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Under contract with the Black Hills Audubon Society, I am submitting comments on three critical areas categories of the Draft Critical Areas Ordinances (2005, 2007) and supporting Best Available Science (2005). The critical areas categories commented on in this document include Critical Aquifer Recharge Areas, Geologic Hazard Areas, and Administrative Procedures.

The following documents were reviewed:

1. AMENDMENTS TO THE CRITICAL AREAS REGULATIONS - Critical Aquifer Recharge Areas; Thurston County, DRAFT in progress, TCC 17.15.500, 10/07.
2. BEST AVAILABLE SCIENCE/GUIDANCE – CRITICAL AQUIFER RECHARGE AREA; Thurston County Best Available Science/Guidance Document, July 2005, Planning Commission Public Hearing Draft.
3. AMENDMENTS TO THE CRITICAL AREAS REGULATIONS - Geologic Hazard Area; Thurston County, DRAFT in progress, TCC 17.15.800, 10/07.
4. BEST AVAILABLE SCIENCE/GUIDANCE – GEOLOGIC HAZARD AREAS; Thurston County Best Available Science/Guidance Document, July 2005, Planning Commission Public Hearing Draft.
5. AMENDMENTS TO THE CRITICAL AREAS REGULATIONS - Administrative Procedures: Thurston County, DRAFT in progress TCC 17.15.400, 10/07.

Limits on time available for reviewing the documents precluded itemized comments on specific statements or codes, and focused attention rather on perspectives and broader scientific concepts being addressed in the documents listed above. Concepts are discussed, and references to those that were the basis for decisions on regulations or procedures. Where more clarification is needed, I tried to bring in the appropriate discussion or references. I was impressed by the thoroughness of the documents individually for each discipline listed.

However, for the sake of efficiency in compiling this document, I did not comment on items, issues, or applications of scientific concepts, where I found no reason for revision. My responsibilities were to read and review documents pertaining to Critical Aquifer Recharge Areas and Geologic Hazard Areas, and my comments address only these topics – although with some brief reference to linkages with other categories of critical areas.

Italicized text blocks are inclusions from Thurston County documents.

- Bulleted text blocks (and numbered text below) are comments and recommendations

Review Summary

Clear scientific linkages exist, and are reported in the scientific literature, between the functions and effects of forest canopy cover, impervious surfaces, stormwater run-off (surface and groundwater), erosion and slope instability, and water quality – all elements of the Hydrologic Cycle and geologic processes. These linkages and the BAS supporting them should be strengthened and better communicated in the BAS and CAO documents, helping to illustrate the objectives of CAO regulations, and improve their implementation and effectiveness.

Field investigations repeatedly demonstrate that certain geologic and hydrologic hazards might have been prevented through comprehensive drainage management plans. Such plans need to integrate sub-basin scale and site-specific processes and conditions (land cover and land use), and need to be coordinated between private, county, and other property owners.

Geotechnical investigations should be required to identify current and potential future stormwater issues (terrestrial and marine), and delineate any potentially unstable landforms on or adjacent to the property being evaluated. The reports should be required to explain (with geologic cross-sections and other illustrative graphics and text), the scientific basis for and mitigation of effects on site and sub-basin hydrology and slope stability of any proposed landscape/property modifications.

These data (hydrologic modeling results, geologic and geomorphic maps, etc.) should be compiled into a readily-available and user-friendly database maintained by the county for future reference, development planning, and even project monitoring.

The following are broad over-arching comments:

1. Ordinances only weakly follow the BAS stating the importance of preserving forest cover with respect to reducing the effects of impervious surfaces.
2. Hydrology and CARA sections need to expand and strengthen the science discussion relating surface and groundwater and the exchanges between the two.
3. Need to strengthen science around the role of groundwater in slope stability, particularly with regard to deep-seated landslides.
4. Need to tailor technical reports to specific issues at a given site
5. Need to link issues between categories – specifically hydrologic issues relating to geologic hazards and aquifer recharge areas (see more below)

6. Find ways to incorporate/fund monitoring to feed into adaptive management.
7. BAS and the successful application of CAO regulations would benefit from more reference to and consideration of potential climate change effects.

