

# **Module Manual**

Master of Science (M.Sc.)

# Water and Environmental Engineering

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# **Program description**

## Content

# Master of Science in 'Water and Environmental Engineering'

The Master of Science in Water and Environmental Engineering gives students a choice of three areas of specialization - Water, Environment and City. Graduates of the Master in Water and Environmental Engineering are able to translate the engineering, mathematical and scientific knowledge gained on the course into practice in order to analyze problems scientifically and solve them even when they are unusually or incompletely defined and have complex specifications. Graduates have the ability to work independently, to apply the methods and processes required to solve technical and planning problems, and to apply, critically scrutinize, and further develop new findings. They are also qualified to plan exacting (household) water management projects and projects geared to environmental protection and to plan them paying due attention to the necessary clarifications and examination of existing information and resources. They can

- · Collaborate successfully with professional and non-professional players in public administration, industry, and academia
- Independently define research tasks for theoretical and experimental exploration of environmental and water management issues and plan and execute projects in those areas
- · Responsibly assess and take into account the concerns of those affected by planning and implementation and of society in general
- work together in international teams on international subjects with cross-cultural competence.

# **Core Qualification**

| Module M0523: Busin            | ess & Management  |
|--------------------------------|---|
| Module Responsible             | Prof. Matthias Meyer  |
| Admission Requirements         | None  |
| Recommended Previous           | None  |
| Knowledge                      |   |
| <b>Educational Objectives</b>  | After taking part successfully, students have reached the following learning results  |
| <b>Professional Competence</b> |   |
| Knowledge                      | <ul> <li>Students are able to find their way around selected special areas of management within the scope of business managemer</li> <li>Students are able to explain basic theories, categories, and models in selected special areas of business management.</li> <li>Students are able to interrelate technical and management knowledge.</li> </ul> |
| Skills                         | <ul> <li>Students are able to apply basic methods in selected areas of business management.</li> <li>Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.</li> </ul>   |
| Personal Competence            |   |
| Social Competence              | Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems  |
| Autonomy                       | Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.   |
| Workload in Hours              | Depends on choice of courses  |
| Credit points                  | 6   |

# Courses

Information regarding lectures and courses can be found in the corresponding module handbook published separately.

# Module M0524: Non-technical Courses for Master

| Module | Responsible | Dagmar | Rich |
|--------|-------------|--------|------|
|        |             |        |      |

Admission Requirements None

**Recommended Previous** None

Knowledge

Educational Objectives After taking part successfully, students have reached the following learning results

#### **Professional Competence**

#### Knowledge The Nontechnical Academic Programms (NTA)

imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its teaching architecture, in its teaching and learning arrangements, in teaching areas and by means of teaching offerings in which students can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.

#### The Learning Architecture

consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.

The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".

The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.

#### Teaching and Learning Arrangements

provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.

## Fields of Teaching

are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.

The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goaloriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.

## The Competence Level

of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.

This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.

# Specialized Competence (Knowledge)

## Students can

- · explain specialized areas in context of the relevant non-technical disciplines,
- outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area.
- different specialist disciplines relate to their own discipline and differentiate it as well as make connections,
- sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,
- Can communicate in a foreign language in a manner appropriate to the subject.

## Skills Professional Competence (Skills)

# In selected sub-areas students can

· apply basic and specific methods of the said scientific disciplines,

- · aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,
- · to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner,
- justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

| Personal Competence |   |
|---------------------|---|
| Social Competence   | Personal Competences (Social Skills)  |
|                     | <ul> <li>Students will be able</li> <li>to learn to collaborate in different manner,</li> <li>to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,</li> <li>to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen),</li> <li>to explain nontechnical items to auditorium with technical background knowledge.</li> </ul> |
| Autonomy            | Personal Competences (Self-reliance)  |
|                     | Students are able in selected areas   |
|                     | <ul> <li>to reflect on their own profession and professionalism in the context of real-life fields of application</li> <li>to organize themselves and their own learning processes</li> <li>to reflect and decide questions in front of a broad education background</li> <li>to communicate a nontechnical item in a competent way in writen form or verbaly</li> <li>to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)</li> </ul>                                 |
|                     | Depends on choice of courses  |
| Credit points       | 6   |

# Courses

Information regarding lectures and courses can be found in the corresponding module handbook published separately.

| Module M0826: Biolo              | gy, Geology and Chemist  | rv   |                         |              |
|----------------------------------|--|--|-------------------------|--------------|
|                                  |  |  |                         |              |
| Courses                          |  |  |                         |              |
| Title                            |  | Тур  | Hrs/wk                  | СР           |
| Biology (L1428)                  |  | Lecture  | 2                       | 2            |
| Geology and Soil Science (L0903) |  | Lecture  | 2                       | 1            |
| Environmental Analysis (L0354)   |  | Lecture  | 2                       | 3            |
| Module Responsible               | Dr. Dorothea Rechtenbach   |  |                         |              |
| Admission Requirements           | None   |  |                         |              |
| Recommended Previous             | Fundamentals of inorganic/organic of   | chemistry and biology (knowledge acquired at school)     |                         |              |
| Knowledge                        |  |  |                         |              |
|                                  |  |  |                         |              |
| Educational Objectives           | After taking part successfully, stude  | ents have reached the following learning results         |                         |              |
| <b>Professional Competence</b>   |  |  |                         |              |
| Knowledge                        | With the completion of this module students acquire profound knowledge of the geo- and pedosphere, biogeochemical processes      |  |                         |              |
|                                  | and the fate of migrating compounds in soil and groundwater. They learn about methods to investigate sites for different use.    |  |                         |              |
| Skills                           | With the completion of this module students can apply the acquired theoretical knowledge to model sites and assess the situation |  |                         |              |
|                                  | · ·  | are able to draw comparisons on different investi        | -                       |              |
|                                  | projects can be devised and treated  | •  | 3                       | 4            |
| Personal Competence              |  |  |                         |              |
| •                                | Students can discuss technical and   | scientific tasks within a seminar subject specific and i | ntardicciplinan         |              |
| Social Competence                | Students can discuss technical and s   | scientific tasks within a seminar subject specific and i | nterdisciplinary .      |              |
| Autonomy                         | Students can independently exploit   | sources , acquire the particular knowledge of the sub    | ject and apply it to ne | ew problems. |
| Workload in Hours                | Independent Study Time 96, Study 1   | Time in Lecture 84                                       |                         |              |
| Credit points                    | 6  |  |                         |              |
| Course achievement               | None   |  |                         |              |
| Examination                      | Written exam   |  |                         |              |
| Examination duration and         | 2 Std. 15 Min.   |  | <u> </u>                |              |
| scale                            |  |  |                         |              |
| Assignment for the               | Civil Engineering: Specialisation Wat  | ter and Traffic: Elective Compulsory                     |                         |              |
| Following Curricula              | Water and Environmental Engineering  | ng: Core Qualification: Compulsory                       |                         |              |

| Course L1428: Biology | Course L1428: Biology  |  |  |
|-----------------------|--|--|--|
| Тур                   | Lecture  |  |  |
| Hrs/wk                | 2  |  |  |
| СР                    | 2  |  |  |
| Workload in Hours     | Independent Study Time 32, Study Time in Lecture 28  |  |  |
| Lecturer              | Dr. Anna Krüger, Prof. Garabed Antranikian   |  |  |
| Language              | DE/EN  |  |  |
| Cycle                 | WiSe   |  |  |
| Content               |  |  |  |
| Literature            | Umweltmikrobiologie, Reineke, W. und Schlömann, M. (2015) 2. Aufl., Springer Spektrum Verlag |  |  |

| Course L0903: Geology and | Soil Science  |
|---------------------------|---|
| Тур                       | Lecture   |
| Hrs/wk                    | 2   |
| СР                        | 1   |
| Workload in Hours         | Independent Study Time 2, Study Time in Lecture 28  |
| Lecturer                  | Dr. Joachim Gerth, Sonja Götz   |
| Language                  | DE  |
| Cycle                     | WiSe  |
| Content                   | Geology: formation of the Earth, plate tectonics, macroscopic rock identification, introduction to Earth history, introduction to halokinesis.  Soil science: soil use and function in ecosystems, faktors and processes of soil formation, mineral and organic components, surface types and properties, retention of nutrients and pollutants, hazards from faulty land use, erosion, salinization, and contamination, measures to preserve soils |
| Literature                | R. Vinx (2011): "Gesteinsbestimmung im Gelände"  H. Bahlburg & C. Breitkreutz (2012): "Grundlagen der Geologie", TUB Signatur GWB-318  R. Walter (2003): "Ergeschichte" TUB Signatur: 2816-1769  F.Scheffer und P. Schachtschabel (2002): "Lehrbuch der Bodenkunde" TUB Signatur AGG-308  W.E.H. Blum (2007): "Bodenkunde in Stichworten" TUB Signatur AGG-317  |

| Course L0354: Environmenta | ıl Analysis  |  |
|----------------------------|--|--|
| Тур                        | Lecture  |  |
| Hrs/wk                     | 2  |  |
| СР                         | 3  |  |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28  |  |
| Lecturer                   | Dr. Dorothea Rechtenbach, Dr. Henning Mangels  |  |
| Language                   | EN   |  |
| Cycle                      | WiSe   |  |
| Content                    | Introduction   |  |
|                            | Sampling in different environmental compartments, sample transportation, sample storage  |  |
|                            | Sample preparation   |  |
|                            | Photometry   |  |
|                            | Wastewater analysis  |  |
|                            | Introduction into chromatography   |  |
|                            | Gas chromatography   |  |
|                            | HPLC   |  |
|                            | Mass spectrometry  |  |
|                            | Optical emission spectrometry  |  |
|                            | Atom absorption spectrometry   |  |
|                            | Quality assurance in environmental analysis  |  |
| Literature                 | Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd., 2002 (TUB: USD-728)   |  |
|                            | Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716)   |  |
|                            | Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741)  |  |
|                            | Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis<br>RSC Publ., Cambridge, 2006 (TUB: USD-720)   |  |
|                            | Werner Funk, Vera Dammann, Gerhild Donnevert, Sarah lannelli (Translator), Eric lannelli (Translator), Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, Biotechnology, and Medical Engineering, 2nd Edition, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007 (TUB: CHF-350) |  |
|                            | STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 21st Edition, Andrew D. Eaton, Leonore S. Clesceri, Eugene W. Rice, and Arnold E. Greenberg, editors, 2005 (TUB:CHF-428)   |  |
|                            | K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of<br>Modern Chromatographic Methods, Academic Press  |  |
|                            | G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag  |  |
|                            | H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley  |  |
|                            | W. Gottwald, GC für Anwender, VCH  |  |
|                            | B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley   |  |
|                            | K. K. Unger, Handbuch der HPLC, GIT Verlag   |  |
|                            | G. Aced, H. J. Möckel, Liquidchromatographie, VCH  |  |
|                            | Charles B. Boss and Kenneth J. Fredeen, Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry Perkin-Elmer Corporation 1997, On-line available at:  |  |
|                            | http://files.instrument.com.cn/bbs/upfile/2006291448.pdf   |  |
|                            | Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614)  |  |
|                            | Royal Society of Chemistry, Atomic absorption spectometry (http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf)  |  |

| Engineering                          |  |                                       |                       |                       |
|--------------------------------------|--|---------------------------------------|-----------------------|-----------------------|
| Module M0962: Susta                  | inability and Risk Management  |                                       |                       |                       |
| Courses                              |  |                                       |                       |                       |
| Title                                |  | Тур                                   | Hrs/wk                | СР                    |
| Safety, Reliability and Risk Assessn | nent (L1145)   | Seminar                               | 2                     | 3                     |
| Environment and Sustainability (L0   | 319)   | Lecture                               | 2                     | 3                     |
| Module Responsible                   | Prof. Kerstin Kuchta   |                                       |                       |                       |
| Admission Requirements               | None   |                                       |                       |                       |
| <b>Recommended Previous</b>          | none   |                                       |                       |                       |
| Knowledge                            |  |                                       |                       |                       |
| <b>Educational Objectives</b>        | After taking part successfully, students have reac   | hed the following learning results    |                       |                       |
| <b>Professional Competence</b>       |  |                                       |                       |                       |
| Knowledge                            | Students are able to describe single techniques  | and to give an overview for the field | of safety and risk as | sessment as well as   |
|                                      | environmental and sustainable engineering, in de   | tail:                                 |                       |                       |
|                                      | basics in safety and reliability of technical  | facilities                            |                       |                       |
|                                      | safety and reliability analysis methods  | demacs                                |                       |                       |
|                                      | risk assessment  |                                       |                       |                       |
|                                      | <ul> <li>Production and usage of bio-char</li> </ul>   |                                       |                       |                       |
|                                      | energy production and supply   |                                       |                       |                       |
|                                      | sustainable product design   |                                       |                       |                       |
| Skills                               | Students are able apply interdisciplinary systemevaluate the effort and costs for processes and se |                                       |                       | reporting. They can   |
| Personal Competence                  |  |                                       |                       |                       |
| Social Competence                    |  |                                       |                       |                       |
| •                                    | Students can gain knowledge of the subject are   | a from given sources and transform it | to new guestions. Fu  | rthermore, they can   |
| ,                                    | define targets for new application or research-ori   | •                                     | •                     | -                     |
|                                      | the potential social, economic and cultural impac  | t.                                    |                       |                       |
| Workload in Hours                    | Independent Study Time 124, Study Time in Lector   | ure 56                                |                       |                       |
| Credit points                        | 6  |                                       |                       |                       |
| Course achievement                   | None   |                                       |                       |                       |
| Examination                          | Written elaboration  |                                       |                       |                       |
| Examination duration and             | Elaboration and presentation (45 minutes in grou   | ps)                                   |                       |                       |
| scale                                |  |                                       |                       |                       |
| Assignment for the                   | Civil Engineering: Core Qualification: Compulsory  |                                       |                       |                       |
| Following Curricula                  | Bioprocess Engineering: Specialisation C - Bio   | economic Process Engineering, Focu    | s Management and      | Controlling: Elective |
|                                      | Compulsory   |                                       |                       |                       |
|                                      | International Management and Engineering: Spec   | •                                     |                       |                       |
|                                      | Product Development, Materials and Production:   | ·                                     |                       |                       |
|                                      | Product Development, Materials and Production:   | ·                                     |                       |                       |
|                                      | Product Development, Materials and Production:   | ·                                     | ulsory                |                       |
|                                      | Water and Environmental Engineering: Core Qual   | ification: Compulsory                 |                       |                       |

| Committee Color Bulliot      | The control of the co |
|------------------------------|--|
| Course L1145: Safety, Reliab |  |
|                              | Seminar  |
| Hrs/wk                       |  |
| СР                           | 3  |
| Workload in Hours            | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                     | Dr. Marco Ritzkowski   |
| Language                     | DE   |
| Cycle                        | WiSe   |
|                              | An introduction in safety and risk assessment is given and some typical problems of structural and environmental engineering are treated:  • basics in safety and reliability of technical facilities • safety and reliability analysis methods • risk assessment • practical examples and excursions • discussions and presentations  |
| Literature                   | - Vorlesungsunterlagen - Schneider, J., Schlatter, H.P.: Sicherheit und Zuverlässigkeit im Bauwesen. www.risksafety.ch/files/ <b>sicherheit</b> _und_zuverlaessigkeit.pdf  |

| Тур               | Lecture  |
|-------------------|--|
| Hrs/wk            | 2  |
| СР                | 3  |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer          | Prof. Kerstin Kuchta   |
| Language          | EN   |
| Cycle             | WiSe   |
| Content           | This course presents actual methodologies and examples of environmental relevant, sustainable technologies, concepts and           |
|                   | strategies in the field of energy supply, product design, water supply, waste water treatment or mobility. The following list show |
|                   | examples.  |
|                   | Production and Usage of Bio-char   |
|                   | Engergy production with algae  |
|                   | Environmental product design   |
|                   | Clean Development mechanism (CDM)  |
|                   | Democracy and Energy   |
|                   | New Concepts for a sustainable Energy Supply   |
|                   | Recycling of Wind Turbines   |
|                   | Alternative Mobility   |
|                   | Disposal of Nuclear Wastes   |
|                   | Waste2Energy   |
|                   | Offshore Wind energy   |
| Literature        | Wird in der Veranstaltung bekannt gegeben.   |

