



A POLYTECHNIC INSTITUTION

Course Outline

School of Construction & the Environment

Course Number: RENR 8102

Program: Bachelor of Technology in Ecological Restoration

Course Name: Restoration of Freshwater Salmonid Ecosystems

Prerequisites:

RENR 7100 Introduction to Ecological Restoration

RENR 8201 Terrain and Stream Channel Assessment

Course is a prerequisite for:

Hours/Week:	4	Lecture:	2	Lab:	2	Total Hours:	60	Level:	Degree
						Total Weeks:	15	Credits:	4

Course Description:

This course will give a detailed overview of freshwater restoration techniques used primarily to mitigate losses of salmonid habitat and stocks. The spectrum will examine physical, chemical, thermal, and biological restoration technologies used in this province, some of which are new and innovative, while others have been used extensively over the last 100 years. Aspects of this course will include; spawning channels, fish ladders, development of off-channel habitats, in-stream woody debris placement, lake fertilization, stream fertilization, hypolimnetic cold-water withdrawal, mitigation of Total Gas Pressure (TGP) supersaturation at dams, lake destratification, hypolimnetic aeration/oxygenation, fish passage and culvert re-design, and biomanipulation.

Students will require a laptop and access to the internet to complete some in-class assignments.

Course Learning Outcomes

At the end of this course the student will be able to:

1. Conceptualize salmonid spawning requirements in terms of basic design criteria and ecological requirements;
2. Evaluate the use of fish ladders in British Columbia including those on local North Shore streams;
3. Apply the objectives and criteria for design of off-channel salmonid rearing habitat for their construction at any given location;

4. Monitoring the design and production of off-channel salmonid rearing habitat structures;
5. Evaluate where, when and how large-woody debris habitats used by fish in both main-channel and off-channel ecosystems should be constructed;
6. Understand lake/reservoir and stream baseline assessments, treatment assessments and commonly used methodologies for fertilization to restore fish production as implemented in British Columbia;
7. Assess how hypolimnetic water withdrawals can assist in lowering temperatures in streams for fish;
8. Understand the concept of gas supersaturation (Total Gas Pressure TGP) in water and its effect of fish (Gas Bubble Trauma GBT) in the context of mitigating these at dams;
9. Analyze the processes and benefits of lake destratification and hypolimnetic aeration/oxygenation in British Columbia;
10. Assess when and where culverts require re-design and re-construction to allow for fish passage, daylighting of streams and restoration of urban water quality and stream flow

Lectures and Laboratory Exercises

Lecture 1: *Setting the stage for ecological restoration; Watershed Restoration 1: Overview of watershed restoration, review of impacts of forest harvesting and urbanization on aquatic resources*

Lab 1: *On campus field trip* – walking tour of Guichon Creek on BCIT Campus

Lecture 2: *Watershed Restoration 2: Timing and sequencing of restoration works, planning, regulatory approval process*

Lab 2: Video - *Salmonid Four Seasons Habitat Requirements-23:43; BC Watershed Restoration Program-16:25*

Lab 2 Exercise: *Identification and selection of class term projects*

Lecture 3: *Watershed Restoration 3: Watershed geomorphology and fish habitat;*

Lab 3: *Field trip* – *Lower Mosquito Creek, North Vancouver habitat inspection, Mosquito Creek fish ladder and tour of Northwest Hydraulics Consultants physical scale-model laboratory - B. Chilibeck, P. Eng.*

Lecture 4: *Watershed Restoration 4: Salmonid biostandards for estimating production benefits of fish rehabilitation techniques*

Lab 4: Video – *Guide to BC Salmonids-25:22; Trout and Salmon Habitat:30:00*

Lecture 5: *Watershed Restoration 5: Restoration of large wood in streams and rivers*

Lab 5: Field trip – *Lynn Creek large woody debris placements*

Lecture 6: *Watershed Restoration 6: In-stream boulders and off-channel habitat creation and complexing*

Lab 6: Field trip – *Middle Mosquito Creek, North Vancouver off-channel habitat projects*

Lecture 7: *Watershed Restoration 7: Restoring fish access and spawning gravel, spawning channels, fish ladders*

Lab 7: Field trip – *Upper Capilano River fish downstream passage and smolt trapping project; Lower Capilano River - effects of dams on fish habitat; Hadden Creek fish passage, West Vancouver*

Lecture 8: *Watershed Restoration 8: **Mid-term exam**; Steambank stabilization;*

Lab 8: On campus training: *Boulder and log drilling, cable cutting, Hilti epoxy*

