of water on earth. Because of water’s ubiquity and importance to physical, chemical, and biological processes, understanding and predicting Earth’s water cycle, surface water and groundwater. Preparations. Applicants to the program are expected to be well-versed in the techniques to water resource planning, analysis, and management. Water allocation, capacity expansion, and reservoir operation. Construction of water, surface water and groundwater. Water quality management. Irrigation planning and operation models. (Same course as Biological Systems Engineering 243.)—[II] Marino

252. Hillslope Geomorphology and Sediment Budgets (4)
Lecture—3 hours, fieldwork—3 hours. Prerequisite: course 141 or Geology 35 or Civil and Environmental Engineering 142 or consent of instructor. Exploration of the theoretical and empirical foundations of sediment production on hillslopes using computer models and field experiments to promote an understanding of how watersheds evolve naturally and with human impacts. Offered in alternate years.—III. Pasternack

256. Geomorphology of Estuaries and Deltas (4)
Lecture—3 hours, fieldwork—3 hours. Prerequisite: course 141 or Geology 35 or Civil and Environmental Engineering 12 or consent of instructor. Survey of the processes and landforms associated with sediment deposition in the coastal zone. Application of geomorphic principles to coastal management issues. Offered in alternate years.—II. Pas- ternack

264. Modeling of Spatial Processes (3)
Lecture—3 hours. Prerequisite: course 141 or the equivalent and Statistics 102 or the equivalent. Techniques used to model the spatial-temporal structure of rainfall and runoff are introduced. Procedures studied include those based on stochastic point processes, chaos theory, fractal geometry, and fractional noises. Offered in alternate years.—III. Fogg

269. Numerical Modeling of Groundwater Systems (3)
Lecture—3 hours. Prerequisite: course 145A or Civil Engineering 144 and course 145B, Mathematics 228. Finite difference and finite element techniques in modeling groundwater flow and transport. Fundamentals of constructing and calibrating models with hands-on applications. Methods and limitations of numerical solution of transport equations. Model interpretation and ethics.—[II] Puente

273. Introduction to Geostatistics (3)
Lecture—3 hours. Prerequisite: Statistics 130A and 130B, or the equivalent. Statistical treatment of spatial data with emphasis on hydrologic problems. Topics include theory of random functions, variogram analysis, Kriging, co-Kriging, indicator geostatistics, and stochastic simulation of spatial variability. Demonstration and use of interactive geostatistical software included. Offered in alternate years.—I. Fogg

274. Practice of Groundwater Flow and Transport Modeling (3)
Lecture—2 hours; laboratory—0.5 hours; lecture/demonstration—0.5 hours. Prerequisite: course 269, Civil and Environmental Engineering 2728, or Civil and Environmental Engineering 272C. Selecting and building groundwater flow and transport models. Planning, execution, examination, presentation, and review of modeling projects. Review of methods, assumptions, and limitations of groundwater models, practicing with MODFLOW, MT3D, associated GUIs and groundwater modeling software of choice. Offered in alternate years.—III. Harter

275. Analysis of Spatial Processes (3)
Lecture—3 hours. Prerequisite: Statistics 102 or the equivalent; course 273 or Statistics 273A recommended. Characterization of homogeneous random fields; extremes and spectral parameters; geometry of excursions, local averaging; scale of fluctuation; non-Gaussian random fields, geostatistical applications. Offered in alternate years.—III. Puente

286. Selected Topics in Environmental Remote Sensing
Discussion—2 hours; lecture—1 hour; project. Prerequisite: consent of instructor; Environmental and Resource Sciences 186 or equivalent required; Environmental and Resource Sciences 186 recommended. In-depth investigation of advanced topics in remote sensing applications, measurements, and theory. (Same course as Geography 258) May be repeated for credit. Offered irregularly.—I. Ustin

Hydrology

(Hydrology (Course of study in Agricultural and Environmental Sciences) Faculty. See under Department of Land, Air and Water Resources, on page 364, Hydrology Section.

The Major Program
Hydrology is the study of the occurrence, distribution, circulation, and behavior of water and waterborne materials in the environment of Earth. It includes practical measurement and technical analysis of water phenomena underground, on the Earth’s surface, and in the atmosphere. Contemporary hydrologic problems continue to grow. Each year include environmental restoration, sustainability, and natural disasters such as floods, droughts, landslides, avalanches, and land subsidence. The management of these problems demands hydrologic scientists with the comprehensive, interdisciplinary education embodied in this program. Beyond its societal utility, hydrology can be an exciting science for the curious-minded. Hydrologists explore natural phenomena such as climate change, waterfalls, health of coral reefs, biogeochemical cycles, and aquifers.