The following comments apply to the Administrative Procedures section TCC 17.15.400:

1. County process would benefit from review and possible revision of the order in which permit applications are reviewed, what type of professional(s) is(are) required to do the investigation and submit the report, and to what professional standards supporting documents are held.
2. Planners should be (are now?) in the loop.
3. Need to address issues associated with multi-structure developments differently from single-family development.
4. Need to address process by which developer can divide lot into smaller units to avoid requirements associated with larger developments.
5. Need to consider issues of lot ‘buildability’ together with septic viability. One shouldn’t necessarily guarantee the other.
6. Need to investigate thresholds for runoff and infiltration in different settings (ravine, bluff, upland flats, etc.)
7. Need to define what triggers requirement for geotechnical report and what questions need to be answered for a particular site or sub-basin. These questions need to be answered with supporting BAS from applicant. (see more below)
8. Reference to “Licensed hydrologist or engineer”, should include, “with specific experience in the hydrogeologic issues being addressed” – or some such language. **This should be included in all sections addressing requirements of special reports.**

Thurston Co Critical Areas Ordinance – Critical Aquifer Recharge Areas

17.15.500 Purposes

17.15.510 Applicability

17.15.520 Restricted and prohibited uses and activities

17.15.530 Standards for restricted uses and activities

17.15.540 Special reports

17.15.550 Performance monitoring and reporting

(see bulleted comments below)

NOTE: This review provides no comments on contaminant transport and chemistry.

Best Available Science - Aquifer Recharge Draft: 02/20/05

2. Methods of determining aquifer susceptibility.

- Lacks attention to land cover/land use and projected changes through time, and cumulative effects.
- Criteria listed don’t clearly distinguish between confined and unconfined aquifers beyond definitions. Ordinances should be able to address, and studies need to evaluate, potential effects on each aquifer and type of aquifer, and the relationship between confined and unconfined where relevant.

B. Impervious Surface/Tree Cover.

King County BAS 2/04: The addition of impervious surfaces can have a large impact to groundwater recharge by changing the local water balances and volumes and decreasing base flow components (Holman Dodds et al., 2003). The use of low impact, infiltration based, development (LID) in storm water management can offset the losses of recharge, and in some cases completely eliminate the losses due to impervious surface additions (Konrad and Burges, 2001; Holman-Dodds et al., 2003). It should be noted that increasing impervious surfaces does not necessary lead to decreases in recharge or base flow. For example, if a forested area is replaced with a paved surface for which runoff is collected in a recharge pond, net recharge may be greater than under the original condition in which much of the precipitation is lost to interception and evapotranspiration (Bidlake and Payne, 2001).

- CAO's should link this discussion to water quality issues, making sure both are addressed in discussions of infiltration
- The definition of IMPERVIOUS should be clearly stated as 100% (if that is the case), as it currently does not appear to include degrees of imperviousness such as lawns, gravel, etc. vs. concrete. Much rides on the definition regarding mitigation requirements.
- Much of the cited BAS clearly states that loss of forest is more important than just considering % impervious surface. Current CAO's are not using these criteria for mitigation. (Booth, 2002) at least at rural densities.
- Apply information from studies addressing riparian vegetation to applicability to bluff stability, both in marine and upland fluvial settings
- (Mantech, 1996) speaks to cumulative impacts of forest cover changes. The CAO needs to address summer low flow changes and should encourage more studies, particularly in areas that are being considered for, or are already undergoing restoration efforts.

S. Bolton and A. Watts: Reports on data from studies on the impact on streams of traditional timber harvest and applies them to forest cover removal in urban settings. Concludes that changes in urban areas are analogous to those due to harvest but are more severe and more long lasting. To minimize excess storm flow generation in streams, it is crucial to maximize natural areas, provide for infiltration opportunity, and minimize the generation of overland flow." Particularly true in small basins, which are more common urban settings.

*In summary, studies of forest hydrology give us an understanding of how alteration of the land affects the hydrologic cycle. Changes in urban areas are analogous to those due to **harvest but are more severe and longer lasting**. To minimize excess storm flow generation in streams, it is crucial to maximize natural areas, provide for infiltration opportunity, and minimize the generation of overland flow.*

- "Because of the extreme variability that is exhibited by areas that are subject to landsliding, site-specific studies **may** [SHOULD?] be required in order to design, construct, and safely occupy a structure that is to be built in or adjacent to one."
- With continuing geologic mapping efforts, field mapping should be used to define landslide hazard areas, rather than slope steepness thresholds (except for certain types of slides.) Tubbs (1975) was based on Seattle, and on certain type of slides.

