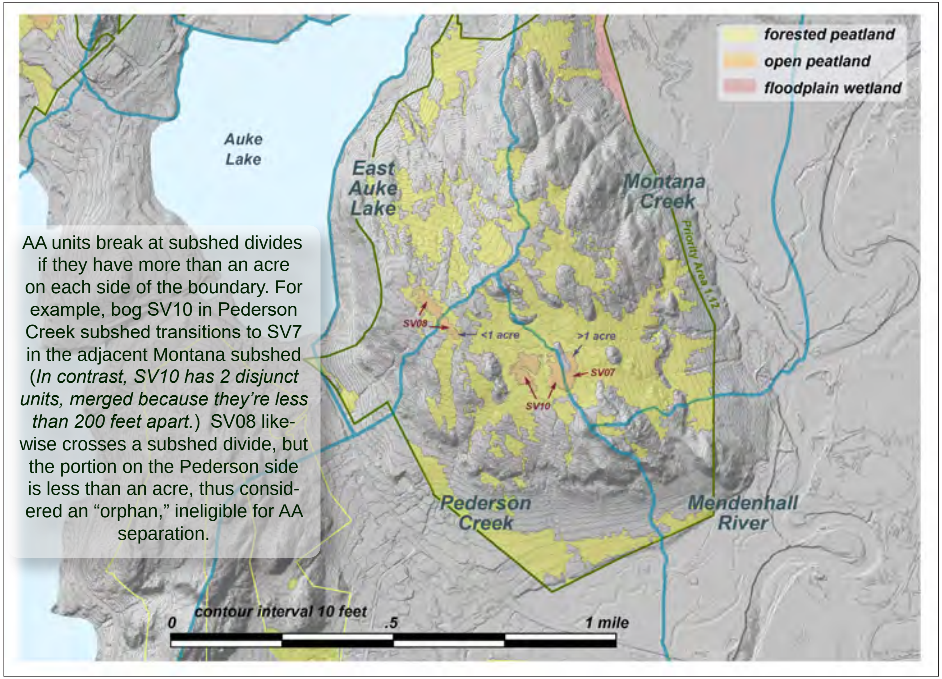
No existing spatial database depicts watershed units at the scale necessary for Juneau-area wetlands mapping. The 2 layers that come closest are Hydrologic Unit Codes (HUC) by the US Geological Survey, and Value Comparison Units (VCU) by the US Forest Service. Neither display true hydrologic watersheds.

Hydrologic connectivity and segregation are fundamental criteria for Assessment Area (AA) mapping under WESPAK-SE. We've mapped "subsheds"—so called because they are sub-units of the smallest local HUC units (HUC-12). This finer-scale mapping has only recently become feasible, thanks to a high-resolution Digital Elevation Model (DEM) and associated data delivered to CBJ in 2013.

I traced subshed boundaries by reference to 10- or 2-foot contours at a scale of 1:1,000 or finer. Boundary-&-basin questions are of increasing importance moving into more complex terrain, farther from roads. And watershed configuration—even where boundaries are far from the AA unit itself—are fundamental to ecological, hydrological and jurisdictional analysis.

In addition to fine contours, our subshed mapping is also informed by high-resolution stream models from the LiDAR DEM. Extending the model to finest tributaries, they can be seen as 'fingers' reaching up to hydrologic divides; the boundary is woven between those fingertips.

