Geosciences 560: Fluvial Geomorphology
Spring 2009
University of Montana
4 credits
Tuesday, Thursday 10:10-12; Clapp 348

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Office Hours: M 3:10-4 PM, W 4-5 PM, or by appointment

Fluvial Geomorphology will provide an in-depth investigation of the processes that determine the form and evolution of rivers and streams. The course will combine lectures, discussions, field data collection, and modeling activities. This is not a straight lecture class! Active learning and student participation will be an essential component.

Our inquiries this semester will be guided by several related questions / themes:

- What processes determine the form and evolution of rivers and streams?
- How can we infer process from form and vice versa?
- How do river form and process vary spatially? Temporally?
- How can we apply knowledge about fluvial geomorphic processes to river restoration and management?

Goals

As a result of your experiences in G560, you will have the opportunity to:

- gain a strong understanding of river channel processes and of the linkages between river channel form and process
- acquire fundamental knowledge about fluvial geomorphic processes needed to manage and restore rivers
- communicate an understanding of the interrelationships among fluvial geomorphic concepts and theories to peers and others
- use models, data, and logical reasoning to critically evaluate and connect information about river processes
- interpret and analyze literature about fluvial geomorphology from both secondary and primary sources
- improve your capacity to work as a member of a productive, collaborative team
- gain experience collecting and analyzing field data
- improve writing skills.

Course Website: This course will use Blackboard (http://courseware.umt.edu/) and ERes (for pdf's of journal papers; http://eres.lib.umt.edu/eres/courseindex.aspx?error=&page=search). You should get in the habit of checking the Blackboard site DAILY for course announcements, notes, and assignments. Lecture notes will be posted when I use powerpoint but not when I rely on the board. Revised versions of the schedule for class session and readings in this syllabus may also be posted; if so I will announce that.

Prerequisites
There are no formal prerequisites, but some background in calculus, physics, and river processes are expected. In lectures and journal papers, you will see a fair amount of derivatives, integrals, and physics concepts such as force, stress, and Newton's Second Law (F=ma). However, extensive manipulation of equations will not be required of students. A degree of computer literacy is also required. Assignments will be given involving the use of spreadsheets and retrieval of data over the internet.

Grading and related notes:
25% Group project
25% Final independent project
40% Assignments and assessments: 1) periodic homework assignments that will test and develop quantitative skills; some of which will require use of computer spreadsheets; 2) in-class activities testing and applying material from readings and lectures.
10% Class participation (including leadership of a paper discussion, active participation in paper discussions, questions and other participation during lectures and other in-class activities)

1. First the good news. There will be no tests.
2. Now the bad news. There will be a lot of work in this class.
3. Attendance is critical. Much of the material covered in class will not be in the assigned reading. There will be occasional in-class activities, typically not announced in advance but also typically open note, that you won't get credit for if you are not in class
4. Email. Feel free to communicate with me by email, but 1) I'm not an online help service for homeworks, i.e., don't email me when you get stuck on a homework question- come to office hours or ask questions at the beginning of class; 2) if you miss class, please do not email me to ask what you missed- check Blackboard and/or talk to classmates; 3) if you hand in assignments electronically, they must be well organized and consolidated into at most two files; you will lose points otherwise.

Field trips
Two Saturday field trips are planned. Each will involve data collection and associated assignments. As a consequence, these are required; please plan your schedules accordingly.
1. Rattlesnake Creek, Saturday, March 7. Data collected on this trip will be used in the group project. It will likely be a cold day for to be in the field, but we need to collect data early enough to begin moving forward with other aspects of the project. Our field data will be used for various geomorphic calculations, modeling, and analyses. Stay tuned for details.
2. Bitterroot River, Saturday, April 11. We will float from approximately Stevensville to Florence, stopping at numerous locations to conduct pebble counts and collect other geomorphic data. I will repeat this trip and data collection with classes in future years to develop a long-term dataset on the Bitterroot. The Bitterroot is a dynamic, geomorphically fascinating river that is at the crux of many land use and growth issues, so my hope is that this will become a useful and interesting long-term project. You will complete a writeup and some other geomorphic analyses based on this trip.

Independent project:
The final project will consist of an independent, hypothesis-driven research project on a topic in fluvial geomorphology of the student's choice. Students are encouraged to pursue a topic that will contribute to their graduate or senior thesis research; otherwise I will happily assist students in developing a project. The project must use original research (i.e., not only literature review, and not work already completed prior to this semester) to investigate and test a hypothesis about fluvial processes. A variety of tools may be used, including field data collection, modeling, GIS analysis, etc. The project will culminate in a paper of ≤10 pages (1.5 line spacing) and in-class presentations by each student. The paper must follow standard journal paper format (Abstract, Introduction, Methods, Results, Discussion, Conclusion, References Cited, Tables and Figures), and you should consult the "Guidelines for paper writing" posted on Blackboard. Students are encouraged to assist each other with field data collection.
Proposal due: March 26
Meeting with ACW to discuss project: before April 9
Presentations: Each student will give a 10 minute presentation, plus time for questions, on their project. Presentations will be spread out over the last month of class. We will spend approximately ½ hour, one day a week starting after spring break, on presentations. Those that volunteer to present earlier will be expected to have less in the way of results and can expect to benefit more from the feedback of their classmates in terms of developing their project. The presentations will be graded as part of your overall independent project grade.
Paper due date: May 8, 5 pm