The Program. A hydrologist needs a strong background across the basic sciences of physics, mathematics, chemistry, and biology. Breadth of understanding comes from exposure to ecology, geology, engineering, policy, and law. Depth of understanding comes from exposure to ecology, geology, engineering, policy, and law. Depth of understanding comes from exposure to ecology, geology, engineering, policy, and law. Depth of understanding comes from exposure to ecology, geology, engineering, policy, and law. Depth of understanding comes from exposure to ecology, geology, engineering, policy, and law.
agencies, private consulting firms, environmental interest groups, irrigation districts, and utility compa-
尼斯. Federal agencies hiring hydrologists include the U.
 Geological Survey, U. Department of Agriculture (Fish and Wildlife, Agricultural Research, Forest Service, and National Resource Conservation Service), Environmental Protection Agency, and national research laboratories (Lawrence Livermore National Laboratory, Oak Ridge National Labora-
tory). State and local agency employers include Cal-
ifornia Department of Water Resources, Conservation, Fish and Game, and Toxic Substances as well as the Water Resources Control Board and Regional Water Quality Control Boards. To obtain higher levels of responsibility and salary, hydrolo-
gists often seek advanced degrees, and the hydrolog-
y major is designed to provide students with a highly competitive education to get into graduate school.

B.S. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>UNITS</th>
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<tbody>
<tr>
<td>Biological Sciences 2A, 28</td>
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<tr>
<td>Chemistry 2A, 2B, 2C</td>
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<tr>
<td>Physics 9A, 9B, 9C</td>
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<tr>
<td>Mathematics 21A, 21B, 21C, 21D, 22A, 22B</td>
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<tr>
<td>Geology 50, 50X</td>
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<td>Engineering 6 or the equivalent</td>
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Depth Subject Matter

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<th>UNITS</th>
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<tbody>
<tr>
<td>Hydrologic Science 103N or Engineering 103 or Water Resources Management 103</td>
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<tr>
<td>Civil and Environmental Engineering 114 or Statistics 130A and 130B</td>
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<tr>
<td>Hydrologic Science 134, 141, 142, 144, 151</td>
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<td>Soil Science 107</td>
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<tr>
<td>Select one of Hydrologic Science 150, Agricultural and Resource Economics 147, Environmental Science and Policy 161, 166N</td>
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<tr>
<td>Select three of Hydrologic Science 110, 124, 143, 146, Civil and Environmental Engineering 147, Applied Biological Systems Technology 165</td>
</tr>
</tbody>
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Restricted Electives

| UNITS |
| 16-26 |

To supplement or expand areas of student interest selected with approval of adviser

Total Units for the Major

| 129-148 |

Minor Advisor. Peter Hernes (Land, and Water Resources)

Minor Program Requirements:

Hydrology

The Hydrology Section of the Department of Land, Air and Water Resources offers the minor in Hydro-
logy for environmental or natural science students who have an interest in water/environmental issues. The interested student should have completed preparatory course work in calculus (Mathematics 16A, 16B), chemistry (Chemistry 2A; Chemistry 2B recommended), physics (Physics 7A), and biology (Biological Sciences 2A). Course work in the minor provides fundamental skills and knowledge of the hydrologic sciences. This minor is intended for environ-
mental, natural, or social science students who have an interest in the interfaces between hydrology, ecol-
ogy, policy and management. The interested student should have completed preparatory course work in calculus (Mathematics 16A, 16B), chemistry (Chemistry 2A; Chemistry 2B recommended), physics (Physics 7A), and biology (Biological Sciences 2A). Course work in the minor provides fundamental skills and knowledge of the management of watersheds in the context of current water resources and ecological problems.