# **Specialization Cities**

| Module M0830: Environmental Protection and Management |  |                                      |                     |   |  |
|---|--|--------------------------------------|---------------------|---|--|
| Courses   |  |                                      |                     |   |  |
| Title   |  | Тур                                  | Hrs/wk              | СР                                      |  |
| Integrated Pollution Control (L0502                   | )  | Lecture                              | 2                   | 2                                       |  |
| Health, Safety and Environmental I                    |  | Lecture                              | 2                   | 3                                       |  |
| Health, Safety and Environmental I                    | Management (L0388)   | Recitation Section (small)           | 1                   | 1                                       |  |
| Module Responsible                                    | Prof. Ralf Otterpohl   |                                      |                     |   |  |
| Admission Requirements                                | None   |                                      |                     |   |  |
| Recommended Previous                                  | Good knowledge in Technologies for Environment   | al Protection (end-of-pipe integrate | d solutions)        |   |  |
| Knowledge   | Good knowledge of the relevant Environmental Le  |                                      |                     |   |  |
|   | Basic knowledge of instruments for Environmenta  |                                      |                     |   |  |
|   | -  |                                      |                     |   |  |
| Educational Objectives                                | After taking part successfully, students have reached th   | e following learning results         |                     |   |  |
| Professional Competence                               |  |                                      |                     |   |  |
| Knowledge   | The students are able to describe the basics of regul  |                                      |                     |   |  |
|   | legislation ISO 14001, EMAS and Responsible Care ISO   |                                      |                     | •                                       |  |
|   | substance cycles and approaches from end-of-pipe to  |                                      |                     | _                                       |  |
|   | knowledge of complex industry related problems. They   | , ,                                  |                     |   |  |
|   | carry out innovative technical solutions, remediation in   |                                      | as well as concept  | tual problem solving                    |  |
|   | approaches in the full range of problems in different ind  | ustrial sectors.                     |                     |   |  |
|   |  |                                      |                     |   |  |
| Skills  | Students are able to assess surrent problems and situation   | stions in the field of environmental | protection Thou c   | an consider the best                    |  |
| SKIIIS  | Students are able to assess current problems and situal available techniques and to plan and suggest concrete          |                                      |                     |   |  |
|   | solve problems on a technical, administrative and legisla  |                                      | ecilic context. By  | this means they can                     |  |
|   | asolve problems on a teermical, administrative and legism  | delive level.                        |                     |   |  |
|   |  |                                      |                     |   |  |
| Personal Competence                                   |  |                                      |                     |   |  |
| •   | The students can work together in international groups.  |                                      |                     |   |  |
| Social Competence                                     | The stadents can none together in international groups.  |                                      |                     |   |  |
|   |  |                                      |                     |   |  |
| Autonomy  | Students are able to organize their work flow to prepar  | e themselves for presentations and   | contributions to tl | he discussions. They                    |  |
| ,   | can acquire appropriate knowledge by making enquiries  |                                      |                     | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |  |
|   | 5 - 1 - 4 - 1 - 4 - 1 - 1 - 1 - 1 - 1 - 1  |                                      |                     |   |  |
|   |  |                                      |                     |   |  |
| Workload in Hours                                     | Independent Study Time 110, Study Time in Lecture 70   |                                      |                     |   |  |
| Credit points   |  |                                      |                     |   |  |
| Course achievement                                    | None   |                                      |                     |   |  |
| Examination   | Written exam   |                                      |                     |   |  |
| Examination duration and                              |  |                                      |                     |   |  |
| scale   |  |                                      |                     |   |  |
| Assignment for the                                    | Civil Engineering: Specialisation Water and Traffic: Elect   | ive Compulsory                       |                     |   |  |
| Following Curricula                                   | Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective |                                      |                     |   |  |
|   | Compulsory   |                                      |                     |   |  |
|   | Energy and Environmental Engineering: Specialisation E   | nvironmental Engineering: Elective   | Compulsory          |   |  |
|   | Environmental Engineering: Core Qualification: Compuls   | ory                                  |                     |   |  |
|   | Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory  |                                      |                     |   |  |
|   | Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory |                                      |                     |   |  |
|   | Product Development, Materials and Production: Special   | lisation Product Development: Electi | ve Compulsory       |   |  |
|   | Product Development, Materials and Production: Special   | · ·                                  | -                   |   |  |
|   | Product Development, Materials and Production: Specialisation Materials: Elective Compulsory                           |                                      |                     |   |  |
|   | Water and Environmental Engineering: Specialisation Environment: Compulsory  |                                      |                     |   |  |
|   | Water and Environmental Engineering: Specialisation Ci   | ties: Compulsory                     |                     |   |  |

| Course L0502: Integrated Po | illution Control  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 2   |
| СР                          | 2   |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     | The lecture focusses on:  |
|                             | <ul> <li>The Regulatory Framework</li> <li>Pollution &amp; Impacts, Characteristics of Pollutants</li> <li>Approaches of Integrated Pollution Control</li> <li>Sevilla Process, Best Available Technologies &amp; BREF Documents</li> <li>Case Studies: paper industry, cement industry, automotive industry</li> <li>Field Trip</li> </ul> |
| Literature                  | Förstner, Ulrich (1998): Integrated Pollution Control, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-80313-0  Shen, Thomas T. (1999): Industrial Pollution Prevention, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-65208-3  |

| Course L0387: Health, Safety | y and Environmental Management  |
|------------------------------|---|
| Тур                          | Lecture   |
| Hrs/wk                       | 2   |
| СР                           | 3   |
| Workload in Hours            | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                     | Hans-Joachim Nau  |
| Language                     | EN  |
| Cycle                        | WiSe  |
| Content                      | <ul> <li>Objectives of and benefit from HSE management</li> <li>From dilution and end-of-pipe technology to eco-efficiency and eco-effectiveness Behaviour control: regulations, economic instruments and voluntary initiatives</li> <li>Fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements Environmental performance evaluation Risk management: hazard, risk and safety Health and safety at the workplace</li> <li>Crisis management</li> </ul> |
| Literature                   | C. Stephan: Industrial Health, Safety and Environmental Management, MV-Verlag, Münster, 2007/2012 (can be found in the library under GTG 315)  Exercises can be downloaded from StudIP  |

| ourse L0388: Health, Safety and Environmental Management |   |  |  |
|--|---|--|--|
| Тур  | Recitation Section (small)                          |  |  |
| Hrs/wk   | 1   |  |  |
| СР   | 1   |  |  |
| Workload in Hours  | Independent Study Time 16, Study Time in Lecture 14 |  |  |
| Lecturer   | Hans-Joachim Nau                                    |  |  |
| Language   | EN  |  |  |
| Cycle  | WiSe  |  |  |
| Content  | See interlocking course                             |  |  |
| Literature   | See interlocking course                             |  |  |

| Linginieering                           |   |   |                        |        |
|---|---|---|------------------------|--------|
| Module M0902: Wasto                     | ewater Treatment and Air Pollut   | tion Abatement                            |                        |        |
| Courses                                 |   |   |                        |        |
| itle                                    |   | Тур                                       | Hrs/wk                 | СР     |
| Biological Wastewater Treatment (L0517) |   | Lecture                                   | 2                      | 3      |
| ir Pollution Abatement (L0203)          |   | Lecture                                   | 2                      | 3      |
| Module Responsible                      | Dr. Swantje Pietsch-Braune  |   |                        |        |
| Admission Requirements                  | None  |   |                        |        |
| Recommended Previous                    | Basic knowledge of biology and chemistry  |   |                        |        |
| Knowledge                               |   |   |                        |        |
|   | basic knowledge of solids process engineering   | and separation technology                 |                        |        |
|   |   |   |                        |        |
| Educational Objectives                  | After taking part suggessfully students have s  | anched the following learning recults     |                        |        |
| Educational Objectives                  | After taking part successfully, students have re  | cached the following learning results     |                        |        |
| Professional Competence                 | After successful completion of the madula at  | dents are able to                         |                        |        |
| Knowieage                               | After successful completion of the module stud  | dents are able to                         |                        |        |
|   | <ul> <li>name and explain biological processes</li> </ul>   | for waste water treatment,                |                        |        |
|   | <ul> <li>characterize waste water and sewage sl</li> </ul>  | ludge                                     |                        |        |
|   | <ul> <li>discuss legal regulations in the area of e</li> </ul>  | emissions and air quality                 |                        |        |
|   | <ul> <li>classify off gas tretament processes and</li> </ul>  | to define their area of application       |                        |        |
| Skills                                  | Students are able to  |   |                        |        |
|   |   |   |                        |        |
|   | <ul> <li>choose and design processs steps for the biological waste water treatment</li> <li>combine processes for cleaning of off-gases depending on the pollutants contained in the gases</li> </ul> |   |                        |        |
|   | • combine processes for cleaning of oπ-ga   | ases depending on the pollutants contain  | ed in the gases        |        |
| Personal Competence                     |   |   |                        |        |
| Social Competence                       |   |   |                        |        |
| Autonomy                                |   |   |                        |        |
| Workload in Hours                       | Independent Study Time 124, Study Time in Le  | ecture 56                                 |                        |        |
| Credit points                           | 6   |   |                        |        |
| Course achievement                      | None  |   |                        |        |
| Examination                             | Written exam  |   |                        |        |
| Examination duration and                | 90 min  |   |                        |        |
| scale                                   |   |   |                        |        |
| Assignment for the                      | Civil Engineering: Specialisation Water and Tra   | iffic: Elective Compulsory                |                        |        |
| Following Curricula                     | Bioprocess Engineering: Specialisation A - Gen  | eral Bioprocess Engineering: Elective Cor | npulsory               |        |
|   | Chemical and Bioprocess Engineering: Speciali   | sation General Process Engineering: Elec  | tive Compulsory        |        |
|   | Energy and Environmental Engineering: Specia  | alisation Environmental Engineering: Elec | tive Compulsory        |        |
|   | Environmental Engineering: Specialisation Was   |   |                        |        |
|   | International Management and Engineering: Sp  |   |                        |        |
|   | Joint European Master in Environmental Studie   | • •                                       | n Water: Elective Comp | ulsory |
|   | Renewable Energies: Specialisation Bioenergy  | , ,                                       |                        |        |
|   | Process Engineering: Specialisation Environme   |   | ulsory                 |        |
|   | Process Engineering: Specialisation Process En  |   |                        |        |
|   | Water and Environmental Engineering: Special  |   |                        |        |
|   | Water and Environmental Engineering: Special  | · · ·                                     |                        |        |
|   | Water and Environmental Engineering: Special  | isation Cities: Compulsory                |                        |        |

| Тур               | Lecture   |  |  |  |
|-------------------|---|--|--|--|
| Hrs/wk            |   |  |  |  |
| СР                | 3   |  |  |  |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28 |  |  |  |
| Lecturer          | Dr. Joachim Behrendt                                |  |  |  |
| Language          | DE/EN   |  |  |  |
| Cycle             | WiSe  |  |  |  |
| Content           | Charaterisation of Wastewater                       |  |  |  |
|                   | Metobolism of Microorganisms                        |  |  |  |
|                   | Kinetic of mirobiotic processes                     |  |  |  |
|                   | alculation of bioreactor for wastewater treatment   |  |  |  |
|                   | oncepts of Wastewater treatment                     |  |  |  |
|                   | Design of WWTP                                      |  |  |  |
|                   | Excursion to a WWTP                                 |  |  |  |
|                   | Biofilms  |  |  |  |
|                   | Biofim Reactors                                     |  |  |  |
|                   | Anaerobic Wastewater and sldge treatment            |  |  |  |
|                   | resources oriented sanitation technology            |  |  |  |
|                   | Future challenges of wastewater treatment           |  |  |  |

| Literature | Gujer, Willi   |
|------------|--|
|            | Siedlungswasserwirtschaft : mit 84 Tabellen  |
|            | ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?    |
|            | id=2842122&prov=M&dok_var=1&dok_ext=htm  |
|            | Berlin [u.a.] : Springer, 2007   |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Wastewater treatment : biological and chemical processes   |
|            | ISBN: 3540422285 (Pp.)   |
|            | Berlin [u.a.] : Springer, 2002   |
|            | TUB_HH_Katalog   |
|            | Imhoff, Karl (Imhoff, Klaus R.;)   |
|            | Taschenbuch der Stadtentwässerung : mit 10 Tafeln  |
|            | ISBN: 3486263331 ((Gb.))   |
|            | München [u.a.]: Oldenbourg, 1999   |
|            | TUB_HH_Katalog   |
|            | Lange, Jörg (Otterpohl, Ralf; Steger-Hartmann, Thomas;)  |
|            | Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft  |
|            | ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334          |
|            | Donaueschingen-Pfohren : Mall-Beton-Verl., 2000  |
|            | TUB_HH_Katalog   |
|            | Mudrack, Klaus (Kunst, Sabine;)  |
|            | Biologie der Abwasserreinigung : 18 Tabellen   |
|            | ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903                  |
|            | Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003  |
|            | TUB_HH_Katalog   |
|            | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)  |
|            | Wastewater engineering: treatment and reuse  |
|            | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))  |
|            | Boston [u.a.] : McGraw-Hill, 2003  |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Activated sludge models ASM1, ASM2, ASM2d and ASM3   |
|            | ISBN: 1900222248   |
|            | London: IWA Publ., 2002  |
|            | TUB_HH_Katalog   |
|            | Kunz, Peter  |
|            | Umwelt-Bioverfahrenstechnik  |
|            | Vieweg, 1992   |
|            | Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt (Deutsche Vereinigung für                |
|            | Wasserwirtschaft, Abwasser und Abfall, ;)  |
|            | Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe |
|            | aus der Abwasserbehandlung, Kleinkläranlagen   |
|            | ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL:  |
|            | http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf   |
|            | Weimar : Universitätsverl, 2006  |
|            | TUB_HH_Katalog   |
|            | Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall   |
|            | DWA-Regelwerk  |
|            | Hennef: DWA, 2004  |
|            | TUB_HH_Katalog   |
|            | Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)  |
|            | Fundamentals of biological wastewater treatment  |
|            | ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm              |
|            | Weinheim: WILEY-VCH, 2007  |
|            | TUB_HH_Katalog   |
|            |  |
|            |  |

| Course L0203: Air Pollution A | Course L0203: Air Pollution Abatement  |  |  |  |
|-------------------------------|--|--|--|--|
| Тур                           | Lecture  |  |  |  |
| Hrs/wk                        | 2  |  |  |  |
| СР                            | 3  |  |  |  |
| Workload in Hours             | Independent Study Time 62, Study Time in Lecture 28  |  |  |  |
| Lecturer                      | Dr. Swantje Pietsch-Braune, Christian Eichler  |  |  |  |
| Language                      | EN   |  |  |  |
| Cycle                         | WiSe   |  |  |  |
| Content                       | In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators. |  |  |  |
| Literature                    | Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff Amsterdam [u.a.] : Butterworth-Heinemann, 2002  Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson Cambridge [u.a.] : Cambridge Univ. Press, 2002  Air pollution control technology handbook, Karl B. Schnelle Boca Raton [u.a.] : CRC Press, c 2002  Air pollution, Jeremy Colls 2. ed London [u.a.] : Spon, 2002  |  |  |  |

| Courses                           |  |
|-----------------------------------|--|
| litle                             | Typ Hrs/wk CP  |
| ntegrated Transportation Planning |  |
| Module Responsible                |  |
| Admission Requirements            |  |
|                                   | some knowledge of transport planning, e.g. through taking the undergraduate class "Transport Planning and Traffic Engineerin   |
| Knowledge                         | g  |
|                                   | After taking part successfully, students have reached the following learning results   |
| Professional Competence           |  |
| Knowledge                         | Students are able to:  |
|                                   |  |
|                                   | <ul> <li>describe interdependencies between land-use/location choice and transportation/mobility behaviour</li> <li>explain and evaluate the social, ecological and economic effects of transport and land-use policy measures.</li> </ul>   |
|                                   | <ul> <li>relate current issues in the area of integrated transport planning and formulate an opinion on them.</li> </ul>   |
|                                   | Federe current issues in the area of integrated datispore planning and formulate an opinion on atems.  |
|                                   |  |
| Skills                            | Students are able to:  |
|                                   |  |
|                                   | quantify important parameters, which influence travel demand or are influenced by it.  |
|                                   | comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document to the comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document to the comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document to the comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document to the comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document to the comprehensive and |
|                                   | results in accordance with scientific conventions.   |
|                                   |  |
| Personal Competence               |  |
|                                   | Students are able to:  |
| Social Competence                 | Stauchts and able to.  |
|                                   | provide feedback on topical contents and their teaching.   |
|                                   | constructively handle feedback on their own work.  |
|                                   | produce results in group work and document these.  |
|                                   |  |
| Autonomy                          | Students are able to:  |
|                                   | assess potential consequences of their future professional activities  |
|                                   | <ul> <li>independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means</li> </ul>   |
|                                   | its execution.   |
|                                   |  |
|                                   |  |
| Workload in Hours                 | Independent Study Time 124, Study Time in Lecture 56   |
| Credit points                     | 6  |
| Course achievement                | None   |
| Examination                       | Written elaboration  |
| Examination duration and          | written assignment with presentation during the semester   |
| scale                             |  |
| Assignment for the                | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |
| Following Curricula               | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |
|                                   | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |
|                                   | Civil Engineering: Specialisation Water and Traffic: Compulsory  |
|                                   | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory  |
|                                   | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   |
|                                   | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |
|                                   | Water and Environmental Engineering: Specialisation Cities: Compulsory   |

| Course L1068: Integrated Transportation Planning |  |  |  |
|--|--|--|--|
| Тур  | Project-/problem-based Learning  |  |  |
| Hrs/wk   | 4  |  |  |
| СР   | 6  |  |  |
| Workload in Hours                                | Independent Study Time 124, Study Time in Lecture 56   |  |  |
| Lecturer   | Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß   |  |  |
| Language   | DE   |  |  |
| Cycle  | WiSe   |  |  |
| Content  | The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.:  • interactions between transport and the environment and consequent limitations  • characteristics of integrated planning  • complex planning processes  • interdependencies of location choice and mobility behaviour  • transport and land-use policies  • project on current issues in transportation studies |  |  |
| Literature                                       | Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin.  Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin,  Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)  |  |  |