Paper readings and discussion:
We will read 1-2 journal papers each week and spend a portion of one class section each week (usually Thursday) discussing the paper. Discussion leadership will rotate among students. Discussion leaders are expected to read and follow the "Guidelines for discussion leadership" posted on Blackboard. These discussions will be designed to encourage critical thinking about primary literature and broad participation.

Students will also be asked to submit a written critical review (not a summary; ≤1 page single spaced) on any one journal paper other than the one for which you lead discussion (please see "Guidelines for paper review" posted on Blackboard). This will be counted as part of your assignments grade; due date: 4/23.

Seminars
Required: Monday, Apr. 13, 4:10-5, Clapp 304: Wes Lauer: "Modeled Long-Term Response of the Clark Fork River Floodplain to Mine-Related Sediment Loading"
Attendance is encouraged at other departmental seminars as well (schedule on Blackboard)
Also, we are conducting a faculty search for a Watershed Hydrologist and will have 3 candidates coming to give talks in February. Details of these job talks will be announced in class, your attendance will be encouraged and appreciated, and your feedback on the candidates will be sought.

Academic Integrity: All students need to be familiar with and abide by the Student Conduct Code and its definitions of academic misconduct. The Code is available for review online at http://life.umt.edu/SA/documents/fromWeb/StudentConductCode1.pdf.

Tentative schedule

Wk	*Date*	*Topics*	*Readings (tentative)*	*Notes*
1	Jan. 27 Jan. 29	Introduction River hydraulics	Knighton 1-8	
2	Feb. 3 Feb. 5	River hydraulics	Knighton 96-107 Parker e-book Chaps 1, 5 Montgomery & Buffington 1997	
3	Feb. 10 Feb. 12	River hydraulics	Parker e-book 5 Nelson etal 2003	
4	Feb. 17 Feb. 19	River hydraulics	Nelson etal 2003 Knighton 107-141 Church 2006	
5	Feb. 24 Feb. 26	Hydraulics Sediment transport	Parker 2008 Parker e-book 6 Knighton 107-141 Lamb et al. 2008	
6	March 3 March 5	Sediment transport	Parker 2008 Parker e-book 4 Buffington & Montgomery 1999a	3/7: Field trip
7	March 10 March 12	Sediment transport	Parker 2008 Parker e-book 7 Knighton 141-150 Buffington & Montgomery 1999b	
8	March 17 March 19	Sediment transport	Parker e-book 9 Knighton 151-166 Wilcock 2004, 1998	
9	March 24 March 26	Flow regimes Dominant discharge	Knighton 167-187 Wolman & Miller 1960	Independent project proposals due (3/26)
10	April 7 April 9	Hydraulic geometry Bedforms Flow in bends	Knighton 187-205 Parker e-book 8 Walter & Merritts 2008 Montgomery 2008 Dietrich & Whiting 1989	Start presentations 4/9: Deadline for project meeting with ACW 4/11: Field trip
11	April 14 April 16	Meandering Floodplains	Knighton 205-260 Lauer & Parker 2008a&b	4/13: Wes Lauer talk 4/16: Group project due
12	April 21 April 23	Long profiles Bedrock rivers	Knighton 242-307 Whipple 2004	4/23: Paper review due
13	April 28 April 30	Ecogeomorphology River management and restoration	Knighton 307-335 Wohl et al. 2005 Schmidt & Wilcock 2007 Montgomery et al. 2003	Field assignment #2 due
14	May 5 May 7	Restoration Wrap-up	TBA	5/8: Independent project due
15		NO FINAL		

Topics covered

1. Introduction: Overview of river processes, dichotomies in approaches
2. River hydraulics / Flow mechanics
    a. Overview of open-channel flow
    b. Conservation equations
    c. Types of flow (Steady uniform flow, super vs subcritical, turbulent vs laminar)
    d. Flow resistance and shear stress partitioning
    e. Velocity profiles
3. Sediment transport
    a. Forces on particles
    b. Incipient motion & critical shear stress
    c. Estimating transport rates
    d. Armoring, supply effects
    e. Sediment transport and channel change
    f. Sediment budgets
4. Channel morphology (alluvial rivers)
    a. The bankfull channel
        i. Hydraulic geometry
        ii. Flow regimes and dominant discharge
    b. Bedforms
    c. Bars and meandering
    d. Multi-thread channels
    e. Floodplains and terraces
    f. River long profiles: Graded streams, base level, downstream fining
    g. Channel classification
    h. Interpreting channel condition, historical and reference approaches
5. Bedrock rivers
    a. Morphology
    b. Erosion processes
    c. Role in landscape evolution
6. Ecogeomorphology
    a. Riparian vegetation
    b. Large woody debris
7. River management and restoration
    a. Dams
    b. Linking process knowledge to restoration