- Geologic and hydrologic controls on slope stability need to be considered with steepness criteria, and sometimes separately from steepness criteria. Thus, proper site characterization is required.
- Most of the discussion for Thurston Co. is of coastal landslides. However, citations are not all relevant to coastal (*i.e. Sidle*). Inland landslides also occur in Thurston Co., and must be included.
- Need to make a clearer connection of forest canopy to surface and groundwater hydrology (CARA) and the resultant relationship to slope stability.
- Setback guidelines based on slope steepness are generally irrelevant on deep-seated landslides. Need to delineate extent of unstable landform and define potential hazard area with each site investigation.
- Reports need to include DATA on groundwater conditions and slope stability – this data exists from various sources. “Professional judgments” need to be substantiated with site-specific analyses to determine risks and sensitivity to site modification, etc.

“Shipman, Coastal Landsliding on Puget Sound, 2001. The Coastal Zone Atlas of Washington [Washington Department of Ecology, 1977-1980] comprises the only comprehensive mapping of unstable slopes along the shores of Puget Sound and we believe it is the primary source for a variety of published estimates for the amount of shoreline susceptible to landsliding.”

- This is no longer the case. Division of Geology and Earth Resources has published numerous maps over the last 10 yrs. There should also be numerous individual reports contained within Thurston Co. files.

17.15.540 Special reports

- Recommend including reference to geographic area to be addressed in the geologic/hydrologic investigation. This should extend beyond the property boundaries include relevant landforms and basin or sub-basin boundaries. Any discussion of groundwater should also address stability, runoff, wetland issues, stream recharge, and other relevant and related potential effects.

Thurston County Critical Areas Ordinance - Geologic Hazard Areas

17.15.600 Purposes

E. Identify and map geologic hazard areas.

- Does this mean there is a method set up to capture data as it comes in, to build a growing database of areas of slope hazards? Pro-action, such as field mapping *should* qualify as mitigation and should be supported.

17.15.610 Applicability

No specific comments

17.15.620 Buffers

Setbacks, vegetation, See general comments

17.15.630 ~~Special management areas~~ Nisqually Hillside Overlay District

See comments regarding ground and surface hydrology and relevance to slope stability, water quality, erosion, etc.

17.15.640 Allowable uses and activities within geologic hazard areas and associated buffers

17.15.650 Performance standards for allowed uses and activities

- **See general comments** – Need to have more of a comprehensive discussion of surface and groundwater. This should incorporate discussion of regulatory and land-use objectives for protecting public health and safety, adjacent property, habitat, etc., particularly in items A (4-8).
- Efforts should be made to develop scientifically-backed thresholds for performance, process, conditions, and health (human, habitat). At this point it's hard to track where numbers come from, sometimes seeming arbitrary, subjective, based on personal opinions, and lack of better information.
- Need to plug holes in loopholes in allowing emergency waivers without adequate investigation.
- Regarding Vegetation Removal (E), Roads, etc. – See general discussions for concerns with Forest Practice Conversions, forest removal, and general hydrology issues.

17.15.660 Special reports

- Should have standards that correspond to those outlined by DOL geologist licensing program.
- Contents should be specific to site with all the criteria as currently listed, but with the addition of specific questions that need to be answered in order to meet objectives of site problems, conditions, concerns, proposed uses, and future issues (see suggestions below).
- The 3rd party reviews should not be paid for directly by the proponent. Doing so would result in the occurrence or appearance of a potential conflict of interest. (see additional comments below).
- Reports should incorporate and be required to show references for Best Available Science. Need to assure that the science of conditions and processes are site-specifically addressed through verifiable field observations, not just the objectives of the applicant.
- Technical reports should incorporate current literature to either support or refute specific CAO issues they are addressing.
- Literature should be published in past few years and be specific to the issues being investigated/addressed (e.g. riparian buffers, Infiltration/runoff, Slope stability, Habitat, Bulkheads (replacement/ construction materials, alternatives)).
- Reports advocating for bulkheads should be asked to present evidence for **lack of negative effects**.