| Module M0511: Electr               | icity Generation from Wind and                   | l Hydro Power                                |                        |                      |
|------------------------------------|--|--|------------------------|----------------------|
| Courses                            |  |  |                        |                      |
| Title                              |  | Тур  | Hrs/wk                 | СР                   |
| Sustainability Management (L0007)  |  | Lecture                                      | 2                      | 1                    |
| Hydro Power Use (L0013)            |  | Lecture                                      | 1                      | 1                    |
| Wind Turbine Plants (L0011)        |  | Lecture                                      | 2                      | 3                    |
| Wind Energy Use - Focus Offshore ( | L0012)   | Lecture                                      | 1                      | 1                    |
| Module Responsible                 | Dr. Isabel Höfer                                 |  |                        |                      |
| Admission Requirements             | None   |  |                        |                      |
| <b>Recommended Previous</b>        | Module: Technical Thermodynamics I,              |  |                        |                      |
| Knowledge                          |  |  |                        |                      |
|                                    | Module: Technical Thermodynamics II,             |  |                        |                      |
|                                    | Module: Fundamentals of Fluid Mechanics          |  |                        |                      |
| <b>Educational Objectives</b>      | After taking part successfully, students have i  | eached the following learning results        |                        |                      |
| Professional Competence            | -  | -  |                        |                      |
| Knowledae                          | By ending this module students can explain       | in detail knowledge of wind turbines with    | a particular focus of  | wind energy use in   |
| 3                                  | offshore conditions and can critical comment     |  |                        |                      |
|                                    | to describe fundamentally the use of water po    | ·  | •                      | -                    |
|                                    | in the implementation of renewable energy pr     |  | .,                     |                      |
|                                    | 5,7  | .,   |                        |                      |
|                                    | Through active discussions of various topics     | within the seminar of the module, stude      | ents improve their un  | derstanding and the  |
|                                    | application of the theoretical background and    | are thus able to transfer what they have le  | earned in practice.    |                      |
| Skille                             | Students are able to apply the acquired the      | poratical foundations on exemplany water     | or wind nower system   | as and avaluate and  |
| SKIIIS                             |  |  |                        |                      |
|                                    | assess technically the resulting relationships   |  |                        |                      |
|                                    | compare critically the special procedure for the |  |                        | side Europe with the |
|                                    | in principle applied approach in Europe and ca   | an apply this procedure on exemplary theol   | reticai projects.      |                      |
| B                                  |  |  |                        |                      |
| Personal Competence                |  |  |                        |                      |
| Social Competence                  | Students can discuss scientific tasks subjet-s   | pecificly and multidisciplinary within a sem | inar.                  |                      |
| 4                                  | Charles and independently applet according       | :- +b  |                        |                      |
| Autonomy                           | Students can independently exploit sources       |  | ture material to clear | the contents of the  |
|                                    | lecture and to acquire the particular knowledge  | je about the subject area.                   |                        |                      |
| Workload in Hours                  | Independent Study Time 96, Study Time in Le      | cture 84                                     |                        |                      |
| Credit points                      | 6  |  |                        |                      |
| Course achievement                 | None   |  |                        |                      |
| Examination                        | Written exam                                     |  |                        |                      |
| Examination duration and           | 2.5 hours written exam + Prensentation in su     | stainability management                      |                        |                      |
| scale                              |  |  |                        |                      |
| •                                  | Civil Engineering: Specialisation Structural En  |  |                        |                      |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical   | Engineering: Elective Compulsory             |                        |                      |
|                                    | Civil Engineering: Specialisation Coastal Engir  | eering: Elective Compulsory                  |                        |                      |
|                                    | Energy and Environmental Engineering: Speci      | alisation Energy Engineering: Elective Com   | pulsory                |                      |
|                                    | International Management and Engineering: S      | pecialisation II. Renewable Energy: Elective | e Compulsory           |                      |
|                                    | International Management and Engineering: S      | pecialisation II. Energy and Environmental   | Engineering: Elective  | Compulsory           |
|                                    | Product Development, Materials and Production    | ·  |                        |                      |
|                                    | Product Development, Materials and Production    | on: Specialisation Production: Elective Com  | pulsory                |                      |
|                                    | Product Development, Materials and Production    | on: Specialisation Materials: Elective Comp  | ulsory                 |                      |
|                                    | Renewable Energies: Core Qualification: Comp     | pulsory                                      |                        |                      |
|                                    | Theoretical Mechanical Engineering: Technical    | l Complementary Course: Elective Compuls     | sory                   |                      |
|                                    | Theoretical Mechanical Engineering: Specialis    | ation Energy Systems: Elective Compulsory    | 1                      |                      |
|                                    | Process Engineering: Specialisation Environme    | ental Process Engineering: Elective Compul   | sory                   |                      |
|                                    | Water and Environmental Engineering: Specia      | lisation Environment: Compulsory             |                        |                      |
|                                    | Water and Environmental Engineering: Specia      | lisation Cities: Elective Compulsory         |                        |                      |
|                                    |  | · · · · ·                                    |                        |                      |

| Course L0007: Sustainability | Management  |  |
|------------------------------|---|--|
| Тур                          | Lecture   |  |
| Hrs/wk                       | 2   |  |
| СР                           | 1   |  |
| Workload in Hours            | ndependent Study Time 2, Study Time in Lecture 28   |  |
| Lecturer                     | Dr. Anne Rödl   |  |
| Language                     | DE  |  |
| Cycle                        | WiSe  |  |
| Content                      | The lecture sustainability management provide an insight into the various aspects and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples.  • Introduction to the topic of sustainability  • Dimensions of sustainability:  • ecology  • economics  • social  • Transition from the environmental assessment for sustainability management  • Case Studies  • Excursion  Objective: The aim of the course is to learn methods for the assessment of sustainability aspects and apply for sustainability management. |  |
| Literature                   | Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in globaler Verantwortung. Wiesbaden: Gabler Verlag.   |  |

| Course L0013: Hydro Power | Use .  |
|---------------------------|--|
| ,                         | Lecture  |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Prof. Stefan Achleitner, Hugo Götsch   |
| Language                  | DE   |
| Cycle                     | SoSe SoSe  |
| Content                   | <ul> <li>Introduction, importance of water power in the national and global context</li> <li>Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>Hydropower and the Environment</li> <li>Examples from practice</li> </ul> |
| Literature                | <ul> <li>Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>  |

| Course L0011: Wind Turbine Plants |   |  |
|-----------------------------------|---|--|
| Тур                               | Lecture   |  |
| Hrs/wk                            | 2   |  |
| СР                                | 3   |  |
| Workload in Hours                 | Independent Study Time 62, Study Time in Lecture 28   |  |
| Lecturer                          | Dr. Rudolf Zellermann, Dr. Jochen Oexmann   |  |
| Language                          | DE  |  |
| Cycle                             | SoSe  |  |
| Content                           | <ul> <li>Historical development</li> <li>Wind: origins, geographic and temporal distribution, locations</li> <li>Power coefficient, rotor thrust</li> <li>Aerodynamics of the rotor</li> <li>Operating performance</li> <li>Power limitation, partial load, pitch and stall control</li> <li>Plant selection, yield prediction, economy</li> <li>Excursion</li> </ul> |  |
| Literature                        | Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005   |  |

| Course L0012: Wind Energy | Use - Focus Offshore   |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Prof. Martin Skiba   |
| Language                  | DE   |
| Cycle                     | SoSe   |
| Content                   | <ul> <li>Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>Physical fundamentals for utilization of wind energy</li> <li>Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>Development and planning of offshore wind farms</li> <li>Operation and optimization of offshore wind farms</li> <li>Day excursion</li> </ul> |
| Literature                | <ul> <li>Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage</li> <li>Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage</li> <li>Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>   |

| Module M0703: Soil a   | nd Groundwater Contaminatio  | n   |                      |                      |
|--|--|---|----------------------|----------------------|
| •  |  |   |                      |                      |
| Courses  |  |   |                      |                      |
| Title  |  | Тур   | Hrs/wk               | СР                   |
| Contamination and Remediation (L   |  | Project Seminar                                 | 3                    | 3                    |
| NAPL in Soil and Groundwater (L05<br>NAPL in Soil and Groundwater (L05                               |  | Lecture<br>Recitation Section (small)           | 1<br>2               | 1<br>2               |
|  | ·<br>!   | Recitation Section (Small)                      |                      | 2                    |
| Module Responsible  Admission Requirements   | None   |   |                      |                      |
| Recommended Previous   | None   |   |                      |                      |
| Knowledge  | <ul> <li>Ground water hydrology</li> </ul>   |   |                      |                      |
| Kilowiedge   | <ul> <li>Geohydraulic and solute transport</li> </ul>  |   |                      |                      |
|  | <ul> <li>Hydromechanics</li> </ul>   |   |                      |                      |
| Educational Objectives   | After taking part successfully, students have  | reached the following learning results          | _                    |                      |
|  | Arter taking part successiony, students have   | reactied the following learning results         |                      |                      |
| Professional Competence  | The students are able to analyse contamination in soils and groundwater. They are able to create remediation concepts for LNAPL  |   |                      |                      |
| Knowleage  | , and the second | •   | reate remediation    | n concepts for LNAPL |
|  | contamnations. They are faminliar with Mon   | itored Natural Attenuation                      |                      |                      |
|  |  |   |                      |                      |
|  |  |   |                      |                      |
| Skills   | The students are able to analyse contaminations in soils and groundwater using special engineering methods. They can   |   | •                    |                      |
| transport modelling in the unsaturated zone, estimations of groundwater pollution and analyse the in |  |   |                      |                      |
|  | measures. They can forecast die distribution   | , mobility and remediation of non aquaous phase | : liquias in soil an | a groundwater.       |
| Personal Competence  |  |   |                      |                      |
| •  | · · ·  | ontamination issues in teamwork and are able to | find remediation     | measures.            |
| Autonomy   |  |   |                      |                      |
|  | Independent Study Time 96, Study Time in L   | ecture 84                                       |                      |                      |
| Credit points  |  |   |                      |                      |
| Course achievement   |  |   |                      |                      |
|  |  | Written exam                                    |                      |                      |
| Examination duration and   | Klausur 60 min; Referat 15 min;  |   |                      |                      |
| scale  |  |   |                      |                      |
| Assignment for the   | Civil Engineering: Specialisation Water and 1  | Fraffic: Elective Compulsory                    |                      |                      |
| Following Curricula  | Water and Environmental Engineering: Spec  | ialisation Water: Elective Compulsory           |                      |                      |
|  | Water and Environmental Engineering: Spec  | ialisation Environment: Elective Compulsory     |                      |                      |
|  | Water and Environmental Engineering: Spec  | ialisation Cities: Elective Compulsory          |                      |                      |

| Course L0547: Contamination and Remediation |  |  |
|---|--|--|
| Тур   | Project Seminar  |  |
| Hrs/wk                                      | 3  |  |
| СР  | 3  |  |
| Workload in Hours                           | Independent Study Time 48, Study Time in Lecture 42  |  |
| Lecturer                                    | Prof. Nima Shokri, Hannes Nevermann  |  |
| Language                                    | EN   |  |
| Cycle                                       | SoSe   |  |
| Content                                     | Processing of a complex soil and groundwater contamination site. Students perform analyses of data to detect the contamination |  |
|   | and to analyse the groundwater hazard and to develop a concept for remediation of the damage.                                  |  |
| Literature                                  | entfällt   |  |

| Course L0545: NAPL in Soil and Groundwater |  |  |
|--|--|--|
| Тур  | Lecture  |  |
| Hrs/wk                                     | 1  |  |
| СР   | 1  |  |
| Workload in Hours                          | Independent Study Time 16, Study Time in Lecture 14  |  |
| Lecturer                                   | Prof. Nima Shokri  |  |
| Language                                   | EN   |  |
| Cycle                                      | SoSe   |  |
| Content                                    | concept of capillarity, multi phase distribution in poraus media, residual saturation, rellative permeability, infiltration of NAPL into |  |
|  | the subsurface, vertical distribution of LNAPL, specific volume  |  |
| Literature                                 | Charbeneau, R.J. (2000): Groundwater Hydraulics and pollutant Transport  |  |

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| Course L0546: NAPL in Soil and Groundwater |   |  |
|--|---|--|
| Тур  | Recitation Section (small)                          |  |
| Hrs/wk                                     | 2   |  |
| СР   | 2   |  |
| Workload in Hours                          | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                                   | Prof. Nima Shokri                                   |  |
| Language                                   | EN  |  |
| Cycle                                      | SoSe  |  |
| Content                                    | See interlocking course                             |  |
| Literature                                 | See interlocking course                             |  |

| Engineering"  |   |   |                  |                      |
|---|---|---|------------------|----------------------|
| Module M0749: Wasto   | e Treatment and Solid Matter Process  | Technology                              |                  |                      |
| Courses   |   |   |                  |                      |
| <b>Title</b> Solid Matter Process Technology fo Thermal Waste Treatment (L0320) | r Biomass (L0052)   | <b>Typ</b><br>Lecture<br>Lecture        | Hrs/wk<br>2<br>2 | <b>CP</b> 2 2        |
| Thermal Waste Treatment (L1177)   |   | Recitation Section (large)              | 1                | 2                    |
| Module Responsible  | Prof Kerstin Kuchta   |   |                  |                      |
| Admission Requirements  |   |   |                  |                      |
| Recommended Previous  |   |   |                  |                      |
| Knowledge   | 243.65 0.   |   |                  |                      |
| 3   | <ul> <li>thermo dynamics</li> </ul>   |   |                  |                      |
|   | <ul><li>fluid dynamics</li><li>chemistry</li></ul>  |   |                  |                      |
| Educational Objectives  | After taking part successfully, students have reached the   | e following learning results            |                  |                      |
| Professional Competence   | •   |   |                  |                      |
| Knowledge   | The students can name, describe current issue and engineering and contemplate them in the context of the  |   | aste treatment a | and particle process |
|   | The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity, heat and mineral recyclables. |   |                  |                      |
| Skills  | The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts.   |   |                  |                      |
| Personal Competence   |   |   |                  |                      |
| Social Competence   | Students can  |   |                  |                      |
|   | <ul> <li>respectfully work together as a team and discuss technical tasks</li> <li>participate in subject-specific and interdisciplinary discussions,</li> <li>develop cooperated solutions</li> <li>promote the scientific development and accept professional constructive criticism.</li> </ul>  |   |                  |                      |
| Autonomy  | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.  |   |                  |                      |
| Workload in Hours   | Independent Study Time 110, Study Time in Lecture 70  |   |                  |                      |
| Credit points   | 6   |   |                  |                      |
| Course achievement  | None  |   |                  |                      |
| Examination   | Written exam  |   |                  |                      |
| Examination duration and scale  | 120 min   |   |                  |                      |
| Assignment for the  | Civil Engineering: Specialisation Water and Traffic: Election   | ve Compulsory                           |                  |                      |
| Following Curricula   | Bioprocess Engineering: Specialisation A - General Biopro   |   |                  |                      |
|   | Energy and Environmental Engineering: Specialisation En   | • |                  | -                    |
|   | International Management and Engineering: Specialisation  | • •                                     |                  | Compulsory           |
|   | International Management and Engineering: Specialisation  | • •                                     | npulsory         |                      |
|   | Renewable Energies: Specialisation Bioenergy Systems:   | , ,                                     |                  |                      |
|   | Process Engineering: Specialisation Chemical Process En<br>Process Engineering: Specialisation Process Engineering.   |   |                  |                      |
|   | Process Engineering: Specialisation Environmental Process   |   |                  |                      |
|   | Water and Environmental Engineering: Specialisation En  |   |                  |                      |
|   | Water and Environmental Engineering: Specialisation Cit   |   |                  |                      |
|   |   | -                                       |                  |                      |

| Course L0052: Solid Matter Process Technology for Biomass |  |  |
|---|--|--|
| Тур   | Lecture  |  |
| Hrs/wk  | 2  |  |
| СР  | 2  |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer  | Prof. Werner Sitzmann  |  |
| Language  | DE   |  |
| Cycle   | SoSe   |  |
| Content   | The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture. |  |
| Literature  | Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4  Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe,  Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de  Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175  |  |

| Course L0320: Thermal Wast | re Treatment  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Prof. Kerstin Kuchta  |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | <ul> <li>Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals</li> <li>basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition</li> <li>Incineration techniques: grate firing, ash transfer, boiler</li> <li>Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination</li> <li>Ash treatment: Mass, quality, treatment concepts, recycling, disposal</li> </ul> |
| Literature                 | Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.   |

| Course L1177: Thermal Wast | Course L1177: Thermal Waste Treatment               |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (large)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                   | Prof. Kerstin Kuchta                                |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| Engineering                                |  |  |               |                       |
|--|--|--|---------------|-----------------------|
| Module M0827: Mode                         | ling in Water Management   |  |               |                       |
| Courses                                    |  |  |               |                       |
| Title                                      |  | Тур  | Hrs/wk        | СР                    |
| Groundwater Modeling using Modflow (L0543) |  | Lecture                                    | 1             | 1                     |
| Groundwater Modeling using Modflow (L0544) |  | Recitation Section (small)                 | 2             | 2                     |
| Modeling of Water Supply and Sewe          | er Network (L0875)   | Project-/problem-based Learning            | 2             | 3                     |
| Module Responsible                         | Dr. Klaus Johannsen  |  |               |                       |
| ·  | None   |  |               |                       |
|  | Groundwater  |  |               |                       |
| Knowledge                                  | groundwater hydraulics and transport of substar  | nces                                       |               |                       |
|  | Pipe Systems   |  |               |                       |
|  | <ul> <li>Knowledge on urban water infrastructures, in</li> </ul>   | particular drinking water systemsand u     | rban drainag  | e systems including   |
|  | special structures   |  | _             |                       |
|  | Hydraulics of drinking water supply systems and  | sewer systems                              |               |                       |
|  | Basic knowledge on water management  |  |               |                       |
| Educational Objectives                     | After taking part successfully, students have reached t  | he following learning results              |               |                       |
| Professional Competence                    | •  | •  |               |                       |
| Knowledge                                  | The students are able to describe the modelling of grou  | undwater flow and transport as well as urb | an water infr | astructures. They can |
| -  | carry out systems analyses and can detect technical a  |  |               | -                     |
|  | are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.  |  |               |                       |
|  |  |  |               |                       |
|  |  |  |               |                       |
| Skills                                     | The students are able to construct and apply scientific  | c groundwater models indipendently. The    | y can work o  | n different scenarios |
|  | and can compare or assess different solutions for existing problems by application of selected software products. The students are |  |               |                       |
|  | able to use different software solutions (e.g. EPANET, EPA-SWMM).  |  |               |                       |
|  |  |  |               |                       |
|  |  |  |               |                       |
|  |  |  |               |                       |
| Personal Competence                        |  |  |               |                       |
| ·  | Wird nicht vermittelt.   |  |               |                       |
| Social competence                          | wird mene vermitteit.  |  |               |                       |
| Autonomy                                   | Wird nicht vermittelt.   |  |               |                       |
| Workload in Hours                          | Independent Study Time 110, Study Time in Lecture 70   | )  |               |                       |
| Credit points                              | 6  |  |               |                       |
| Course achievement                         | None   |  |               |                       |
| Examination                                | Oral exam  |  |               |                       |
| Examination duration and                   | 20 min   |  |               |                       |
| scale                                      |  |  |               |                       |
| -  | Civil Engineering: Specialisation Structural Engineering   | • •  |               |                       |
| Following Curricula                        | Civil Engineering: Specialisation Geotechnical Engineer  | , ,  |               |                       |
|  | Civil Engineering: Specialisation Coastal Engineering: E   | • •  |               |                       |
|  | Civil Engineering: Specialisation Water and Traffic: Elec  |  |               |                       |
|  | Water and Environmental Engineering: Specialisation V  |  |               |                       |
|  | Water and Environmental Engineering: Specialisation E  | • • •                                      |               |                       |
|  | Water and Environmental Engineering: Specialisation C  | Cities: Elective Compulsory                |               |                       |

| Course L0543: Groundwater | Modeling using Modflow   |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Sonja Götz   |
| Language                  | DE/EN  |
| Cycle                     | SoSe   |
| Content                   | Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work |
|                           | with the model PMWIN for practical case studies.   |
| Literature                | MODFLOW-Handbuch   |
|                           | Chiang, Wen Hsien: PMWIN   |
|                           |  |