Lecture 9: *Reducing runoff and increasing infiltration in urban watersheds; daylighting of urban streams - Dave Hutch, City of Vancouver*

Lab 9: Field trip – *Hasting Park Creek daylighting, Acadia Creek and Spanish Bank Creek fish passage, UBC*

Lecture 10: *Watershed Restoration 9: Stream fertilization, protocol for adding nutrients to streams and rivers*

Lab 10: Video - *Helicopter application of slow fertilizer-26:00; Salmon Carcass chipper treatment-16:20*

Lab 10 exercise: *Calculation of nutrient loading for stream enrichment*

Lecture 11: *Lake Restoration 1: Lake and reservoir fertilization, protocol for adding nutrients to lake and reservoirs*

Lab 11: Video - *Westland TV Series - Kootenay Lake Fertilization video-30:00; Westland TV Series- Report on the Lakes (Kootenay, Arrow and Okanagan) – 30:00*

Lab 11 exercise: *Calculation of critical loading; calculation of nutrient loading for lake and reservoir enrichment*

Lecture 12: *Lake Restoration 2: Lake stratification and circulation, separating sanitary and storm sewers in urban watersheds - Keith Der, City of Vancouver*

Lab 12: Field trip - *Trout Lake, John Hendry Park*

Lecture 13: *Lake Restoration 3: Gas transfer; destratification and hypolimnetic aeration*

Lab 13: Video - *Restoration of Lake Delevan* - 23:00

Lab 13: *Calculation of hypolimnetic oxygen depletion rates*

Lecture 14: *Lake Restoration 4: Food web biomanipulation; effects of hydroelectric systems on fish: nutrients, gravel, LWD, TGP, entrainment*

Lab 14: Video - *Westland TV Series - The Mysis Crisis on Okanagan Lake*- 30:00;
Westland TV Series – The Columbia River Treaty -30:00; *Ruskin Dam spillway-TGP testing*-9:35; *Fish entrainment at GM Shrum Generation Station*-25:00

Lecture 15: Final exam; *Presentation of project reports*

Evaluation

Mid-term exam	25%	Comments: The student will have a number of field trips on which to draw information. The exams will include questions pertaining specifically to these trips.
Final exam	50%	
Project report and quizzes	25%	
Total	<hr/> 100%	

Text(s) and Equipment:

Required: *Field note book, digital camera, rain gear, work gloves*

Recommended:

Anders, P.J. and K.I. Ashley. 2007. The Clear-water Paradox of Aquatic Ecosystem Restoration. *Fisheries* 32 (3):125-128.

Ashley, K.I. 1983. Hypolimnetic aeration of a naturally eutrophic lake. *Can. J. Fish. Aquat. Sci.* 40:1343-1359.

Ashley, K.I. 1985. Hypolimnetic aeration: practical design and application. *Water Research* 19:735-740.

Ashley, K.I., S. Hay and G. Scholten. 1987. Hypolimnetic aeration: field test of the empirical sizing method. *Water Research* 21:223-227.

Ashley, K.I. 1988. Hypolimnetic aeration research in British Columbia. *Verh. Internat. Verein. Limnol.* 23:215-219.

Ashley, K.I., K. Tsumura and B.M. Chan. 1992. Fisheries Management of Winterkill Lakes in Southern Interior British Columbia. pp. 287-297. In: *Aquatic Ecosystems in Semi-Arid Regions:*

Implications for Resource Management, R.D. Robarts and M.L. Bothwell (eds.). N.H.R.I. Symposium Series 7, Environment Canada, Saskatoon, Saskatchewan, Canada.

Ashley, K.I. and P.A. Slaney. 1997. Accelerating recovery of stream, river and pond productivity by low-level nutrient replacement (Chapter 13). In: Fish Habitat Rehabilitation Procedures. P.A. Slaney and D. Zaldokas (eds.). Province of B.C., Ministry of Environment, Lands and Parks, and Ministry of Forests. Watershed Restoration Technical Circular No. 9: 341p.

Ashley, K. and R. Nordin. 1999. Lake aeration in British Columbia: Applications and Experiences. pp. 87-108. In: Aquatic Restoration in Canada. T. Murphy and M. Munawar (eds.). Ecovision World Monograph Series, Backhuys Publishers, Leiden, Netherlands.

Ashley, K., L.C. Thompson, D. Sebastian, D.C. Lasenby, K.E. Smokorowski and H. Andrusak. 1999. Restoration of kokanee salmon in Kootenay Lake, a large intermontane lake, by controlled seasonal additions of nutrients. pp. 127-170. In: Aquatic Restoration in Canada. T. Murphy and M. Munawar (eds.). Ecovision World Monograph Series, Backhuys Publishers, Leiden, Netherlands.