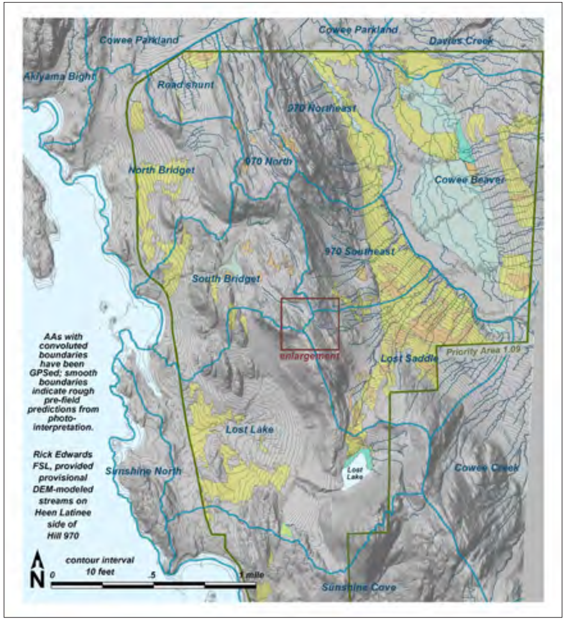
Depiction of subshed units should be based upon fairly stable, well defined criteria:



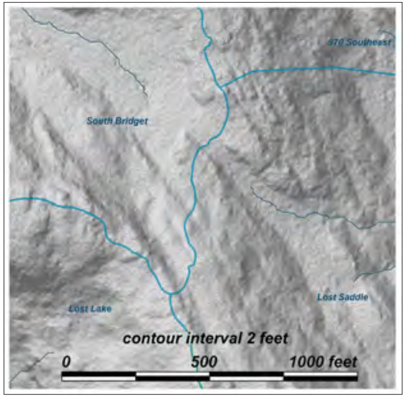
"Subshed" boundaries created by the Bosworth team for Hill 560 separating Auke Lake from Mendenhall Valley. Ten-foot contours are shown, generated from DEM provided to us by CBJ. In areas where finer topographical resolution was needed—such as the subtle divides on the summit of Hill 560—we mapped boundaries from 2-foot contours.

- Streams and tributaries in the subshed generally converge toward one 'receiving' channel. In the case of some coastal subsheds, minor streams—both ephemeral and perennial—may reach saltwater independently, but are generally not named on maps or listed in the Department

	subshed name	acres
Cowee Creek	Road Shunt	87
Cowee Creek	970 North	126
Cowee Creek	970 Southeast	199
Cowee Creek	970 Northeast	309
Cowee Creek	South Bridget	319
Cowee Creek	Lost Saddle	360
Cowee Creek	North Bridget	372
Cowee Creek	Sunshine Cove	663
Cowee Creek	Lost Lake	714
Cowee Creek	Cowee Beaver	810
Hill 560	East Auke Lake	185
Hill 560	Pederson Creek	1409
Hill 560	Montana Creek	9757
Hill 560	Mendenhall River	17812



Left: Subsheds at Cowee Creek and Hill 560, ranked by increasing acreage. ● **Right:** Detail from center of preceding map of Hill 970, Two-foot contours generated from DEM. Streams also from DEM, by Rick Edwards, Forestry Sciences Laboratory. Thresholds for stream order can be set even finer, showing predicted ephemeral channels that help fine-tune the subshed boundaries.



of Fish and Game's Anadromous Waters Catalog (AWC).

● Conversely, the dominant 'receiving' channel of each subshed is generally named on maps, or at least shown as fish-bearing in the AWC. Exceptions include situations such as Hill 560, from which small streams radiate outward; topography here tends to splay streams outward, rather than gathering channels into third or fourth-order waterways. Other exceptions include significant channels in the Cowee headwaters that are unnamed and uncatalogued, but that *would* have names, were they closer to roads or even trails.

● Subsheds drain basins of 50 acres or larger. The smallest subshed named on the preceding map of Cowee Creek is 87 acres, titled "Road Shunt" because flow from NW-striking gullies on the shoulder of Hill 970 is diverted northeastward by the highway berm.

● Subsheds are named by their dominant stream (*eg* Waydelich Creek), or if no named stream exists, by their best-known geographic feature (*eg* Point Louisa). Lacking any such widely-known feature, in a few cases we resorted to referential names such as "970 Northeast." (off the northeast side of Hill 970) or "Lost Saddle" (over the saddle from Lost Lake)

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