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| Course L0544: Groundwater Modeling using Modflow |   |  |
|--|---|--|
| Тур  | Recitation Section (small)                          |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours                                | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer   | Sonja Götz  |  |
| Language   | DE/EN   |  |
| Cycle  | SoSe  |  |
| Content  | See interlocking course                             |  |
| Literature                                       | See interlocking course                             |  |

| urse L0875: Modeling of Water Supply and Sewer Network |  |  |  |
|--|--|--|--|
| Тур  | Project-/problem-based Learning  |  |  |
| Hrs/wk   | 2  |  |  |
| СР   | 3  |  |  |
| Workload in Hours                                      | Independent Study Time 62, Study Time in Lecture 28  |  |  |
| Lecturer   | Dr. Klaus Johannsen, Weitere Mitarbeiter   |  |  |
| Language   | DE   |  |  |
| Cycle  | SoSe   |  |  |
| Content  |  |  |  |
| Literature   | Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014. |  |  |

| Module M0828: Urbar                   | n Environmental Management   |         |                |   |
|---------------------------------------|--|---------|----------------|---|
|                                       |  |         |                |   |
| Courses                               |  |         |                |   |
| Title                                 | Тур  |         | Hrs/wk         | CP                                      |
| Noise Protection (L1109)              | Lecture  |         | 2              | 2                                       |
| Urban Infrastructures (L0874)         | Project-/problem-based Lea   | rning   | 2              | 4                                       |
| Module Responsible                    | Dr. Dorothea Rechtenbach   |         |                |   |
| Admission Requirements                | None   |         |                |   |
| Recommended Previous                  | Knowledge on Urban planning  |         |                |   |
| Knowledge                             | Knowledge on measures for climate protection   |         |                |   |
|                                       | General knowledge of scientific writing/working  |         |                |   |
| Educational Objectives                | After taking part successfully, students have reached the following learning results   |         |                |   |
| Professional Competence               | The taking part succession, yet addition in the reaction and its longitude in the succession in the su |         |                |   |
| Knowledge                             | Students can describe urban development corridors as well as current and future urban e  | nvironm | nental proble  | ms. They are able to                    |
|                                       | explain the causes of environmental problems (like noise).   |         |                | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |
|                                       | Students can specify applications for various technical innovations and explain why these  | contrib | oute to the in | nprovement of urbar                     |
|                                       | life. They can, for example, derive and discuss measures for effective noise abatement.  |         |                | ,                                       |
|                                       |  |         |                |   |
| Skills                                | Students are able to develop specific solutions for correcting existing or future e  |         |                | •                                       |
|                                       | development. They can define a range of conceptual and technical solutions for environments.   |         |                | •                                       |
|                                       | paths. To solve specific urban environmental problems they can select technical innovation.  | ions ar | nd integrate   | them into the urbar                     |
| Damanal Commetence                    | context.   |         |                |   |
| Personal Competence Social Competence | The students can work together in international groups.  |         |                |   |
| 30Clar Competence                     | The students can work together in international groups.  |         |                |   |
| Autonomy                              | Students are able to organize their work flow to prepare themselves for presentations ar   | d contr | ributions to t | he discussions. The                     |
|                                       | can acquire appropriate knowledge by making enquiries independently.   |         |                |   |
| Workload in Hours                     | Independent Study Time 124, Study Time in Lecture 56   |         |                |   |
| Credit points                         | 6  |         |                |   |
| Course achievement                    | None   |         |                |   |
| Examination                           | Written elaboration  |         |                |   |
| Examination duration and              | Written Report plus oral Presentation  |         |                |   |
| scale                                 |  |         |                |   |
| Assignment for the                    | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |         |                |   |
| Following Curricula                   | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |         |                |   |
|                                       | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |         |                |   |
|                                       | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |         |                |   |
|                                       | Environmental Engineering: Core Qualification: Elective Compulsory   |         |                |   |
|                                       | Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualificati   | on: Con | npulsory       |   |
|                                       | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Co  | mpulso  | ory            |   |
|                                       | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |         |                |   |
|                                       | Water and Environmental Engineering: Specialisation Cities: Compulsory   |         |                |   |

| Course L1109: Noise Protection |  |  |  |
|--------------------------------|--|--|--|
| Тур                            | Lecture  |  |  |
| Hrs/wk                         | 2  |  |  |
| СР                             | 2  |  |  |
| Workload in Hours              | Independent Study Time 32, Study Time in Lecture 28  |  |  |
| Lecturer                       | Prof. Martin Jäschke   |  |  |
| Language                       | EN   |  |  |
| Cycle                          | SoSe   |  |  |
| Content                        |  |  |  |
| Literature                     | 1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German)                                   |  |  |
|                                | 2) WHO (1999): Guidelines for Community Noise  |  |  |
|                                | 3) Environmental Noise Directive 2002/49/EG  |  |  |
|                                | 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation |  |  |

| Course L0874: Urban Infrast | ructures  |
|-----------------------------|---|
| Тур                         | Project-/problem-based Learning   |
| Hrs/wk                      | 2   |
| СР                          | 4   |
| Workload in Hours           | Independent Study Time 92, Study Time in Lecture 28   |
| Lecturer                    | Dr. Dorothea Rechtenbach  |
| Language                    | EN  |
| Cycle                       | SoSe  |
| Content                     | Problem Based Learning  |
|                             | Main topics are:  |
|                             | <ul> <li>Car Free Cities.</li> <li>Multifunctional Places in Cities.</li> <li>The Sustainability of Freight Transport in Cities.</li> </ul> |
| Literature                  | Depends on chosen topic.  |

| Module M0857: Geocl                | hemical Engineering  |   |                    |                       |
|------------------------------------|--|---|--------------------|-----------------------|
|                                    |  |   |                    |                       |
| Courses                            |  |   |                    |                       |
| Title                              |  | Тур                                       | Hrs/wk             | CP                    |
| Contaminated Sites and Landfilling |  | Lecture                                   | 2                  | 2                     |
| Contaminated Sites and Landfilling | (L0907)  | Recitation Section (large)                | 1                  | 2                     |
| Geochemical Engineering (L0904)    |  | Lecture                                   | 2                  | 2                     |
| Module Responsible                 | Dr. Marco Ritzkowski   |   |                    |                       |
| Admission Requirements             | None   |   |                    |                       |
| Recommended Previous               | Module: General and Inorganic Chemistry,   |   |                    |                       |
| Knowledge                          | Module:Organic Chemistry,  |   |                    |                       |
|                                    | Biology (Basic Knowledge)  |   |                    |                       |
|                                    |  |   |                    |                       |
|                                    |  |   |                    |                       |
| Educational Objectives             | After taking part successfully, students have reached  | the following learning results            |                    |                       |
| Professional Competence            |  |   |                    |                       |
| Knowledge                          | With the completion of this module students acquire  | profound knowledge of biogeochemica       | al processes, the  | fate of pollutants in |
|                                    | soil and groundwater, and techniques to deposit conta  | aminated waste material. They are able    | to describe in pri | nciple the behaviou   |
|                                    | of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites.                 |   |                    |                       |
| Skills                             | With the completion of this module students can app  | oly the acquired theoretical knowledge    | to model cases     | of site pollution and |
|                                    | critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strat |   |                    |                       |
|                                    | and techniques. Model projects can be devised and tre  |   |                    |                       |
|                                    |  |   |                    |                       |
| Personal Competence                |  |   |                    |                       |
| Social Competence                  | Students can discuss technical and scientific tasks wi   | thin a seminar subject specific and inter | disciplinary .     |                       |
| Autonomy                           | Students can independently exploit sources , acquire   | the particular knowledge of the subject   | and apply it to ne | w problems.           |
| Workload in Hours                  | Independent Study Time 110, Study Time in Lecture 7  | 0   |                    |                       |
| Credit points                      | 6  |   |                    |                       |
| Course achievement                 | None   |   |                    |                       |
| Examination                        | Written exam   |   |                    |                       |
| Examination duration and           | 2 hours  |   |                    |                       |
| scale                              |  |   |                    |                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: Ele   | ctive Compulsory                          |                    |                       |
| Following Curricula                | Environmental Engineering: Core Qualification: Electiv   | e Compulsory                              |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation  | Water: Elective Compulsory                |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation  | Environment: Elective Compulsory          |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation  | Cities: Elective Compulsory               |                    |                       |

| Course L0906: Contaminated | Sites and Landfilling   |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Dr. Marco Ritzkowski, Dr. Joachim Gerth   |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects.  The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare. |
| Literature                 | 1) Waste Management. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105, Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) Solid Waste Technology and Management. Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3, Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) Natural attenuation of fuels and chlorinated solvents in the subsurface. Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844   |

| ourse L0907: Contaminated Sites and Landfilling |   |  |
|---|---|--|
| Тур   | Recitation Section (large)                          |  |
| Hrs/wk  | 1   |  |
| СР  | 2   |  |
| Workload in Hours                               | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer  | Dr. Marco Ritzkowski, Dr. Joachim Gerth             |  |
| Language  | EN  |  |
| Cycle   | SoSe  |  |
| Content   | See interlocking course                             |  |
| Literature                                      | See interlocking course                             |  |

| Course L0904: Geochemical | Engineering  |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 2  |
| СР                        | 2  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                  | Dr. Joachim Gerth  |
| Language                  | EN   |
| Cycle                     | SoSe   |
|                           | As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment. |
| Literature                | Geochemistry, groundwater and pollution. C. A. J. Appelo; D. Postma Leiden [u.a.] Balkema 2005 Lehrbuchsammlung der TUB, Signatur GWC-515  |

| Module M0870: Mana                   | gement of Surface Water   |  |                 |                       |
|--------------------------------------|---|--|-----------------|-----------------------|
| Courses                              |   |  |                 |                       |
| Title                                |   | Тур  | Hrs/wk          | СР                    |
| Modelling of Flow in Rivers and Estu | uaries (L0810)  | Lecture                                    | 3               | 4                     |
| Nature-Oriented Hydraulic Engineer   | ring / Integrated Flood Protection (L0961)  | Project-/problem-based Learning            | 2               | 2                     |
| Module Responsible                   | Prof. Peter Fröhle  |  |                 |                       |
| Admission Requirements               | None  |  |                 |                       |
| Recommended Previous                 | Fundamentals of Hydromechanics, Hydraulics, Hydro   | ogy and Hydraulic Engineering; Hydra       | ulic Engineer   | ing I and Hydraulic   |
| Knowledge                            | Engineering II  |  |                 |                       |
| <b>Educational Objectives</b>        | After taking part successfully, students have reached th  | e following learning results               |                 |                       |
| Professional Competence              |   |  |                 |                       |
| Knowledge                            | Students are able to define in detail the basic proces  | sses that are related to the modelling     | of flows in hy  | draulic engineering.  |
|                                      | Besides, they can describe the basic aspects of numer   | cal modelling and actual numerical mod     | els for the sin | nulation of flows and |
|                                      | waves. They can also depict the concepts of nature orie   | nted hydraulic engineering.                |                 |                       |
| Skille                               | Students are able to apply bydrodynamic numerical me  | dals to practical budraulic angineering to | sks Eurthorm    | ore the students are  |
| SKIIIS                               | Students are able to apply hydrodynamic-numerical mo<br>able to set up flood-risk management concepts and are |  |                 |                       |
|                                      | able to set up 11000-113k management concepts and are   | able to apply basic concepts of reflaction | lon to practice | ai problems.          |
| Personal Competence                  |   |  |                 |                       |
| Social Competence                    | The students are able to deploy their gained knowledg   | e in applied problems of the practical na  | ture-based hy   | draulic engineering.  |
|                                      | Additionaly, they will be able to work in team with engir   | neers of other disciplines.                |                 |                       |
| Autonomy                             | The students will be able to independently extend their   | knowledge and apply it to new problems     |                 |                       |
| Workload in Hours                    | Independent Study Time 110, Study Time in Lecture 70  |  |                 |                       |
| Credit points                        | 6   |  |                 |                       |
| Course achievement                   | None  |  |                 |                       |
| Examination                          | Written exam  |  |                 |                       |
| Examination duration and             | The duration of the examination is 150 min. The exam  | mination includes tasks with respect to    | the general ι   | inderstanding of the  |
| scale                                | lecture contents and calculations tasks.  |  |                 |                       |
| Assignment for the                   | Civil Engineering: Specialisation Water and Traffic: Com  | pulsory                                    |                 |                       |
| Following Curricula                  | Environmental Engineering: Core Qualification: Elective   | Compulsory                                 |                 |                       |
|                                      | Joint European Master in Environmental Studies - Cities   | and Sustainability: Core Qualification: Co | mpulsory        |                       |
|                                      | Water and Environmental Engineering: Specialisation W   | ater: Compulsory                           |                 |                       |
|                                      | Water and Environmental Engineering: Specialisation Er  | vironment: Compulsory                      |                 |                       |
|                                      | Water and Environmental Engineering: Specialisation Ci  | ties: Elective Compulsory                  |                 |                       |

| Course L0810: Modelling of F | Course L0810: Modelling of Flow in Rivers and Estuaries |  |
|------------------------------|---|--|
| Тур                          | Lecture   |  |
| Hrs/wk                       | 3   |  |
| СР                           | 4   |  |
| Workload in Hours            | Independent Study Time 78, Study Time in Lecture 42     |  |
| Lecturer                     | Dr. Edgar Nehlsen, Prof. Peter Fröhle                   |  |
| Language                     | DE/EN   |  |
| Cycle                        | SoSe  |  |
|                              | Basics of numerial models / application of models       |  |
|                              |   |  |
| Literature                   | Vorlesungsskript  |  |

| Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection |   |  |
|---|---|--|
| Тур   | Project-/problem-based Learning   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer  | Dr. Natasa Manojlovic, Prof. Peter Fröhle   |  |
| Language  | DE/EN   |  |
| Cycle   | SoSe  |  |
| Content   | <ul> <li>Regime-Theory and application for the development of environmental guiding priciples of rivers</li> <li>Engineering - biological measures for the stabilization of rivers</li> <li>Risk management in flood protection</li> <li>Design techniques in technical flood protection</li> <li>Methods for the assessment of flood caused damages</li> </ul> |  |
| Literature  | Vorlesungsumdruck   |  |

| <u> </u>                                |  |   |                 |                       |
|---|--|---|-----------------|-----------------------|
| Module M0871: Hydro                     | ological Systems   |   |                 |                       |
|   |  |   |                 |                       |
| Courses                                 |  |   |                 |                       |
| Title                                   |  | Тур   | Hrs/wk          | СР                    |
| Applied Surface Hydrology (L0289)       |  | Lecture   | 2               | 2                     |
| Applied Surface Hydrology (L1412)       |  | Project-/problem-based Learning   | 1               | 2                     |
| Interaction Water - Environment in      | Fluvial Areas (L0295)  | Project-/problem-based Learning   | 1               | 2                     |
| Module Responsible                      | Prof. Peter Fröhle   |   |                 |                       |
| Admission Requirements                  | None   |   |                 |                       |
| <b>Recommended Previous</b>             | Fundamentals of Hydromechanics and Hydrau                                | lic Engineering: Hydraulic Engineering I and Hydra  | ulic Engineeri  | ng II                 |
| Knowledge                               |  |   |                 |                       |
| <b>Educational Objectives</b>           | After taking part successfully, students have re                         | eached the following learning results   |                 |                       |
| Professional Competence                 |  |   |                 |                       |
| Knowledge                               | The students are able to define the basic con                            | cepts of hydrology and water management. They   | are able to o   | lescribe and quantify |
|   | the relevant processes of the hydrological wat                           | ter cycle. Besides, the students know the main as   | pects of rainfa | ll-run-off-models and |
|   | are able to theoretically derive established res                         | servoir / storage models and a unit-hydrograph.   |                 |                       |
|   |  |   |                 |                       |
| Skills                                  | · ·  | ological concepts and approaches and are able   |                 | •                     |
|   |  | ph as the basis for rainfall-run-off-models. The st   |                 |                       |
|   |  | d hydrodynamic values in nature and are able to   | •               |                       |
|   | assess these measurements. Furthermore, the                              | ey are able to apply a hydrological model to basic  | hydrological p  | roblems.              |
| Personal Competence                     |  |   |                 |                       |
| •                                       | The students are able to deploy their gained k                           | nowledge in applied problems of the hydrology ar  | nd water mana   | gement. Additionaly.  |
| , | they will be able to work in team with enginee                           |   |                 | ,                     |
| Autonomy                                | ,  | end their knowledge and apply it to new problems  |                 |                       |
|   |  |   |                 |                       |
| Workload in Hours                       | Independent Study Time 124, Study Time in Le                             | ecture 56   |                 |                       |
| Credit points                           | 6  |   |                 |                       |
| Course achievement                      | None   |   |                 |                       |
| Examination                             | Written exam   |   |                 |                       |
| Examination duration and                | The duration of the examination is 90 min. The                           | The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lectur |                 |                       |
| scale                                   | contents and calculations tasks.   |   |                 |                       |
| Assignment for the                      | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory |   |                 |                       |
| Following Curricula                     | Environmental Engineering: Core Qualification: Elective Compulsory       |   |                 |                       |
|   | Joint European Master in Environmental Studie                            | es - Cities and Sustainability: Core Qualification: Co  | mpulsory        |                       |
|   | Water and Environmental Engineering: Special                             | lisation Water: Elective Compulsory   |                 |                       |
|   | Water and Environmental Engineering: Special                             | lisation Environment: Elective Compulsory   |                 |                       |
|   | Water and Environmental Engineering: Special                             | lisation Cities: Elective Compulsory  |                 |                       |