Minor Program Requirements:

Hydrology Science

<table>
<thead>
<tr>
<th>UNITS</th>
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<tr>
<td>Hydrologic Science 141 or Environmental Science and Management 100</td>
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<tr>
<td>Soil Science 107, 118</td>
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<td>Hydrologic Science 144 or Soil Science 107</td>
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<td>Hydrologic Science 124, or Hydrologic Science 143</td>
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<tr>
<td>Hydrologic Science 143, Environmental Science and Management 144, or Environmental Science and Policy 151</td>
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<tr>
<td>Hydrologic Science 150, Environmental Science and Management 121, or Environmental Science and Policy 161</td>
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</tbody>
</table>

Minor Advisor. Graham Fogg 530-752-6810; gefogg@ucdavis.edu

Advising Center. 1150 PES Building

Courses in Hydrologic Science (HYD)

Watershed Science

Questions pertaining to the following courses should be directed to the instructor or to the Resource Sci-
ences Teaching Center in 113 Vehmeyer Hall or in 1150 Plant and Environmental Sciences Building 530-752-1403

Lower Division

10. Water, Power, Society (3)

Lecture—2 hours; discussion—1 hour. Water resources issues. How water has been used to gain and wield socio-political power. Water resources development in California as related to current and future sustainability and quality. Rules of science and policy in solving water prob-
lems. (Same course as Science and Society 10.) GE credit: SciEng or SocSci, Wrt | SE or SS, SL—III. (III.) Foam

47. Watershed Processes and Water Quality in the Tahoe Basin (3)

Lecture/labatory—21 hours; fieldwork—9 hours; discussion—3 hours; term paper. Prerequisite: basic knowledge of introductory soil, or hydrologic sci-
ences. Watershed processes, runoff water-quality management, restoration in Lake Tahoe Basin. Soils, precipitation-runoff, revegetation and adaptive manage-
ment related to erosion control, effective solu-
tions, development of restoration strategies. Students develop field restoration. Course involves 3 days of instruction in Tahoe City. (Same course as Environmental Science 147.) Not open to students who have successfully completed Environmental and Resource Sciences 47. (Formerly Envi-

92. Hydrologic Science Internship (1-12)

Internship—3-36 hours. Prerequisite: lower division student, consent of instructor. Work experience off and on campus in Hydrologic Science. Internship supervised by a member of the faculty. (P/NP grading only) | I, II, III, (I, II, III)

98. Directed Group Study (1-5)

Prerequisite: consent of instructor. Offered irregu-
larly. (P/NP grading only)

Upper Division

103N. Fluid Mechanics Fundamentals (4)

Lecture—4 hours. Prerequisite: Physics 9B. Fluid mechanics axioms, fluid motion in a pipe, viscosity fields for one-dimensional incompressible flow and boundary layers, turbulent flow time averaging, potential flow, dimensional analysis, and macro-
scopic balances to solve simple physical problems. (Same course as Biological Systems Engineering 103.) Offered irregularly. GE credit: SciEng | QL, SE, VL—I, (I.) Wällander

110. Irrigation Principles and Practices (3)

Lecture—2 hours; laboratory—3 hours. Prerequisite: Physics 7A; Soil Science 100 recommended. Gen-
ceral course for agricultural and engineering students dealing with soil and plant aspects of irrigation and drainage. Soil-water principles including water movement, plant responses to irrigation regimes, water use by crops; also irrigation systems and water quality. Not open for credit to students who have completed Water Science 102. Offered in alternate years. GE credit: SciEng | SE, SL—(III.) Goldhamer, Grattan

124. Plant-Water-Soil Relationships (4)

Lecture—3 hours; discussion—1 hours. Prerequisite: one upper division course in soil science, such as Soil Science 100; and one upper division course in plant science or plant biology, such as Plant Biology 111; or consent of instructor. Principles of plant inter-
actions with soil and atmospheric water environ-
ments and practical applications to crop management (e.g., irrigation) and plant eco-physiolog-
y (e.g., drought). Not open for credit to students who have completed Water Science 104. GE credit: SciEng | QL, SE, SL—III. (III.) Shackel

134. Aqueous Geochemistry (6)

Lecture—4 hours; laboratory—3 hours. Prerequisite: Chemistry 2B. Chemistry of natural waters; diel
c properties of water; thermodynamic properties of water; solute-solvent interactions; metal hydrolysis; acid-base equilibria; metalcoordination chemistry; solubility calculations; electron-exchange reactions; sorptive partitioning; ion exchange; and discharge of organic matter. GE credit: SciEng | QL, SE, SL—III. (III.) Hernes, Parikh