C. OPTION: Landslide Hazard Areas and Marine Bluff Hazard Areas - Reduced Buffer. The approval authority may allow a buffer of less than fifty feet when the following conditions are met:

1. A geotechnical professional, through a geotechnical assessment, confirms that there will be no public safety risk and no adverse cumulative impacts to the stability of the slope or bluff or to adjacent properties.

2. *Third party review, at the applicant's expense, is required. The third party review must reach the same conclusions as the original geotechnical assessment before a buffer reduction is allowed.*

- If an applicant/proponent pays for the review it is not truly 3rd party. The risk is that such a review would weigh in support of the client. The county might consider creating a pool of “qualified technical experts” who may at times consult for such clients, but who may also be called on to review other projects. This is a common system for professional peer review and might be paid for from a fund contributed, for example, by various stakeholders, regulating agencies, impact fees, permit filing fees, etc.
- **Vegetation Removal** – Any discussions on removal/management regulations would benefit from more specifics and references on aspect, soils, site objectives, long-term management plans. Should correlate language for single-family residences with those on forest conversions. These often slip through the cracks, especially in dealing with hydrologic effects, slope stability, groundwater recharge.

7. *Avoid the need for shoreline stabilization. The approval authority shall deny proposed developments and uses if s/he determines that the development or use would require structural shoreline stabilization measures at the time of construction/implementation or over the life of the development. (Adapted from WAC 173-26-221)*

- There is no reference in the BAS to the stated 5000sq ft building limit. Need to explain the basis and thereby justification for this number.

Landslide and erosion hazard areas and associated buffers. *If there is no alternative with less impact, stormwater facilities shall be constructed as follows:*

a. Surface drainage down the face of the slope must be avoided. If drainage must be discharged, it shall be collected upland of the top of the slope and conveyed by tight line drain through a high-density polyethylene pipe with fuse-welded joints, or similar product that is technically equal or superior. The pipe shall be located on the surface of the ground and properly anchored so that it will continue to function in the event of an underlying slide or active erosion conditions.

And...

If tight lining is not possible, *stormwater retention and detention systems, such as dry wells and infiltration systems (including those utilizing buried pipe or French drains), within a landslide or erosion hazard area or associate buffers shall require approval of a Reasonable Use Exception, in compliance with Section 17.15.460.*

Any such system receiving approval of a Reasonable Use Exception shall be designed by a licensed civil engineer and shall include a geological assessment indicating that such a system will not affect the stability of the slope. Monitoring wells shall be required through one wet season, at a minimum, for a proposed infiltration system and the results included in the geotechnical assessment.

- The topic of infiltration vs. slope stability on bluffs or other landslide-prone areas is not very well studied. Needs more research with follow-up monitoring. Such research, and any required permit studies, should be done by a hydrogeologist or engineering geologist with knowledge and experience specific to these issues.
- Need to answer the questions: Where is infiltration appropriate and where not? How could stormwater be routed through geo hazard areas if there are no safer, lower-impact alternatives? Should development be allowed there in the first place?
- ‘Tight-lining’ is unsightly, commonly not well-maintained and therefore likely to result in long-term problems, and allows for other drainage management inadequacies.
- On a case-by-case basis, there might be creative ways to convey this water via aesthetic and safe surface water features. We need to explore these possibilities.
- Consider **bioengineering** before engineered solutions, but make sure all agree on the definition, and the objectives.
- For any solutions to stormwater and slope management, the county should consider how best to achieve shared liability among the landowner, county, consultant, and other potentially affected parties.
- **Mine Hazard** section – under special reports, is there a drainage plan required? If not, why not?
- Minimum report standards – see DOL report guidelines.
- Consider having a list of questions for specific CA’s, to be addressed in any technical report required for permit applications in those areas and under those ordinances.

Here’s an example from Forest Practices regulations - **Per WAC 222-10-030 (1) (a,b,c)**:

(1) In order to determine whether such forest practices are likely to have a probable significant adverse impact, and therefore require an environmental impact statement, the applicant must submit the following additional information, prepared by a qualified expert. The expert must describe the potentially unstable landforms in and around the application site and analyze:

(a) The likelihood that the proposed forest practices will cause movement of the potentially unstable slopes or landforms, or contribute to further movement of a potentially unstable slope or landforms.

(b) The likelihood of delivery of sediment or debris to any public resources or in a manner that would threaten public safety; and

(c) Any possible mitigation for the identified hazards and risks.