| Course L0289: Applied Surface Hydrology |   |  |
|---|---|--|
| Тур                                     | Lecture   |  |
| Hrs/wk                                  | 2   |  |
| СР                                      | 2   |  |
| Workload in Hours                       | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer                                | Prof. Peter Fröhle  |  |
| Language                                | DE/EN   |  |
| Cycle                                   | SoSe  |  |
| Content                                 | Basics of hydrology:  |  |
|   | <ul> <li>Hydrological cycle</li> <li>Data acquisition</li> <li>Data analyses and statistical assessment</li> <li>Statistics of extremes</li> <li>Regionalization methods for hydrological values</li> <li>Rainfall-run-off modelling on the basis of a unit hydrograph conceps</li> <li>Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul> |  |
| Literature                              | http://de.wikipedia.org/wiki/Kalypso_(Software)   |  |
|   | http://kalypso.bjoernsen.de/  |  |
|   | http://sourceforge.net/projects/kalypso/  |  |
|   |   |  |

| Course L1412: Applied Surface Hydrology |   |
|---|---|
| Тур                                     | Project-/problem-based Learning                     |
| Hrs/wk                                  | 1   |
| СР                                      | 2   |
| Workload in Hours                       | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                | Prof. Peter Fröhle                                  |
| Language                                | DE/EN   |
| Cycle                                   | SoSe  |
| Content                                 | See interlocking course                             |
| Literature                              | See interlocking course                             |

| Course L0295: Interaction Water - Environment in Fluvial Areas |  |  |
|--|--|--|
| Тур  | Project-/problem-based Learning  |  |
| Hrs/wk   | 1  |  |
| СР   | 2  |  |
| Workload in Hours  | Independent Study Time 46, Study Time in Lecture 14  |  |
| Lecturer   | Prof. Peter Fröhle   |  |
| Language   | DE/EN  |  |
| Cycle  | SoSe   |  |
| Content  | A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester. |  |
| Literature   | -  |  |

| Module M0874: Waste   | ewater Systems  |                                      |                   |                        |
|---|---|--------------------------------------|-------------------|------------------------|
| Courses   |   |                                      |                   |                        |
| Title   |   | Тур                                  | Hrs/wk            | СР                     |
| Wastewater Systems - Collection, Treatment and Reuse (L0934)  |   | Lecture                              | 2                 | 2                      |
| Wastewater Systems - Collection, Treatment and Reuse (L0934) Wastewater Systems - Collection, Treatment and Reuse (L0943) |   | Recitation Section (large)           | 1                 | 1                      |
| Advanced Wastewater Treatment (   | L0357)  | Lecture                              | 2                 | 2                      |
| Advanced Wastewater Treatment (   | L0358)  | Recitation Section (large)           | 1                 | 1                      |
| Module Responsible  | Prof. Ralf Otterpohl  |                                      |                   |                        |
| Admission Requirements  | None  |                                      |                   |                        |
| Recommended Previous  | Knowledge of wastewater management and the key pro-   | cesses involved in wastewater treatm | ent.              |                        |
| Knowledge   |   |                                      |                   |                        |
| Educational Objectives  | After taking part successfully, students have reached the   | e following learning results         |                   |                        |
| Professional Competence   |   |                                      |                   |                        |
| Knowledge   | Students are able to outline key areas of the full range  | of treatment systems in waste water  | management, as    | well as their mutual   |
|   | dependence for sustainable water protection. They can $\boldsymbol{\alpha}$                                 | describe relevant economic, environm | nental and social | factors.               |
| Skille  | Students are able to pre-design and explain the availab   | ale wastewater treatment processes   | and the scene of  | f their application in |
| SKIIIS  | Students are able to pre-design and explain the availal municipal and for some industrial treatment plants. | ole wastewater treatment processes   | and the scope of  | п спен аррисаціон пі   |
|   | municipal and for some industrial treatment plants.   |                                      |                   |                        |
| Personal Competence   |   |                                      |                   |                        |
| Social Competence   | Social skills are not targeted in this module.  |                                      |                   |                        |
| Autonomy  | Students are in a position to work an a subject and t   | n organize their work flow independ  | onthy They can    | alsa prosent on this   |
| Autonomy  | Students are in a position to work on a subject and to subject.   | o organize their work now independ   | entry. They can   | also present on this   |
|   | subject.  |                                      |                   |                        |
| Workload in Hours   | Independent Study Time 96, Study Time in Lecture 84   |                                      |                   |                        |
| Credit points   | 6   |                                      |                   |                        |
| Course achievement  | None  |                                      |                   |                        |
| Examination   | Written exam  |                                      |                   |                        |
| Examination duration and  | 120 min   |                                      |                   |                        |
| scale   |   |                                      |                   |                        |
| Assignment for the  | Civil Engineering: Specialisation Structural Engineering:   | Elective Compulsory                  |                   |                        |
| Following Curricula   | Civil Engineering: Specialisation Geotechnical Engineering  | ng: Elective Compulsory              |                   |                        |
|   | Civil Engineering: Specialisation Coastal Engineering: Ele  | ective Compulsory                    |                   |                        |
|   | Civil Engineering: Specialisation Water and Traffic: Comp   | pulsory                              |                   |                        |
|   | Bioprocess Engineering: Specialisation A - General Biopro   |                                      | -                 |                        |
|   | Energy and Environmental Engineering: Specialisation E  | • •                                  | ompulsory         |                        |
|   | Environmental Engineering: Specialisation Water: Electiv  |                                      |                   |                        |
|   | International Management and Engineering: Specialisation  |                                      |                   |                        |
|   | International Management and Engineering: Specialisation  | • •                                  | nnology: Elective | Compulsory             |
|   | Process Engineering: Specialisation Environmental Proce   |                                      |                   |                        |
|   | Process Engineering: Specialisation Process Engineering   |                                      |                   |                        |
|   | Water and Environmental Engineering: Specialisation Water and Environmental Engineering: Specialisation En  | , ,                                  |                   |                        |
|   | Water and Environmental Engineering: Specialisation En  |                                      |                   |                        |
|   | Water and Environmental Engineering: Specialisation Cit   | ies. Compuisory                      |                   |                        |

| Course L0934: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|--|--|--|
| Тур  | Lecture  |  |
| Hrs/wk   | 2  |  |
| СР   | 2  |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer   | Prof. Ralf Otterpohl   |  |
| Language   | EN   |  |
| Cycle  | SoSe   |  |
| Content  | •Understanding the global situation with water and wastewater  |  |
|  | *Regional planning and decentralised systems   |  |
|  | Overview on innovative approaches  |  |
|  | •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse |  |
|  | Mathematical Modelling of Nitrogen Removal   |  |
|  | •Exercises with calculations and design  |  |
| Literature   | Henze, Mogens:   |  |
|  | Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages                                |  |
|  | George Tchobanoglous, Franklin L. Burton, H. David Stensel:  |  |
|  | Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy  |  |
|  | McGraw-Hill, 2004 - 1819 pages   |  |

| Course L0943: Wastewater S | urse L0943: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|----------------------------|--|--|--|
| Тур                        | Recitation Section (large)                                       |  |  |
| Hrs/wk                     | 1  |  |  |
| СР                         | 1  |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14              |  |  |
| Lecturer                   | Prof. Ralf Otterpohl   |  |  |
| Language                   | EN   |  |  |
| Cycle                      | SoSe   |  |  |
| Content                    | See interlocking course  |  |  |
| Literature                 | See interlocking course  |  |  |

| Course L0357: Advanced Wa | stewater Treatment   |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 2  |
| СР                        | 2  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                  | Dr. Joachim Behrendt   |
| Language                  | EN   |
| Cycle                     | SoSe   |
| Content                   | Survey on advanced wastewater treatment  |
|                           | reuse of reclaimed municipal wastewater  |
|                           | Precipitation  |
|                           | Flocculation   |
|                           | Depth filtration   |
|                           | Membrane Processes   |
|                           | Activated carbon adsorption  |
|                           | Ozonation  |
|                           | "Advanced Oxidation Processes"   |
|                           | Disinfection   |
| Literature                | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003  |
|                           | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987   |
|                           | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007   |
|                           | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |
|                           | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003   |

| Course L0358: Advanced Wa | stewater Treatment   |
|---------------------------|--|
| Тур                       | Recitation Section (large)   |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Dr. Joachim Behrendt   |
| Language                  | EN   |
| Cycle                     | SoSe   |
| Content                   | Aggregate organic compounds (sum parameters)   |
|                           | Industrial wastewater  |
|                           | Processes for industrial wastewater treatment  |
|                           | Precipitation  |
|                           | Flocculation   |
|                           | Activated carbon adsorption  |
|                           | Recalcitrant organic compounds   |
|                           |  |
| Literature                | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003  |
|                           | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987   |
|                           | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007   |
|                           | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |
|                           | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003   |

| Module M0875: Nexus   | s Engineering - Water, Soil, Food and                                  | d Energy                            |                            |                      |
|---|--|-------------------------------------|----------------------------|----------------------|
| Courses   |  |                                     |                            |                      |
| Title   |  | Тур                                 | Hrs/wk                     | СР                   |
| Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229) |  | Seminar                             | 2                          | 2                    |
| Water & Wastewater Systems in a                                     | Global Context (L0939)   | Lecture                             | 2                          | 4                    |
| Module Responsible  | Prof. Ralf Otterpohl   |                                     |                            |                      |
| Admission Requirements  | None   |                                     |                            |                      |
| Recommended Previous  | Basic knowledge of the global situation with rising                    | poverty, soil degradation, migra    | ation to cities, lack of w | vater resources and  |
| Knowledge   | sanitation   |                                     |                            |                      |
| Educational Objectives  | After taking part successfully, students have reached                  | the following learning results      |                            |                      |
| Professional Competence   |  |                                     |                            |                      |
| Knowledge   | Students can describe the facets of the global water s                 | situation. Students can judge the   | enormous potential of th   | e implementation of  |
|   | synergistic systems in Water, Soil, Food and Energy s                  | upply.                              |                            |                      |
| Ckilla  | Students are able to design espleaied settlements f                    | or different apparanhis and socie   | a acanomic conditions fo   | ur the main climates |
| SKIIIS  | Students are able to design ecological settlements f around the world. | or different geographic and socio   | p-economic conditions to   | or the main climates |
|   | around the world.  |                                     |                            |                      |
| Personal Competence   |  |                                     |                            |                      |
| Social Competence   | The students are able to develop a specific topic in a                 | team and to work out milestones     | according to a given pla   | n.                   |
| Autonomy  | Students are in a position to work on a subject and                    | d to organize their work flow in    | dependently. They can a    | also present on this |
| Autonomy  | subject.   | a to organize their work now inc    | dependently. They can a    | also present on this |
|   | subject.   |                                     |                            |                      |
| Workload in Hours   | Independent Study Time 124, Study Time in Lecture                      | 56                                  |                            |                      |
| Credit points   | 6  |                                     |                            |                      |
| Course achievement  | None   |                                     |                            |                      |
| Examination   | Subject theoretical and practical work                                 |                                     |                            |                      |
| Examination duration and  | During the course of the semester, the students wor                    | k towards mile stones. The work     | includes presentations a   | and papers. Detailed |
| scale   | information can be found at the beginning of the sme                   | ster in the StudIP course module    | handbook.                  |                      |
| Assignment for the  | Civil Engineering: Specialisation Water and Traffic: Ele               | ective Compulsory                   |                            |                      |
| Following Curricula   | Bioprocess Engineering: Specialisation A - General Bio                 | oprocess Engineering: Elective Co   | mpulsory                   |                      |
|   | Chemical and Bioprocess Engineering: Specialisation                    | General Process Engineering: Ele    | ctive Compulsory           |                      |
|   | Environmental Engineering: Core Qualification: Elective                | ve Compulsory                       |                            |                      |
|   | Joint European Master in Environmental Studies - Citie                 | es and Sustainability: Core Qualifi | cation: Compulsory         |                      |
|   | Process Engineering: Specialisation Environmental Process              |                                     | oulsory                    |                      |
|   | Process Engineering: Specialisation Process Engineering                | ng: Elective Compulsory             |                            |                      |
|   | Water and Environmental Engineering: Specialisation                    | Water: Elective Compulsory          |                            |                      |
|   | Water and Environmental Engineering: Specialisation                    |                                     | ry                         |                      |
|   | Water and Environmental Engineering: Specialisation                    | Cities: Elective Compulsory         |                            |                      |

| Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus |  |  |
|---|--|--|
| Тур   | Seminar  |  |
| Hrs/wk  | 2  |  |
| СР  | 2  |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer  | Prof. Ralf Otterpohl   |  |
| Language  | EN   |  |
| Cycle   | SoSe   |  |
| Content   | <ul> <li>Participants Workshop: Design of the most attractive productive Town</li> <li>Keynote lecture and video</li> <li>The limits of Urbanization / Green Cities</li> <li>The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>Global Ecovillage Network: Upsides and Downsides around the World</li> <li>Visit of an Ecovillage</li> <li>Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion</li> <li>TUHH Rural Development Toolbox</li> <li>Integrated New Town Development</li> <li>Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>Outreach: Participants campaign</li> <li>City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul> |  |
| Literature  | <ul> <li>Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in "Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU</li> </ul>  |  |

|                   | tewater Systems in a Global Context   |
|-------------------|---|
| Тур               | Lecture   |
| Hrs/wk            | 2   |
| СР                | 4   |
| Workload in Hours | Independent Study Time 92, Study Time in Lecture 28   |
| Lecturer          | Prof. Ralf Otterpohl  |
| Language          | EN  |
| Cycle             | SoSe  |
| Content           |   |
| Literature        | <ul> <li>Keynote lecture and video</li> <li>Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>Water and it's utilization, Integrated Urban Water Management</li> <li>Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>Rehearsal session, Q&amp;A</li> </ul> |
| Literature        | <ul> <li>Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>  |

| Module M0922: City F                     | Planning   |
|--|--|
| Courses                                  |  |
| Γitle                                    | Typ Hrs/wk CP  |
| City Planning (L1066)                    | Project-/problem-based Learning 4 6  |
| Module Responsible                       | Prof. Carsten Gertz  |
| Admission Requirements                   | None   |
| Recommended Previous                     | for "Principles of Urban Planning": none   |
| Knowledge                                | for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class "Trans Planning and Traffic Engineering"   |
| <b>Educational Objectives</b>            | After taking part successfully, students have reached the following learning results   |
| <b>Professional Competence</b>           |  |
| Knowledge                                | Students are able to:  |
|  | use technical terms of urban planning.   |
|  | describe the main determinants of urban development.   |
|  | explain and compare different possibilities of how urban development can be influenced.  |
|  | discuss requirements for public streetscapes.  |
|  | explain the importance of street design.   |
| Skills                                   | Students are able to:  |
|  | read and analyze urban development concepts and designs for streetscapes   |
|  | appraise such concepts in the context of competing requirements.   |
|  | design, justify and reflect their own solutions for concrete examples.   |
| Personal Competence<br>Social Competence | Students are able to:  • discuss intermediate results with each other.  • constructively accept feedback on their own work.  • provide constructive feedback to others.  |
| Autonomy                                 | Students are able to:  • independently complete a written report including drawings following a broadly pre-defined process.  • assess the consequences of their proposed solutions.  • independently acquire knowledge and apply this to new issues or problem areas. |
| Workload in Hours                        | Independent Study Time 124, Study Time in Lecture 56   |
| Credit points                            | 6  |
| Course achievement                       | None   |
| Examination                              |  |
| Examination duration and                 | written assignment, designwork during the semester   |
| scale                                    |  |
| Assignment for the                       | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |
| Following Curricula                      | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |
|  | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |
|  | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |
|  | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory  |
|  | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   |
|  | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |
|  | Water and Environmental Engineering: Specialisation Cities: Compulsory   |

| Course L1066: City Planning |   |
|-----------------------------|---|
| Тур                         | Project-/problem-based Learning   |
| Hrs/wk                      | 4   |
| СР                          | 6   |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56  |
| Lecturer                    | Prof. Carsten Gertz   |
| Language                    | DE  |
| Cycle                       | SoSe  |
| Content                     | "Principles of Urban Planning" deals with the determinants of urban development and their interactions. Topics include:   |
|                             | <ul> <li>legal framework,</li> <li>instruments and methods of planning,</li> <li>functional requirements,</li> <li>stakeholders and actors</li> <li>basic design requirements</li> <li>different planning levels and</li> <li>historical contexts.</li> </ul> The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign. |
| Literature                  | Albers, Gerd; Wekel, Julian (2009) Stadtplanung: Eine illustrierte Einführung. Primus Verlag. Darmstadt.  Frick, Dieter (2008) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. Wasmuth-Verlag. Tübingen  Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen  Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.   |