141. Physical Hydrology (4)

Lecture—3 hours; discussion—1 hour. Prerequisite: Physics 9B, Mathematics 21B; course 100 recom-
mended. Introduction to the processes that constitute the hydrologic cycle. Special emphasis on a quanti-
tative description of the following processes: precipi-
tation, infiltration, evaporation, transpiration, surface runoff, and groundwater. GE credit: SciEng | QL, SE, SL, VL—I, (I.) Puente

142. Systems Hydrology (4)

Lecture—3 hours; discussion—1 hour. Prerequisite: course 141 or Civil and Environmental Engineering 144. General course covering hydrologic pro-
cesses from a systems or statistical model perspec-
tive. General probability concepts are applied to frequency, time series and spatial data analysis. Lin-
ear systems are also considered in conjunction with Kalman filter techniques. GE credit: SciEng | QL, QL, SE—II. (II.) Puente

143. Hydrological Processes in Ecosystems (3)

Lecture—3 hours. Prerequisite: course 141 or Envi-
ronmental and Resource Science 100. Movement and storage of water are integral parts of landscape and ecosystem functioning. Hydrological processes in individual ecosystems, fluid flow in soil and lake, linking the major components of the landscape. Offered in alternate years. GE credit: SciEng | QL, SE, SL—II. (II.) Paschnack

144. Groundwater Hydrology (4)

Lecture—4 hours. Prerequisite: Mathematics 16B or 21A; course 103 or Engineering 103 recom-
Aquifer tests. Well construction operation and maintenance. Groundwater exploration and quality assessment. Agricultural threats to groundwater quality: fertilizers, pesticides, and salts. [Same course as Hydrologic Science 144.] Offered alternate years. GE credit: ScEng | QL, SE, SL, V—II. (I.)

146. Hydrogeology and Contaminant Transport (3)
Lecture—3 hours; laboratory—2 hours; term paper. Prerequisite: course 144 or Civil and Environmental Engineering 144 or the equivalent. Physical and chemical processes affecting groundwater flow and contaminant transport, with emphasis on realistic hydrogeologic examples. Groundwater geology and chemistry. Fundamentals of groundwater flow and transport analysis. Laboratory includes field pumping test and work with physical and computer models. [Same course as Geology 156.] GE credit: ScEng | SE—II. (II.) Fogg

147. Runoff, Erosion and Water Quality Management in the Tahoe Basin (3)
Lecture/laboratory—30 hours; fieldwork—15 hours; discussion—10 hours; term paper. Prerequisite: Physics 78 or 98, Mathematics 161C or 21C, Civil and Environmental Engineering 142 or course 141 or Environmental and Resource Sciences 100. 5 days of instruction in Tahoe City. Practical hydrology and runoff water quality management from Tahoe Basin slopes. Development of hillslope and riparian restoration concepts, modeling and applications from physical science perspectives including precipitation/runoff relationships, sediment transport, and detention ponds. [Same course as Biological Systems Engineering 147.] GE credit: ScEng | QL, SE, SL—IV. (IV.) Grismer

150. Water Law (3)
Lecture—2 hours; laboratory—3 hours; fieldwork—3 hours. Prerequisite: Environmental and Resource Sciences 100. 121 or consent of instructor. Principles and issues of California Water Law. Types of water rights, groundwater rights and management, and protection of instream uses. Water projects, role of federal government and federal/state relations. Basic water quality acts, endangered species act, water transfers and current water issues. GE credit: SocSci | ACGH, SS—II. (II.) Cahill

151. Field Methods in Hydrology (4)
Lecture—2 hours; laboratory—3 hours; fieldwork—3 hours. Prerequisite: Environmental and Resource Sciences 100 or course 141. Measurement methods and data analysis for evaluation of water storage, movement and distribution in the field. Equipment such as data loggers, water and sediment samplers, pressure transducers, weather stations, surveying equipment, and flow meters will be offered. Offered in alternate years. GE credit: ScEng | QL, SE, SL—II. (II.) Pasternack

182. Environmental Analysis using GIS (4)
Lecture—2 hours; laboratory—4 hours. Prerequisite: Applied Biological Systems Technology 180 or the equivalent GIS experience and skills; general biology and/or ecology courses recommended. Ecosysteem and landscape modeling with emphasis on hydrology and solute transport. Spatial analysis of environmental risk analysis including ecological risk assessment, natural resource management. Spatial database structures, scripting, data models, and error analysis in GIS. Offered in alternate years. [Same course as Applied Biological Systems Technology 182.] GE credit: ScEng | QL, SE, SL, V—II. (II.) Hijmans