- To tailor required reports to specific problems and sites, and not end up with 5+ reports for each, and rather than asking questions like, “Is there an effect?”, **consider posing specific questions that can be objectively evaluated like:**
 - How will the project effect the stability of the slope?
 - What are the expected effects on groundwater levels during different seasons from actions.
 - What specific actions will be taken to minimize or avoid these effects?
 - What is the geologic/hydrologic basis for needing the requested bulkhead, retaining wall, etc. etc.?
 - Do alternatives exist that would better protect the functions and values of the critical area (as required by the CAO and GMA)?

Additional references for possible inclusion in the BAS (some cited in this document, some not):

Booth, Adam M., Roering, Josh J., Perron, J. Taylor (2009); Automated landslide mapping using spectral analysis and high-resolution topographic data: Puget Sound lowlands, Washington, and Portland Hills, Oregon, *Geomorphology*, v109 pp132–147.

Brennan, J.S., and Culverwell, H. 2004; *Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems*; Published by Washington Sea Grant Program; Copyright 2005, UW Board of Regents; Seattle, WA. 34 p.

Clancy, M., I. Logan, J. Lowe, J. Johannessen, A. MacLennan, F.B. Van Cleve, J. Dillon, B. Lyons, R. Carman, P. Cereghino, B. Barnard, C. Tanner, D. Myers, R. Clark, J. White, C. A. Simenstad, M. Gilmer, and N. Chin. 2009. *Management Measures for Protecting the Puget Sound Nearshore*. Puget Sound Nearshore Ecosystem Restoration Project Report No. 2009-01. Published by Washington Department of Fish and Wildlife, Olympia, Washington.

Cruden D.M., Varnes D. J. (1996); *Landslide types and processes*; In: Turner A.K.; Shuster R.L. (eds) *Landslides: Investigation and Mitigation*. Transportation Research Board, Spec. Rep. 247, pp 36–75.

Diefenderfer, Heida L., Sobocinski, Kathryn L., Thom, Ronald M., May, Christopher W., Borde, Amy B., Southard, Susan L., Vavrinec, John, Sather, Nichole K., 2009; *Multiscale Analysis of Restoration Priorities for Marine Shoreline Planning*, Environmental Management, DOI 10.1007/s00267-009-9298-4.

Finlayson, D. 2006. *The geomorphology of Puget Sound beaches*. Puget Sound Nearshore Partnership Report No. 2006-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at <http://pugetsoundnearshore.org> .

Hungr O, Evans SG, Bovis MJ and Hutchinson JN (2001); A review of the classification of landslides of the flow type, *Environmental and Engineering Geoscience*, v7 n3, pp 221-238.

McCullah, J., Gray, D., 2005, *Environmentally Sensitive Channel- and Bank-Protection Measures*; Transportation Research Board NCHRP Report 544, Washington, DC. 50 P.

National Research Council, 1999, *Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends*, *in Science for Decisionmaking; Coastal and Marine Geology at the U.S. Geological Survey*; Washington, D.C., National Academy Press, 113 p.

Varnes D. J. (1996) *Slope movement types and processes*; In: Schuster R. L. & Krizek R. J. Ed., *Landslides, analysis and control*. Transportation Research Board Spec. Rep. No. 176, Nat. Acad. of Sciences, pp. 11–33, 1978.

Van Cleve, F. B., C. Simenstad, F. Goetz, and T. Mumford, 2004. Application of “best available science” in ecosystem restoration: lessons learned from large-scale restoration efforts in the USA. Puget Sound Nearshore Partnership Report No. 2004-01. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at <http://pugetsoundnearshore.org>

British Columbia Stewardship Series, 2003; Coastal Shore Stewardship: A guide for planners, Builders, and Developers on Canada’s Pacific Coast, 92 p. (*incomplete citation*)

Other useful information sources and references:

- Other BC pubs on landslides and risk assessment; responsibilities/liabilities
- DGER coastal mapping- website linking to quadrangle maps
http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/geology_portal.aspx
- Other PSNERP and NST reports from armoring workshop, etc. (see website
http://www.pugetsoundnearshore.org/technical_reports.htm)
- Thurston County permit and other reports and maps documenting unstable slope areas.
- Other slope stability mapping?