| Module M0982: Trans              | portation Modelling  |
|----------------------------------|--|
| Courses                          |  |
| Title                            | Typ Hrs/wk CP  |
| Transportation Modelling (L1180) | Project-/problem-based Learning 4 6  |
| Module Responsible               | Prof. Carsten Gertz  |
| Admission Requirements           | None   |
| Recommended Previous             | some knowledge of transport planning, e.g. through taking the undergraduate class "Transport Planning and Traffic Engineering"   |
| Knowledge                        |  |
| Educational Objectives           | After taking part successfully, students have reached the following learning results   |
| Professional Competence          |  |
| Knowledge                        | Students are able to understand the operation and potential applications of transport models.  |
| Skills                           | Students are able to:  |
|                                  | <ul> <li>use travel demand modelling software packages for solving practical problems.</li> <li>design a database structure for travel demand models.</li> <li>assess modelling results.</li> <li>appraise potential applications and limitations of such models.</li> </ul> |
|                                  | Students are able to independently develop and document solutions.  Students are able to:  independently organise, manage and solve set tasks.  independently prepare written reports.   |
| Workload in Hours                | Independent Study Time 124, Study Time in Lecture 56   |
| Credit points                    | 6  |
| Course achievement               | None   |
| Examination                      | Written elaboration  |
| Examination duration and scale   |  |
| Assignment for the               | Civil Engineering: Specialisation Water and Traffic: Compulsory  |
| Following Curricula              |  |
|                                  | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory  |

| Course L1180: Transportation | n Modelling  |
|------------------------------|--|
| Тур                          | Project-/problem-based Learning  |
| Hrs/wk                       | 4  |
| СР                           | 6  |
| Workload in Hours            | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                     | Prof. Carsten Gertz  |
| Language                     | DE   |
| Cycle                        | SoSe   |
| Content                      | <ul> <li>Principles of transport modelling</li> <li>Role of transport modelling in the planning process</li> <li>Fundamentals of mobility behaviour</li> <li>Design and evaluation of transport/mobility surveys</li> <li>mode of operation and data requirements for different stages of modelling</li> <li>Forecasting and scenarios in the transport planning</li> <li>The range of model applications (from transport infrastructure planning over simulation of traffic flows to integrated landuse and transport models as well as the use of models for evaluating locations)</li> <li>Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use</li> </ul> |
| Literature                   | Lohse, Dieter und Schnabel, Werner (2011): Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung – Band 2. 3. Auflage. Beuth.  Ortúzar, Juan de Dios und Willumsen, Luis G. (2011): Modelling Transport. 4. Auflage. John Wiley & Sons.  |

| Module M0663: Marin                | ne Geotechnics                                 |   |         |    |
|------------------------------------|--|---|---------|----|
|                                    |  |   |         |    |
| Courses                            |  |   |         |    |
| Γitle                              |  | Тур   | Hrs/wk  | СР |
| Marine Geotechnics (L0548)         |  | Lecture                                     | 1       | 2  |
| Marine Geotechnics (L0549)         |  | Recitation Section (large                   |         | 2  |
| Steel Structures in Foundation and |  | Lecture                                     | 2       | 2  |
| Module Responsible                 | , ,  |   |         |    |
| Admission Requirements             | None   |   |         |    |
| Recommended Previous               | complete modules: Geotechnics I-III, Mathen    | natics I-III                                |         |    |
| Knowledge                          | courses: Soil laboratory course                |   |         |    |
| <b>Educational Objectives</b>      | After taking part successfully, students have  | e reached the following learning results    |         |    |
| <b>Professional Competence</b>     |  |   |         |    |
| Knowledge                          |  |   |         |    |
| Skills                             |  |   |         |    |
| Personal Competence                |  |   |         |    |
| Social Competence                  |  |   |         |    |
| Autonomy                           |  |   |         |    |
| Workload in Hours                  | Independent Study Time 110, Study Time in      | Lecture 70                                  |         |    |
| Credit points                      | 6  |   |         |    |
| Course achievement                 | None   |   |         |    |
| Examination                        | Written exam                                   |   |         |    |
| Examination duration and           | 90 min   |   |         |    |
| scale                              |  |   |         |    |
| Assignment for the                 | Civil Engineering: Specialisation Geotechnica  | al Engineering: Compulsory                  |         |    |
| Following Curricula                | Civil Engineering: Specialisation Structural E | Engineering: Elective Compulsory            |         |    |
|                                    | Civil Engineering: Specialisation Coastal Eng  | gineering: Compulsory                       |         |    |
|                                    | Theoretical Mechanical Engineering: Special    | isation Maritime Technology: Elective Comp  | oulsory |    |
|                                    | Theoretical Mechanical Engineering: Technic    | cal Complementary Course: Elective Compu    | Isory   |    |
|                                    | Water and Environmental Engineering: Spec      | cialisation Cities: Elective Compulsory     |         |    |
|                                    | Water and Environmental Engineering: Spec      | cialisation Environment: Elective Compulsor | у       |    |
|                                    | Water and Environmental Engineering: Spec      | cialisation Water: Elective Compulsory      |         |    |

| Course L0548: Marine Geote | chnics   |
|----------------------------|--|
| Тур                        | Lecture  |
| Hrs/wk                     | 1  |
| СР                         | 2  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14  |
| Lecturer                   | Prof. Jürgen Grabe   |
| Language                   | DE   |
| Cycle                      | SoSe   |
| Content                    | <ul> <li>Geotechnical investigation an description of the seabed</li> <li>Foundations of Offshore-Constructions</li> <li>cCliff erosion</li> <li>Sea dikes</li> <li>Port structures</li> <li>Flood protection structures</li> </ul>  |
| Literature                 | <ul> <li>EAK (2002): Empfehlungen für Küstenschutzbauwerke</li> <li>EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke</li> <li>Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst &amp; Sohn, Berlin</li> </ul> |

| Course L0549: Marine Geote | ourse L0549: Marine Geotechnics                     |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)                          |  |  |
| Hrs/wk                     | 2   |  |  |
| СР                         | 2   |  |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28 |  |  |
| Lecturer                   | Prof. Jürgen Grabe                                  |  |  |
| Language                   | DE  |  |  |
| Cycle                      | SoSe  |  |  |
| Content                    | See interlocking course                             |  |  |
| Literature                 | See interlocking course                             |  |  |

## Module Manual M.Sc. "Water and Environmental Engineering"

| Course L1146: Steel Structur | Course L1146: Steel Structures in Foundation and Hydraulic Engineering                                  |  |  |
|------------------------------|---|--|--|
| Тур                          | Lecture   |  |  |
| Hrs/wk                       | 2   |  |  |
| СР                           | 2   |  |  |
| Workload in Hours            | Independent Study Time 32, Study Time in Lecture 28   |  |  |
| Lecturer                     | Frank Feindt  |  |  |
| Language                     | DE  |  |  |
| Cycle                        | SoSe  |  |  |
| Content                      | Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue |  |  |
| Literature                   | EAU 2012, EA-Pfähle, EAB  |  |  |

| Madula M1122, Calas                 | ted Tenies in Environmental Engine  | o win a   |        |    |
|-------------------------------------|---|---|--------|----|
| Module M1125: Selec                 | ted Topics in Environmental Engine  | sering  |        |    |
| Courses                             |   |   |        |    |
| Title                               |   | Тур   | Hrs/wk | СР |
| Environmental Aquatic Chemistry (   | 11444)  | Lecture   | 2      | 3  |
| Excellence in International Project |   | Integrated Lecture  | 2      | 2  |
| Sludge Treatment (L0520)            |   | Lecture   | 2      | 3  |
| Thermal Biomass Utilization (L1767  | ")  | Lecture   | 2      | 2  |
| Thermal Biomass Utilization (L1768  | 3)  | Recitation Section (small)  | 1      | 1  |
| Module Responsible                  | Prof. Mathias Ernst   |   |        |    |
| Admission Requirements              | None  |   |        |    |
| Recommended Previous                |   |   |        |    |
| Knowledge                           |   |   |        |    |
| Educational Objectives              | After taking part successfully, students have reached the following learning results  |   |        |    |
| Professional Competence             |   |   |        |    |
| Knowledge                           |   |   |        |    |
| Skills                              |   |   |        |    |
| Personal Competence                 |   |   |        |    |
| Social Competence                   |   |   |        |    |
| Autonomy                            |   |   |        |    |
| Workload in Hours                   | Depends on choice of courses  |   |        |    |
| Credit points                       | 6   |   |        |    |
| Assignment for the                  | Environmental Engineering: Core Qualification: Elec   | ctive Compulsory  |        |    |
| Following Curricula                 | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory   |   |        |    |
|                                     | Water and Environmental Engineering: Specialisation   | on Environment: Elective Compulsory                                   |        |    |
|                                     | Water and Environmental Engineering: Specialisation   | on Water: Elective Compulsory   |        |    |
| Credit points Assignment for the    | 6 Environmental Engineering: Core Qualification: Elec<br>Water and Environmental Engineering: Specialisati<br>Water and Environmental Engineering: Specialisati | on Cities: Elective Compulsory<br>on Environment: Elective Compulsory |        |    |

| Course L1444: Environmenta | Il Aquatic Chemistry  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28   |
| Examination Form           | Klausur   |
| Examination duration and   | 60 min  |
| scale                      |   |
| Lecturer                   | Dr. Klaus Johannsen   |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | <ul> <li>Concentration and activity</li> <li>Gas-water partitioning</li> <li>Acid/base equilibria</li> <li>Alkalinity and acidity</li> <li>Precipitation/dissolution equilibria</li> <li>Redox equilibria</li> <li>Complex formation</li> <li>Sorption</li> </ul> |
| Literature                 | Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015   |

| Course L2387: Excellence in | Course L2387: Excellence in International Project Delivery |  |
|-----------------------------|--|--|
| Тур                         | Integrated Lecture   |  |
| Hrs/wk                      | 2  |  |
| СР                          | 2  |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28        |  |
| Examination Form            | laut FSPO  |  |
| Examination duration and    | wird zu Beginn der Lehrveranstaltung festgelegt            |  |
| scale                       |  |  |
| Lecturer                    | Dr. Jens Huckfeldt   |  |
| Language                    | EN   |  |
| Cycle                       | SoSe   |  |
| Content                     |  |  |
| Literature                  |  |  |

| Course L0520: Sludge Treatn | nent  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 2   |
| СР                          | 3   |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28                 |
| Examination Form            | Klausur   |
| Examination duration and    | 60 min  |
| scale                       |   |
| Lecturer                    | Dr. Joachim Behrendt  |
| Language                    | EN  |
| Cycle                       | SoSe  |
| Content                     | Sedimentation characteristic and thickening,                        |
|                             | Centrifugation,   |
|                             | Flotation,  |
|                             | Filtration,   |
|                             | Aerobic sludge stabilisation,                                       |
|                             | Sludge Digestion,   |
|                             | Sludge Disintegration,  |
|                             | Sludge Dewatering,  |
|                             | Natural Processes for Sludge Treatment,                             |
|                             | Nutrient Recovery from Sludge,                                      |
|                             | Thermal Processes and Incineration.                                 |
| Literature                  | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)                     |
|                             | Wastewater engineering : treatment and reuse                        |
|                             | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))         |
|                             | Boston [u.a.] : McGraw-Hill, 2003                                   |
|                             | TUB_HH_Katalog  |
|                             | Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes |
|                             | Sludge Treatment and Disposal                                       |
|                             | ISBN 9781843391661  |
|                             | IWA Publishing, 2007  |
|                             |   |

| Course L1767: Thermal Biom |   |  |
|----------------------------|---|--|
| Тур                        | Lecture   |  |
| Hrs/wk                     | 2   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |  |
| Examination Form           | Klausur   |  |
| Examination duration and   | 60 min  |  |
| scale                      |   |  |
| Lecturer                   | Prof. Martin Kaltschmitt  |  |
| Language                   | DE  |  |
| Cycle                      | WiSe  |  |
| Content                    | Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.   |  |
|                            | <ul> <li>Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course</li> <li>Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>Thermo-chemical conversion of solid biofuels</li> </ul>   |  |
|                            | <ul> <li>Basics of thermo-chemical conversion</li> <li>Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use</li> <li>Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning</li> </ul> |  |
|                            | technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material  • Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)  • Bio-chemical conversion of biomass  • Basics of bio-chemical conversion   |  |
| Literature                 | <ul> <li>Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry</li> <li>Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage</li> <li>Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>   |  |
| Literature                 |   |  |

| Course L1768: Thermal Biom | Course L1768: Thermal Biomass Utilization           |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (small)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 1   |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14 |  |
| Examination Form           | Klausur   |  |
| Examination duration and   | 60 min  |  |
| scale                      |   |  |
| Lecturer                   | Prof. Martin Kaltschmitt                            |  |
| Language                   | DE  |  |
| Cycle                      | WiSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| Engineering                        |  |  |        |    |
|------------------------------------|--|--|--------|----|
| Module M1716: Subst                | urface Processes                                       |  |        |    |
|                                    |  |  |        |    |
| Courses                            |  |  |        |    |
| Title                              |  | Тур                                      | Hrs/wk | СР |
| Modeling of Subsurface Processes ( | L2730)   | Lecture                                  | 2      | 2  |
| Modeling of Subsurface Processes ( |  | Recitation Section (small)               | 1      | 1  |
| Modern Techniques for Subsurface   | •  | Lecture                                  | 2      | 2  |
| Modern Techniques for Subsurface   | ·  | Recitation Section (large)               | 1      | 1  |
| Module Responsible                 |  |  |        |    |
| Admission Requirements             | None   |  |        |    |
| Recommended Previous               |  |  |        |    |
| Knowledge                          |  |  |        |    |
| <b>Educational Objectives</b>      | After taking part successfully, students have reache   | ed the following learning results        |        |    |
| <b>Professional Competence</b>     |  |  |        |    |
| Knowledge                          |  |  |        |    |
| Skills                             |  |  |        |    |
| Personal Competence                |  |  |        |    |
| Social Competence                  |  |  |        |    |
| Autonomy                           |  |  |        |    |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84    |  |        |    |
| Credit points                      |  |  |        |    |
| Course achievement                 | None   |  |        |    |
| Examination                        | Written exam   |  |        |    |
| Examination duration and           | 90 min   |  |        |    |
| scale                              |  |  |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Structural Engineer  | ring: Elective Compulsory                |        |    |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engin   | eering: Elective Compulsory              |        |    |
|                                    | Civil Engineering: Specialisation Coastal Engineering  | g: Elective Compulsory                   |        |    |
|                                    | Civil Engineering: Specialisation Water and Traffic: I | Elective Compulsory                      |        |    |
|                                    | Process Engineering: Specialisation Environmental F    | Process Engineering: Elective Compulsory |        |    |
|                                    | Process Engineering: Specialisation Process Engineer   | ering: Elective Compulsory               |        |    |
|                                    | Water and Environmental Engineering: Specialisation    | n Water: Compulsory                      |        |    |
|                                    | Water and Environmental Engineering: Specialisation    | on Environment: Elective Compulsory      |        |    |
|                                    | Water and Environmental Engineering: Specialisation    | on Cities: Elective Compulsory           |        |    |

| Course L2730: Modeling of S | Course L2730: Modeling of Subsurface Processes      |  |
|-----------------------------|---|--|
| Тур                         | Lecture   |  |
| Hrs/wk                      | 2   |  |
| СР                          | 2   |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                    | Sonja Götz  |  |
| Language                    | EN  |  |
| Cycle                       | WiSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Course L2731: Modeling of Subsurface Processes |   |  |
|--|---|--|
| Тур  | Recitation Section (small)                          |  |
| Hrs/wk   | 1   |  |
| СР   | 1   |  |
| Workload in Hours                              | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                                       | Sonja Götz  |  |
| Language                                       | EN  |  |
| Cycle  | WiSe  |  |
| Content  | See interlocking course                             |  |
| Literature                                     | See interlocking course                             |  |

## Module Manual M.Sc. "Water and Environmental Engineering"

| Course L2728: Modern Techniques for Subsurface Solute Transport |   |  |
|---|---|--|
| Тур   | Lecture   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer  | Prof. Nima Shokri                                   |  |
| Language  | EN  |  |
| Cycle   | WiSe  |  |
| Content   |   |  |
| Literature  |   |  |

| Course L2729: Modern Techr | urse L2729: Modern Techniques for Subsurface Solute Transport |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)                                    |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 1   |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14           |  |  |
| Lecturer                   | Hannes Nevermann  |  |  |
| Language                   | EN  |  |  |
| Cycle                      | WiSe  |  |  |
| Content                    | See interlocking course                                       |  |  |
| Literature                 | See interlocking course                                       |  |  |

| Module M1720: Emer                   | ging Trends in Environmental E                  | ngineering                             |        |    |
|--------------------------------------|---|--|--------|----|
| Courses                              |   |  |        |    |
| Title                                |   | Тур                                    | Hrs/wk | СР |
| Microplastics in Environment (L2750) |   | Integrated Lecture                     | 2      | 2  |
| Research Methods for Energy-Wate     | r-Soil-Climate Nexus (L2751)                    | Lecture                                | 1      | 2  |
| Research Trends in Energy-Water-S    | oil-Climate Nexus (L2752)                       | Seminar                                | 2      | 2  |
| Module Responsible                   | Prof. Nima Shokri                               |  |        |    |
| Admission Requirements               | None  |  |        |    |
| <b>Recommended Previous</b>          |   |  |        |    |
| Knowledge                            |   |  |        |    |
| <b>Educational Objectives</b>        | After taking part successfully, students have r | reached the following learning results |        |    |
| <b>Professional Competence</b>       |   |  |        |    |
| Knowledge                            |   |  |        |    |
| Skills                               |   |  |        |    |
| Personal Competence                  |   |  |        |    |
| Social Competence                    |   |  |        |    |
| Autonomy                             |   |  |        |    |
| Workload in Hours                    | Independent Study Time 110, Study Time in L     | ecture 70                              |        |    |
| Credit points                        | 6   |  |        |    |
| Course achievement                   | None  |  |        |    |
| Examination                          | Written elaboration                             |  |        |    |
| Examination duration and             | Report (about 5-10 pages) and Presentation (a   | about 15 min)                          |        |    |
| scale                                |   |  |        |    |
| Assignment for the                   | Civil Engineering: Specialisation Water and Tr  | affic: Elective Compulsory             |        |    |
| Following Curricula                  | Environmental Engineering: Specialisation Wa    | ter: Elective Compulsory               |        |    |
|                                      | Environmental Engineering: Specialisation Wa    | ste and Energy: Elective Compulsory    |        |    |
|                                      | Environmental Engineering: Specialisation Bio   | technology: Elective Compulsory        |        |    |
|                                      | Water and Environmental Engineering: Specia     | lisation Cities: Elective Compulsory   |        |    |
|                                      | Water and Environmental Engineering: Specia     |  |        |    |
|                                      | Water and Environmental Engineering: Specia     | lisation Water: Elective Compulsory    |        |    |