192. Hydrologic Science Internship (1-12)
Internship—3-40 hours. Prerequisite: completion of B4 units and consent of instructor. Work experience off and on campus in water science. Internship supervised by a member of the faculty. (P/NP grading only)—I—II, III—II, III (I, II, III)

198. Directed Group Study (1-5)
(P/NP grading only)—I—II, III—II, III (I, II, III)

199. Special Study for Advanced Undergraduates (1-5)
Prerequisite: senior standing. (P/NP grading only)—I—II, III—II, III (I, II, III)

Immunology (A Graduate Group)

Charles Bevis, M.D., Ph.D., Chairperson of the Group

Group Office. 5217 Vet Med 3A; 530-754-0103; http://immunology.comped.ucdavis.edu FACulty

Iannis Adamopoulos, Ph.D., Associate Professor [Microbiology and Immunology]
Paul Ashwood, Ph.D., Associate Professor [Microbiology, and Immunology]
Nicole Baumgartner, D.V.M., Ph.D., Professor [Center for Comparative Medicine and Pathology, Microbiology and Immunology]
Andreas Baumler, Ph.D., Professor [Microbiology, and Immunology]
Charles Bevis, M.D., Ph.D., Professor [Microbiology, and Immunology]
Christopher L. Bowls, M.D., Associate Professor [Gastroenterology]
Kiho Cho, Ph.D., Associate Adjunct Professor [Surgery]
Satsya Dandekar, Ph.D., Professor and Chair [Microbiology, and Immunology]
Laurel J. Gerwitz, D.V.M., Ph.D., Professor [Pathology, Microbiology, and Immunology]
Tzippora Goldkorn, Ph.D., Professor [Pulmonary and Critical Care Medicine]
Leigh G. Griffiths, D.V.M., Ph.D., Associate Professor [Veterinary Medicine and Epidemiology]
Richard W. Harper, M.D., Ph.D., Associate Professor [Pulmonary and Critical Care Medicine]
Volkan Heinrich, Ph.D., Associate Professor [Biomedical Engineering]
James E.K. Hildreth, M.D., Ph.D., Professor and Dean [Molecular and Cellular Biology]
Daniel Hwang, Ph.D., Adjunct Professor [Nutrition]
Kirk C. Klang, Ph.D., Professor [Animal Science]
T. S. Lam, M.D., Ph.D., Professor and Chief [Hematology and Oncology]
Pam Lein, Ph.D., Professor [Molecular Biosciences]
Patrick S.C. Leung, Associate Adjunct Professor [Rheumatology, Allergy and Clinical Immunology]
Shirley Luckhart, Ph.D., Professor [Pulmonary and Critical Care Medicine]
Emanuel Mavraganis, M.D., Assistant Professor [Dermatology]
Kimberly A. Allister, Ph.D., Associate Professor [Neurology]
Stephen J. McSorley, Ph.D., Associate Professor [Center for Comparative Medicine and Anatomy Physiology]
Lisa A. Miller, Ph.D., Associate Professor [Anatomy, Physiology and Cell Biology]
William J. Murphy, Ph.D., Professor [Dermatology]
Noel Navarrete, Ph.D., Professor [Microbiology and Molecular Genetics]
Robert T. O'Donnell, M.D., Ph.D., Professor [Hematology and Oncology]
John Peters, Ph.D., Associate Professor-in-Residence [Internal Medicine]
Kent E. Pinkerton, Ph.D., Professor and Director [Anatomy, Physiology and Cell Biology]
Distinguished Teaching Award-Graduate/Professional
David Pleasure, M.D., Ph.D., Professor [Neurology and Pediatrics]
Siba Raychaudhuri, M.D., Clinical Assistant Professor and Chief Rheumatologist [Sacramento VA Medical Center]
Grace L. Rosenquist, Ph.D., Assistant Adjunct Professor [Neurobiology, Physiology, and Behavior]
Barbara Shacklett, Ph.D., Associate Professor [Microbiology and Immunology]
Scott I. Simon, Ph.D., Professor [Biomedical Engineering]