Ashley, K.I. 2000. Recent advances in hypolimnetic aeration design. Verh. Internat. Verein. Limnol. 27:2256-2260.

Ashley, K.I. and J.G. Stockner. 2003. Protocol for applying limiting nutrients to inland waters. Pages 245-260. In: J.G. Stockner, editor. Nutrients in salmonid ecosystems: sustaining production and biodiversity. American Fisheries Society, Symposium 34, Bethesda, Maryland.

Ashley, K.I. 2006. Salmon in the 21st Century: Energy, Triage and Choices. In: Salmon 2100. R. Lackey, D. Hach and S. Duncan (eds). Salmon 2100: The Future of Wild Pacific Salmon American Fisheries Society, Symposium 34, Bethesda, Maryland.

Ashley, K.I., D.S. Mavinic and K.J. Hall. 2008. Oxygenation Performance of a Laboratory Scale Speece Cone Hypolimnetic Aerator: Preliminary Assessment. Canadian Journal of Civil Engineering 35:663-675.

Ashley, K.I., D.S. Mavinic and K.J. Hall. 2009. Effect of orifice diameter, depth of air injection and air flow rate on oxygen transfer in a pilot-scale, full-lift, hypolimnetic aerator. Canadian Journal of Civil Engineering 36:137-147.

Bell, M. 1991. Fisheries Handbook of Engineering Requirements and Biological Criteria. US Army Corps of Engineers, North Pacific Division.

DFO Fact Sheet – Culverts http://www.dfo-mpo-gc.ca/canwaters-eauxcan/infocentre/guidelines-conseils/factsheets-feuillets/nfld/fact26_e.asp

Johnston, N.T., M.D. Stamford, K.I Ashley and K. Tsumura. 1999. Responses of rainbow trout (*Oncorhynchus mykiss*) and their prey to inorganic fertilization of an oligotrophic montane lake. Can. J. Fish. Aquat. Sci. 56:1011-1025.

McGrath, K.E.E., Dawley and D.R. Geist. 2006. Total Dissolved Gas Effects on Fishes of the Lower Columbia River. Prepared for: US Army Corps of Engineers, Portland District. Portland, Oregon. Contract Number MIPR W66QKZ52991442.

- Matzinger, A., R. Pieters, K. I. Ashley, G. A. Lawrence, and A. Wüest. 2007. Effects of impoundment on nutrient availability and productivity in lakes. *Limnology and Oceanography* 52(6):2629-2640.
- Perrin, C.J., M.L. Rosenau, T.B. Stables and K.I. Ashley. 2006. Restoration of a montane reservoir fishery using biomanipulation and nutrient addition. *North Amer. J. Fish. Management* 26:391-407.
- Slaney, P.A. and D. Zaldokas (eds.). 1997. *Fish Habitat Rehabilitation Procedures*. Province of B.C., Ministry of Environment, Lands and Parks, and Ministry of Forests. Watershed Restoration Technical Circular No. 9: 341p.
- Soltero, R.A., L.M. Sexton, K.I. Ashley and K.O. McKee. 1994. Partial and full lift hypolimnetic aeration of Medical Lake, WA to improve water quality. *Water Research* 28:2297-2308.
- Sterling, M.S., K.I. Ashley and A.B. Bautista. 2000. Slow-release fertilizer for rehabilitating oligotrophic streams: a physical characterization. *Water Quality Res. J. Canada* 35(1): 73-94.
- Stockner, J.G. and K.I. Ashley. 2003. Salmon nutrients: Closing the circle. Pages 3-16 In: J.G. Stockner, editor. *Nutrients in salmonid ecosystems: sustaining production and biodiversity*. American Fisheries Society, Symposium 34, Bethesda, Maryland.
- Stockner, J.G. (Editor). 2003. *Nutrients in salmonid ecosystems: sustaining production and biodiversity*. American Fisheries Society, Symposium 34, Bethesda, Maryland.
- G.A. Wilson, K.I. Ashley, R.W. Land and P.A. Slaney. 2003. Experimental enrichment of two oligotrophic rivers in south coastal British Columbia. Pages 149-176. **In:** J.G. Stockner, editor. *Nutrients in salmonid ecosystems: sustaining production and biodiversity*. American Fisheries Society, Symposium 34, Bethesda, Maryland.

Course Record:

Developed by: Dr. Ken Ashley Date: Sept 4, 2012
Authoring Instructor