Other topics that may be covered as time permits:

- The channel width problem
- River basin morphology (drainage networks, runoff processes)
- Climate change and river processes
- Geomorphic effects of ice jams
- Modeling tools (computational, physical, remote sensing)

Readings:

Required texts:

Fluvial Forms& Processes: A New Perspective, David Knighton (1998)

E-book by Gary Parker, *1D Sediment Transport Morphodynamics with Application to Rivers and Turbidity Currents* (available for free download at http://cee.uiuc.edu/people/parkerg/morphodynamics_e-book.htm)

Week 1:

Overbye, D. 2009. Elevating science, elevating democracy. New York Times. 26 January.

Week 2:

Montgomery, D.R. and J.M. Buffington. 1997. Channel reach morphology in mountain drainage basins. *GSA Bulletin* 109: 596-611.

Week 3:

Nelson, J.M., Bennett, J.P., and Wiele, S.M. 2003. Flow and sediment-transport modeling, in Kondolf, G.M., and Piegay, H., eds., *Tools in fluvial geomorphology*: England, Wiley, p. 539-576.

Week 4:

Church, M. 2006. Bed material transport and the morphology of alluvial river channels. *Annual Review of Earth and Planetary Sciences* 34: 325-354.

Week 5:

Lamb, M. P., W. E. Dietrich, and J. G. Venditti. 2008. Is the critical Shields stress for incipient sediment motion dependent on channel-bed slope?, J. Geophys. Res., 113, F02008, doi:10.1029/2007JF000831.

Parker, G. 2008. Transport of gravel and sediment mixtures. Chap. 3 in *ASCE Sedimentation Engineering Manual 110*, M. Garcia ed. p. 165-251.

Week 6:

Buffington, J. M., and D. R. Montgomery. 1999a. Effects of hydraulic roughness on surface textures of gravel-bed rivers. *Water Resources Research* 35:3507-3521.

Week 7:

Buffington, J. M., and D. R. Montgomery. 1999b. Effects of sediment supply on surface textures of gravel-bed rivers, *Water Resources Research*, *35*(11), 3523-3530.

Week 8:

Wilcock, P.R. 2004. Sediment Transport in the Restoration of Gravel-bed Rivers, Invited paper, *Proceedings*, ASCE Environmental and Water Resources Institute Annual Congress, Salt Lake City.

Wilcock, P.R. 1998. "Two-fraction model of initial sediment motion in gravel-bed rivers". *Science.* 280: 410 - 412.

Week 9:

Wolman, M.G. and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology* 68: 54-74.

Week 10:

Walter, R.C. and D.J. Merritts. 2008. Natural streams and the legacy of water-powered mills. *Science* 319:299-304.

Montgomery, D. R. 2008. Dreams of natural streams, *Science*, *319*(5861), 291-292.

Dietrich, W.E. and P.J. Whiting. 1989. Boundary shear stress and sediment transport in river meanders of sand and gravel, in *River meandering*, edited by S. Ikeda and G. Parker, pp. 1-50, Am Geophys Union, Washington, D.C.

Week 11:

Lauer, J. W., and G. Parker (2008), Modeling framework for sediment deposition, storage, and evacuation in the floodplain of a meandering river: Application to the Clark Fork River, Montana, Water Resour. Res., 44, W08404, doi:10.1029/2006WR005529.

Lauer, J. W., and G. Parker (2008), Modeling framework for sediment deposition, storage, and evacuation in the floodplain of a meandering river: Theory, Water Resour. Res., 44, W04425, doi:10.1029/2006WR005528.

Week 12:

Whipple, K.X. 2004, Bedrock rivers and the geomorphology of active orogens: *Annual Reviews of Earth and Planetary Science* 32: 151–185.

Week 13:

Wohl E., P. L. Angermeier, B. Bledsoe, G. M. Kondolf, L. MacDonnell, D. M. Merritt, M. A. Palmer, N. L. Poff, D. Tarboton (2005), River restoration, *Water Resour. Res.*, 41, W10301, doi:10.1029/2005WR003985.

Schmidt, J.C. and P.R. Wilcock. 2007. "Metrics for assessing the downstream impacts of dams". *Water Resources Research*.

Montgomery, D. R., B. D. Collins, J. M. Buffington, and T. B. Abbe (2003), Geomorphic effects of wood in rivers, in *The Ecology and Management of Wood in World Rivers*, edited by S. V. Gregory, et al., pp. 21-47, American Fisheries Society, Bethesda, MD.