| Course L2750: Microplastics in Environment          |  |  |
|---|--|--|
| Integrated Lecture                                  |  |  |
| 2   |  |  |
| 2   |  |  |
| Independent Study Time 32, Study Time in Lecture 28 |  |  |
| Prof. Nima Shokri                                   |  |  |
| EN  |  |  |
| WiSe  |  |  |
|   |  |  |
|   |  |  |
|   |  |  |

| Course L2751: Research Met | urse L2751: Research Methods for Energy-Water-Soil-Climate Nexus |  |  |
|----------------------------|--|--|--|
| Тур                        | Lecture  |  |  |
| Hrs/wk                     | 1  |  |  |
| СР                         | 2  |  |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14              |  |  |
| Lecturer                   | Prof. Nima Shokri  |  |  |
| Language                   | EN   |  |  |
| Cycle                      | WiSe   |  |  |
| Content                    |  |  |  |
| Literature                 |  |  |  |

| Course L2752: Research Trends in Energy-Water-Soil-Climate Nexus |   |  |
|--|---|--|
| Тур  | Seminar   |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer   | Dr. Salome Shokri-Kuehni                            |  |
| Language   | EN  |  |
| Cycle  | WiSe  |  |
| Content  |   |  |
| Literature   |   |  |

| Engineering"                    |  |  |                       |                     |
|---------------------------------|--|--|-----------------------|---------------------|
| Module M0581: Wate              | r Protection   |  |                       |                     |
| Courses                         |  |  |                       |                     |
| Title                           |  | Тур  | Hrs/wk                | СР                  |
| Water Protection and Wastewater | Management (L0226)   | Lecture                                    | 3                     | 3                   |
| Water Protection and Wastewater | Management (L2008)   | Project Seminar                            | 3                     | 3                   |
| Module Responsible              | Prof. Ralf Otterpohl   |  |                       |                     |
| Admission Requirements          | None   |  |                       |                     |
| Recommended Previous            | - Pacia knowledge in water management.   |  |                       |                     |
| Knowledge                       | Basic knowledge in water management;      Cood knowledge in urban drainage.  |  |                       |                     |
|                                 | <ul> <li>Good knowledge in urban drainage;</li> <li>Good knowledge of wastewater treatment</li> </ul>                                | t tachniques:                              |                       |                     |
|                                 | Good knowledge of pollutants (e.g. COD, l  | •  |                       |                     |
|                                 | Good knowledge of pollutarits (e.g. COD,   | BOD, 13, N, F) and their properties,       |                       |                     |
| <b>Educational Objectives</b>   | After taking part successfully, students have rea  | ched the following learning results        |                       |                     |
| <b>Professional Competence</b>  |  |  |                       |                     |
| Knowledge                       | The students can describe the basic principles o   | f the regulatory framework related to the  | international and Eu  | ropean water secto  |
|                                 | They can explain limnological processes, subs  | tance cycles and water morphology in       | detail. They are able | e to assess compl   |
|                                 | problems related to water protection, such as  | ecosystem service and wastewater trea      | tment with a special  | focus on innovati   |
|                                 | solutions, remediation measures as well as conc  | eptual approaches.                         |                       |                     |
| Cleilla                         | Students on accurately access surrent problems   | as and situations in a sountry specific or | local contact Though  | an cuasact concr    |
| SKIIIS                          | Students can accurately assess current problem   |  |                       |                     |
|                                 | actions to contribute to the planning of tomor<br>administrative and legislative solutions to solve                                  |  | they can suggest ap   | opropriate technica |
|                                 | administrative and legislative solutions to solve  | triese problems.                           |                       |                     |
|                                 | The students can work together in international  Students are able to organize their work flow to by making enquiries independently. |  | They can acquire ap   | propriate knowled   |
| Workload in Hours               | Independent Study Time 96, Study Time in Lectu   | ure 84                                     |                       |                     |
| Credit points                   | 6  |  |                       |                     |
| Course achievement              | None   |  |                       |                     |
| Examination                     | Presentation   |  |                       |                     |
| Examination duration and        | Term paper plus presentation   |  |                       |                     |
| scale                           |  |  |                       |                     |
|                                 |  |  |                       |                     |
| Assignment for the              |  | , ,  |                       |                     |
| Following Curricula             |  |  |                       |                     |
|                                 | Civil Engineering: Specialisation Coastal Enginee  |  |                       |                     |
|                                 | Civil Engineering: Specialisation Water and Traff  |  |                       |                     |
|                                 | Environmental Engineering: Specialisation Water  | , ,  |                       |                     |
|                                 | International Management and Engineering: Spe  | • •  |                       |                     |
|                                 | Joint European Master in Environmental Studies   | • •  | Water: Elective Comp  | oulsory             |
|                                 | Water and Environmental Engineering: Specialis   | • •  |                       |                     |
|                                 | Water and Environmental Engineering: Specialis   | , ,  |                       |                     |
|                                 | Water and Environmental Engineering: Specialis   | ation Environment: Compulsory              |                       |                     |

| Course L0226: Water Protect | tion and Wastewater Management  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 3   |
| СР                          | 3   |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     | The lecture focusses on:  Regulatory Framework (e.g. WFD)  Main instruments for the water management and protection  In depth knowledge of relevant measures of water pollution control  Urban drainage, treatment options in different regions on the world  Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration  Case Studies and Field Trips   |
| Literature                  | <ul> <li>The literature listed below is available in the library of the TUHH.</li> <li>Water and wastewater technology Hammer, M. J. 1., &amp; . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.</li> <li>Water and wastewater engineering: design principles and practice: Davis, M. L. 1. (2011). New York, NY: McGraw-Hill.</li> <li>Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.</li> </ul> |

| Course L2008: Water Protect | urse L2008: Water Protection and Wastewater Management |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project Seminar  |  |  |
| Hrs/wk                      | 3  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42    |  |  |
| Lecturer                    | Prof. Ralf Otterpohl                                   |  |  |
| Language                    | EN   |  |  |
| Cycle                       | WiSe   |  |  |
| Content                     |  |  |  |
| Literature                  |  |  |  |

| Waste and Environmental Chemistry (L0328) Practical Course 2 Biological Waste Treatment (L0318) Project-/problem-based Learning 3  Module Responsible Prof. Kerstin Kuchta  Admission Requirements None  | rs/wk   | СР                |
|--|---|-------------------|
| Title Typ Hrs Waste and Environmental Chemistry (L0328) Practical Course 2 Biological Waste Treatment (L0318) Prof. Kerstin Kuchta  Module Responsible Prof. Kerstin Kuchta  Admission Requirements None   | rs/wk   | СР                |
| Waste and Environmental Chemistry (L0328) Practical Course 2 Biological Waste Treatment (L0318) Project-/problem-based Learning 3  Module Responsible Prof. Kerstin Kuchta  Admission Requirements None  | rs/wĸ   | CP                |
| Biological Waste Treatment (L0318)  Module Responsible Prof. Kerstin Kuchta  Admission Requirements None   |   |                   |
| Module Responsible Prof. Kerstin Kuchta  Admission Requirements None   |   | 2                 |
| Admission Requirements None  |   |                   |
|  |   |                   |
| Recommended Previous   chemical and biological basics  |   |                   |
| Knowledge  |   |                   |
| Educational Objectives   |   |                   |
| Professional Competence  |   |                   |
| Knowledge  The module aims possess knowledge concerning the planning of biological waste treatment plants. St design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techni plants for biological waste treatment plants and explain different methods for waste analytics.   |   |                   |
|  | The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quali control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der modu and plan additional tests. They are capable of reflecting and evaluating findings in the group. |                   |
| Personal Competence  Social Competence  Students can participate in subject-specific and interdisciplinary discussions, develop cooperated so work results in front of others and promote the scientific development in front of colleagues. Further accept professional constructive criticism.   |   |                   |
| Autonomy  Students can independently tap knowledge from literature, business or test reports and transform it are capable, in consultation with supervisors as well as in the interim presentation, to assess their leasteps on this basis. Furthermore, they can define targets for new application-or research-oriented opotential social, economic and cultural impact. | earning leve  | el and define fur |
| Workload in Hours Independent Study Time 110, Study Time in Lecture 70   |   |                   |
| Credit points 6  |   |                   |
| Course achievement Yes None Subject theoretical and practical work   |   |                   |
| Examination Presentation   |   |                   |
| Examination duration and Scale Elaboration and Presentation (15-25 minutes in groups)  |   |                   |
|  |   |                   |
| Assignment for the Civil Engineering: Specialisation Structural Engineering: Elective Compulsory   |   |                   |
| Following Curricula Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |   |                   |
| Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |   |                   |
| Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |   |                   |
| Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulso  | ory   |                   |
| Environmental Engineering: Core Qualification: Compulsory  |   |                   |
|  |   |                   |
| International Management and Engineering: Specialisation II. Energy and Environmental Engineering:   | setimo Comer  | oulsory           |
| Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elec  | ective Comp   | ,                 |
|  | ective Comp   |                   |

| Course L0328: Waste and Environmental Chemistry |   |  |  |
|---|---|--|--|
| Тур   | Practical Course  |  |  |
| Hrs/wk  | 2   |  |  |
| СР  | 2   |  |  |
| Workload in Hours                               | Independent Study Time 32, Study Time in Lecture 28   |  |  |
| Lecturer  | Prof. Kerstin Kuchta  |  |  |
| Language  | DE/EN   |  |  |
| Cycle   | WiSe  |  |  |
| Content   | The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used  |  |  |
|   | basis for discussing the results and to evaluate the performance of the group and the individual student.                   |  |  |
|   | In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results |  |  |
|   | evaluation.   |  |  |
|   |   |  |  |
|   | Experiments ar e.g.   |  |  |
|   | Screening and particle size determination   |  |  |
|   | Fos/Tac   |  |  |
|   | AAS   |  |  |
|   | Chalorific value  |  |  |
| Literature                                      | Scripte   |  |  |

| Course L0318: Biological Wa | ste Treatment   |
|-----------------------------|---|
| Тур                         | Project-/problem-based Learning   |
| Hrs/wk                      | 3   |
| СР                          | 4   |
| Workload in Hours           | Independent Study Time 78, Study Time in Lecture 42   |
| Lecturer                    | Prof. Kerstin Kuchta  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     | <ol> <li>Introduction</li> <li>biological basics</li> <li>determination process specific material characterization</li> <li>aerobic degradation ( Composting, stabilization)</li> <li>anaerobic degradation (Biogas production, fermentation)</li> <li>Technical layout and process design</li> <li>Flue gas treatment</li> <li>Plant design practical phase</li> </ol> |
| Literature                  |   |

| Module M0620: Speci              | al Aspects of Wast  | te Resource Ma          | anagement           |                                    |                     |                     |
|----------------------------------|---|-------------------------|---------------------|------------------------------------|---------------------|---------------------|
| Courses                          |   |                         |                     |                                    |                     |                     |
| Title                            |   |                         | Тур                 | Hrs/wk                             | СР                  |                     |
| Advanced Topics in Waste Resourc | e Management (L1055)  |                         |                     | Project-/problem-based Learning    | 3                   | 3                   |
| International Waste Management ( | .0317)  |                         |                     | Project-/problem-based Learning    | 2                   | 3                   |
| Module Responsible               | Prof. Kerstin Kuchta  |                         |                     |                                    |                     |                     |
| Admission Requirements           | None  |                         |                     |                                    |                     |                     |
| <b>Recommended Previous</b>      | basics in waste treatment   | technologies            |                     |                                    |                     |                     |
| Knowledge                        |   |                         |                     |                                    |                     |                     |
| <b>Educational Objectives</b>    | After taking part successfu   | ully, students have re  | ached the following | ng learning results                |                     |                     |
| <b>Professional Competence</b>   |   |                         |                     |                                    |                     |                     |
| Knowledge                        | The students are able to  | describe waste as a r   | esource as well a   | as advanced technologies for re    | cycling and re      | covery of resources |
|                                  | from waste in detail. This  | covers collection, trar | sport, treatment    | and disposal in national and inte  | ernational cont     | exts.               |
| CI:II-                           | Charleste and able to calco   |                         |                     |                                    | بعام امتنا المتنطاب |                     |
| SKIIIS                           |   | ·                       |                     | with respect to the national or co |                     | •                   |
|                                  | They can evaluate the eco   | ological impact and th  | e technical effort  | of different technologies and ma   | anagement sys       | stems.              |
| Personal Competence              |   |                         |                     |                                    |                     |                     |
| Social Competence                | Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop |                         |                     |                                    |                     |                     |
|                                  | cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues. |                         |                     |                                    |                     |                     |
|                                  | Furthermore, they can giv   | e and accept professi   | onal constructive   | criticisms.                        |                     |                     |
| Autonomy                         | Students can independen   | thy gain additional k   | nowlodge of the     | subject area and apply it in se    | lying the give      | n course tacks and  |
| Autonomy                         | v Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and   |                         |                     |                                    |                     |                     |
|                                  | projects.   |                         |                     |                                    |                     |                     |
| Workload in Hours                | Independent Study Time 1  | 10, Study Time in Led   | cture 70            |                                    |                     |                     |
| Credit points                    | 6   |                         |                     |                                    |                     |                     |
| Course achievement               | Compulsory Bonus For  | m                       | Description         |                                    |                     |                     |
|                                  | Yes 20 % Wr   | itten elaboration       |                     |                                    |                     |                     |
| Examination                      | Presentation  |                         |                     |                                    |                     |                     |
| Examination duration and         | PowerPoint presentation (   | 10-15 minutes)          |                     |                                    |                     |                     |
| scale                            |   |                         |                     |                                    |                     |                     |
| Assignment for the               | Civil Engineering: Specialis  | sation Water and Traf   | fic: Elective Comp  | oulsory                            |                     |                     |
| Following Curricula              | Environmental Engineering   |                         |                     |                                    |                     |                     |
|                                  | •   |                         |                     | ainability: Specialisation Energy: | Elective Comp       | oulsory             |
|                                  | Water and Environmental   |                         |                     |                                    |                     |                     |
|                                  | Water and Environmental   |                         |                     |                                    |                     |                     |
|                                  | Water and Environmental   | Engineering: Specialis  | sation Cities: Elec | tive Compulsory                    |                     |                     |

| Course L1055: Advanced Top | oics in Waste Resource Management   |
|----------------------------|---|
| Тур                        | Project-/problem-based Learning   |
| Hrs/wk                     | 3   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 48, Study Time in Lecture 42   |
| Lecturer                   | Prof. Rüdiger Siechau   |
| Language                   | EN  |
| Cycle                      | WiSe  |
| Content                    | Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste collection systems).  The course is split into two parts:  1. part: "Conventional" lecture (development of waste management, legislation, collection, transportation and organisation of waste management, costs, fees and revenues).  2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work out the project were given before during the conventional lecture. Course documents are published in StudIP and communication during project work takes place via StudIP.  The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the presentation. |
| Literature                 | Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 PowerPoint slides in Stud IP   |

| Course L0317: International | Waste Management   |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 2  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                    | Prof. Kerstin Kuchta   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics ( Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented.  Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves  Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries.  Single national projects and studies will be prepared and presented by students |
| Literature                  | Basel convention   |

| Module M0801: Wate                 | r Resources and -Supply  |                                       |                   |            |
|------------------------------------|--|---------------------------------------|-------------------|------------|
| Courses                            |  |                                       |                   |            |
| Title                              |  | Тур                                   | Hrs/wk            | СР         |
| Chemistry of Drinking Water Treatr | ment (L0311)   | Lecture                               | 2                 | 1          |
| Chemistry of Drinking Water Treatr | nent (L0312)   | Recitation Section (large)            | 1                 | 2          |
| Water Resource Management (L04)    |  | Lecture                               | 2                 | 2          |
| Water Resource Management (L04)    |  | Recitation Section (small)            | 1                 | 1          |
| Module Responsible                 |  |                                       |                   |            |
| Admission Requirements             | None   | in the district of the second         |                   |            |
| Recommended Previous               | Knowledge of water management and the key processes  | involved in water treatment.          |                   |            |
| Knowledge                          | After taking part suggestibly students have reached the  | following loarning recults            |                   |            |
| Educational Objectives             | After taking part successfully, students have reached the  | : ionowing learning results           |                   |            |
| Professional Competence            | Charles will be able to addition to account of the Charles   |                                       |                   |            |
| Knowledge                          | Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application. |                                       |                   |            |
| Skills                             | Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.                |                                       |                   |            |
| Personal Competence                |  |                                       |                   |            |
| Social Competence                  | Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.  |                                       |                   |            |
| Autonomy                           | Students will be in a position to work on a subject independently and present on this subject.   |                                       |                   |            |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84  |                                       |                   |            |
| Credit points                      | 6  |                                       |                   |            |
| Course achievement                 | None   |                                       |                   |            |
| Examination                        | Written exam   |                                       |                   |            |
| Examination duration and           | 60 min (chemistry) + presentation  |                                       |                   |            |
| scale                              |  |                                       |                   |            |
| Assignment for the                 | Civil Engineering: Specialisation Structural Engineering: I  | Elective Compulsory                   |                   |            |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engineerin  | g: Elective Compulsory                |                   |            |
|                                    | Civil Engineering: Specialisation Water and Traffic: Comp  | ulsory                                |                   |            |
|                                    | Civil Engineering: Specialisation Coastal Engineering: Ele   | ctive Compulsory                      |                   |            |
|                                    | International Management and Engineering: Specialisation   | on II. Energy and Environmental Engir | neering: Elective | Compulsory |
|                                    | Water and Environmental Engineering: Specialisation Wa   | ter: Compulsory                       |                   |            |
|                                    | Water and Environmental Engineering: Specialisation Env  |                                       |                   |            |
|                                    | Water and Environmental Engineering: Specialisation Citi   | ies: Elective Compulsory              |                   |            |

| Course L0311: Chemistry of | Drinking Water Treatment   |
|----------------------------|--|
| Тур                        | Lecture  |
| Hrs/wk                     | 2  |
| СР                         | 1  |
| Workload in Hours          | Independent Study Time 2, Study Time in Lecture 28   |
| Lecturer                   | Dr. Klaus Johannsen  |
| Language                   | DE   |
| Cycle                      | WiSe   |
| Content                    | The topic of this course is water chemistry with respect to drinking water treatment and water distribution  |
|                            | Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DINstandards). |
|                            | Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.                   |
|                            | Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester.   |
| Literature                 | MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.  |
|                            | <b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.  |
|                            | Jensen, J. N.: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.   |

| Course L0312: Chemistry of | ourse L0312: Chemistry of Drinking Water Treatment  |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)                          |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 2   |  |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14 |  |  |
| Lecturer                   | Dr. Klaus Johannsen                                 |  |  |
| Language                   | DE  |  |  |
| Cycle                      | WiSe  |  |  |
| Content                    | See interlocking course                             |  |  |
| Literature                 | See interlocking course                             |  |  |

| Course LOADS: Websi Bosson | ar Managarah  |
|----------------------------|---|
| Course L0402: Water Resour | Lecture   |
| Hrs/wk                     |   |
| СР                         |   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Prof. Mathias Ernst   |
| Language                   | DE  |
| Cycle                      | WiSe  |
| Content                    | The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview:  • Current situation of global water resources  - User and Stakeholder conflicts  - Wasserressourcenmanagement in urbane Gebieten  - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.  - Ökobilanzierung, Benchmarking in der Wasserversorgung |
| Literature                 | <ul> <li>Aktuelle UN World Water Development Reports</li> <li>Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>Ppt der Vorlesung</li> </ul>  |

## Module Manual M.Sc. "Water and Environmental Engineering"

| Course L0403: Water Resource Management |   |  |
|---|---|--|
| Тур                                     | Recitation Section (small)                          |  |
| Hrs/wk                                  | 1   |  |
| СР                                      | 1   |  |
| Workload in Hours                       | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                                | Prof. Mathias Ernst                                 |  |
| Language                                | DE  |  |
| Cycle                                   | WiSe  |  |
| Content                                 | See interlocking course                             |  |
| Literature                              | See interlocking course                             |  |

| Module M0822: Proce                | ss Modeling in Water Technology  |   |                |                       |
|------------------------------------|--|---|----------------|-----------------------|
| Courses                            |  |   |                |                       |
| Title                              |  | Тур   | Hrs/wk         | СР                    |
| Process Modelling of Wastewater T  | reatment (L0522)   | Project-/problem-based Learning               | 2              | 3                     |
| Process Modeling in Drinking Water | Treatment (L0314)  | Project-/problem-based Learning               | 2              | 3                     |
| Module Responsible                 | Dr. Klaus Johannsen  |   |                |                       |
| Admission Requirements             | None   |   |                |                       |
| Recommended Previous               | Knowledge of the most important processes in drinkin                                   | g water and waste water treatment.            |                |                       |
| Knowledge                          |  |   |                |                       |
| Educational Objectives             | After taking part successfully, students have reached                                  | the following learning results                |                |                       |
| Professional Competence            |  |   |                |                       |
| Knowledge                          | Students are able to explain selected processes of d                                   | rinking water and waste water treatment i     | n detail. The  | y are able to explain |
|                                    | basics as well as possibilities and limitations of dynam                               | ic modeling.                                  |                |                       |
| Skills                             | Students are able to use the most important features                                   | s Modelica offers. They are able to transpo   | se selected    | processes in drinking |
| Skiiis                             | water and waste water treatment into a mathematica                                     |   |                | _                     |
|                                    | They are able to set up and apply models and assess                                    | ·   | ,              |                       |
|                                    |  | ·   |                |                       |
|                                    |  |   |                |                       |
| Personal Competence                |  |   |                |                       |
| Social Competence                  | Students are able to solve problems and document so                                    | plutions in a group with members of differe   | nt technical b | background. They are  |
| ,                                  | able to give appropriate feedback and can work const                                   |   |                |                       |
|                                    |  |   |                |                       |
|                                    |  |   |                |                       |
| Autonomy                           | Students are able to define a problem, gain the required knowledge and set up a model. |   |                |                       |
|                                    |  |   |                |                       |
|                                    |  |   |                |                       |
| Workload in Hours                  | Independent Study Time 124, Study Time in Lecture 5                                    | 6   |                |                       |
| Credit points                      | 6  |   |                |                       |
| Course achievement                 | None   |   |                |                       |
| Examination                        | Written exam   |   |                |                       |
| Examination duration and           | 1,5 hours  | _   |                |                       |
| scale                              |  |   |                |                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: Ele                               | ctive Compulsory                              |                |                       |
| Following Curricula                | Environmental Engineering: Specialisation Water: Elec                                  | tive Compulsory                               |                |                       |
|                                    | Joint European Master in Environmental Studies - Citie                                 | s and Sustainability: Specialisation Water: I | Elective Com   | pulsory               |
|                                    | Process Engineering: Specialisation Environmental Pro                                  | cess Engineering: Elective Compulsory         |                |                       |
|                                    | Process Engineering: Specialisation Process Engineering                                |   |                |                       |
|                                    | Water and Environmental Engineering: Specialisation                                    | · ·   |                |                       |
|                                    | Water and Environmental Engineering: Specialisation                                    |   |                |                       |
|                                    | Water and Environmental Engineering: Specialisation                                    | Cities: Elective Compulsory                   |                |                       |

| Course L0522: Process Mode | lling of Wastewater Treatment   |
|----------------------------|---|
| Тур                        | Project-/problem-based Learning   |
| Hrs/wk                     | 2   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                   | Dr. Joachim Behrendt  |
| Language                   | DE/EN   |
| Cycle                      | WiSe  |
| Content                    | Mass and energy balances  |
|                            | Tracer modelling  |
|                            | Activated Sludge Model  |
|                            | Wastewater Treatment Plant Modelling (continously and SBR)  |
|                            | Sludge Treatment (ADM, aerobic autothermal)   |
|                            | Biofilm Modelling   |
| Literature                 | Henze, Mogens (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;)                  |
|                            | Activated sludge modelling: processes in theory and practice; selected proceedings of the 5th Kollekolle Seminar on Activated |
|                            | Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146  |
|                            | [London] : IWA Publ., 2002  |
|                            | TUB_HH_Katalog  |
|                            | Henze, Mogens   |
|                            | Activated sludge models ASM1, ASM2, ASM2d and ASM3  |
|                            | ISBN: 1900222248  |
|                            | London: IWA Publ., 2002   |
|                            | TUB_HH_Katalog  |
|                            | Henze, Mogens   |
|                            | Wastewater treatment : biological and chemical processes  |
|                            | ISBN: 3540422285 (Pp.)  |
|                            | Berlin [u.a.] : Springer, 2002  |
|                            | TUB_HH_Katalog  |
|                            | Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)   |
|                            | Fundamentals of biological wastewater treatment   |
|                            | ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm                     |
|                            | Weinheim: WILEY-VCH, 2007   |
|                            | TUB_HH_Katalog  |
|                            |   |

| Course L0314: Process Mode | ling in Drinking Water Treatment   |
|----------------------------|--|
| Тур                        | Project-/problem-based Learning  |
| Hrs/wk                     | 2  |
| СР                         | 3  |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                   | Dr. Klaus Johannsen  |
| Language                   | DE/EN  |
| Cycle                      | WiSe   |
| Content                    | In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica.  In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements   |
|                            | and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam.  |
| Literature                 | OpenModelica: https://openmodelica.org/index.php/download/download-windows  OpenModelica - Modelica Tutorial: https://openmodelica.org/index.php/useresresources/userdocumentation  OpenModelica - Users Guide: https://openmodelica.org/index.php/useresresources/userdocumentation  Peter Fritzson: Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.  MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.  DVGW (Hrsg.): Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. |

| Engineering                 |  |   |                     |                      |
|-----------------------------|--|---|---------------------|----------------------|
| Module M0802: Meml          | orane Technology                                       |   |                     |                      |
| Courses                     |  |   |                     |                      |
| Title                       |  | Tun   | Hrs/wk              | СР                   |
| Membrane Technology (L0399) |  | <b>Typ</b><br>Lecture                       | 2<br>2              | 3                    |
| Membrane Technology (L0400) |  | Recitation Section (small)                  | 1                   | 2                    |
| Membrane Technology (L0401) |  | Practical Course                            | 1                   | 1                    |
| Module Responsible          | Prof. Mathias Ernst                                    |   |                     |                      |
| Admission Requirements      | None   |   |                     |                      |
| Recommended Previous        | Basic knowledge of water chemistry. Knowledge of       | the core processes involved in water, gas   | and steam treatr    | nent                 |
| Knowledge                   |  |   |                     |                      |
| Educational Objectives      | After taking part successfully, students have reache   | ed the following learning results           |                     |                      |
| Professional Competence     |  |   |                     |                      |
| •                           | Students will be able to rank the technical applicati  | ons of industrially important membrane r    | processes. They w   | vill be able to expl |
|                             | the different driving forces behind existing memb      |   |                     |                      |
|                             | membrane filtration and their advantages and disa      |   |                     |                      |
|                             | membranes in water, other liquid media, gases and      |   |                     |                      |
|                             | 4, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,              | 1   |                     |                      |
| Skills                      | Students will be able to prepare mathematical equ      | uations for material transport in porous a  | and solution-diffus | sion membranes a     |
|                             | calculate key parameters in the membrane separa        | tion process. They will be able to handle   | technical memb      | ane processes us     |
|                             | available boundary data and provide recommenda         | ations for the sequence of different trea   | ntment processes    | . Through their o    |
|                             | experiments, students will be able to classify the     | e separation efficiency, filtration charac  | cteristics and ap   | plication of differ  |
|                             | membrane materials. Students will be able to chara     | cterise the formation of the fouling layer  | in different water  | s and apply techn    |
|                             | measures to control this.                              |   |                     |                      |
| Personal Competence         |  |   |                     |                      |
| Social Competence           | Students will be able to work in diverse teams on t    | asks in the field of membrane technology    | v They will be ab   | le to make decisio   |
| Social competence           | within their group on laboratory experiments to be u   |   |                     | ie to mane accion    |
|                             | 3  | ,   |                     |                      |
| Autonomy                    | Students will be in a position to solve homework       | on the topic of membrane technology in      | dependently. The    | y will be capable    |
|                             | finding creative solutions to technical questions.     |   |                     |                      |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture      | 2 56  |                     |                      |
| Credit points               |  |   |                     |                      |
| Course achievement          | None   |   |                     |                      |
| Examination                 | Written exam   |   |                     |                      |
| Examination duration and    | 90 min   |   |                     |                      |
| scale                       |  |   |                     |                      |
| Assignment for the          | Civil Engineering: Specialisation Water and Traffic: E | Elective Compulsory                         |                     |                      |
| Following Curricula         | Bioprocess Engineering: Specialisation A - General E   | Bioprocess Engineering: Elective Compuls    | ory                 |                      |
|                             | Bioprocess Engineering: Specialisation B - Industrial  | Bioprocess Engineering: Elective Comput     | sory                |                      |
|                             | Chemical and Bioprocess Engineering: Specialisation    | n Chemical Process Engineering: Elective    | Compulsory          |                      |
|                             | Chemical and Bioprocess Engineering: Specialisation    | n General Process Engineering: Elective C   | Compulsory          |                      |
|                             | Energy and Environmental Engineering: Specialisati     | on Energy and Environmental Engineering     | g: Elective Compu   | ılsory               |
|                             | Environmental Engineering: Specialisation Water: El    | ective Compulsory                           |                     |                      |
|                             | Joint European Master in Environmental Studies - Cit   | ties and Sustainability: Specialisation Wat | er: Elective Comp   | oulsory              |
|                             | Process Engineering: Specialisation Process Engineer   | ering: Elective Compulsory                  |                     |                      |
|                             | Process Engineering: Specialisation Environmental F    | Process Engineering: Elective Compulsory    |                     |                      |
|                             | Water and Environmental Engineering: Specialisatio     | n Water: Elective Compulsory                |                     |                      |
|                             | Water and Environmental Engineering: Specialisatio     | n Environment: Elective Compulsory          |                     |                      |
|                             | Water and Environmental Engineering: Specialisatio     | n Citios: Flostivo Compulsory               |                     |                      |

| Course L0399: Membrane Technology |  |  |
|-----------------------------------|--|--|
| Тур                               | Lecture  |  |
| Hrs/wk                            | 2  |  |
| СР                                | 3  |  |
| Workload in Hours                 | Independent Study Time 62, Study Time in Lecture 28  |  |
| Lecturer                          | Prof. Mathias Ernst  |  |
| Language                          | EN   |  |
| Cycle                             | WiSe   |  |
| Content                           | The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well.  |  |
|                                   | Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. |  |
|                                   | The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.  |  |
| Literature                        | <ul> <li>T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.</li> <li>Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>   |  |

| Course L0400: Membrane Te | Course L0400: Membrane Technology                   |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (small)                          |  |
| Hrs/wk                    | 1   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                  | Prof. Mathias Ernst                                 |  |
| Language                  | EN  |  |
| Cycle                     | WiSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Course L0401: Membrane Technology |   |
|-----------------------------------|---|
| Тур                               | Practical Course                                    |
| Hrs/wk                            | 1   |
| СР                                | 1   |
| Workload in Hours                 | Independent Study Time 16, Study Time in Lecture 14 |
| Lecturer                          | Prof. Mathias Ernst                                 |
| Language                          | EN  |
| Cycle                             | WiSe  |
| Content                           | See interlocking course                             |
| Literature                        | See interlocking course                             |

| Module M0864: Pract                | ical Course in Water and Wast                | tewater Technology                              |                      |                        |
|------------------------------------|--|---|----------------------|------------------------|
| Courses                            |  |   |                      |                        |
| Title                              |  | Тур   | Hrs/wk               | СР                     |
| Practical Course in Water and Wast | ewater Technology I (L0503)                  | Practical Course                                | 2                    | 3                      |
| Practicle Course of Wastewater Tec | hnology II (L0607)                           | Practical Course                                | 3                    | 3                      |
| Module Responsible                 | Dr. Dorothea Rechtenbach                     |   |                      |                        |
| Admission Requirements             | None   |   |                      |                        |
| Recommended Previous               | Basic knowledge in chemistry and physics (   | knowledge acquired at school)                   |                      |                        |
| Knowledge                          |  |   |                      |                        |
| <b>Educational Objectives</b>      | After taking part successfully, students hav | e reached the following learning results        |                      |                        |
| Professional Competence            |  |   |                      |                        |
| Knowledge                          | The students know basic analytical proced    | ures for evaluating the quality of water and    | wastewater. They ha  | ve knowledge about     |
|                                    | fundamental process engineering features of  | of important water and wastewater treatment     | technologies.        |                        |
| Skills                             | The students are able to understand and      | to practically apply methodologies for waster   | water analysis as we | ell as descriptions of |
|                                    | experiments and experimental setups in wa    | astewater technology.                           |                      |                        |
| Personal Competence                |  |   |                      |                        |
| Social Competence                  |  |   |                      |                        |
| Autonomy                           | The students are able to conduct experimen   | nts following written procedures without extern | nal assistance.      |                        |
| Workload in Hours                  | Independent Study Time 110, Study Time in    | n Lecture 70                                    |                      |                        |
| Credit points                      | 6  |   |                      |                        |
| Course achievement                 | None   |   |                      |                        |
| Examination                        | Written elaboration                          |   |                      |                        |
| Examination duration and           | ca. 5 Stunden                                |   |                      |                        |
| scale                              |  |   |                      |                        |
| Assignment for the                 | Civil Engineering: Specialisation Water and  | Traffic: Elective Compulsory                    |                      |                        |
| Following Curricula                | Water and Environmental Engineering: Spec    | cialisation Water: Elective Compulsory          |                      |                        |
|                                    | Water and Environmental Engineering: Spec    | cialisation Environment: Elective Compulsory    |                      |                        |
|                                    | Water and Environmental Engineering: Spec    | cialisation Cities: Elective Compulsory         |                      |                        |

| Course L0503: Practical Course in Water and Wastewater Technology I |  |
|---|--|
| Тур   | Practical Course   |
| Hrs/wk  | 2  |
| СР  | 3  |
| Workload in Hours   | Independent Study Time 62, Study Time in Lecture 28                                    |
| Lecturer  | Dr. Dorothea Rechtenbach   |
| Language  | EN   |
| Cycle   | WiSe   |
| Content   | - Impact of pretreatment of wastewater samples on analytical results                   |
|   | - Analysis of nutrients in wastewater samples (different methods for nitrate analysis) |
|   | - Alkalinity   |
|   | - TOC, COD   |
|   | - microscopic analysis of microorganisms relevant in wastewater treatment              |
| Literature  | Skript auf StudIP  |

| Course L0607: Practicle Course of Wastewater Technology II |   |
|--|---|
| Тур  | Practical Course                                    |
| Hrs/wk   | 3   |
| СР   | 3   |
| Workload in Hours  | Independent Study Time 48, Study Time in Lecture 42 |
| Lecturer   | Dr. Joachim Behrendt                                |
| Language   | DE/EN   |
| Cycle  | WiSe  |
| Content  | Experiments:  |
|  | Oxygen transfer                                     |
|  | Oxygen Uptake rate                                  |
|  | Sludge dewatering                                   |
|  | Tracer  |
|  | Flocculation  |
| Literature   | Skript/Script                                       |

| Module M0894: Study                       | Work Cities  |
|---|--|
| Courses                                   |  |
| Title                                     | Typ Hrs/wk CP  |
| Module Responsible                        | Dozenten des SD B  |
| Admission Requirements                    | None   |
| Recommended Previous<br>Knowledge         | <ul> <li>Basics of Urban Planning</li> <li>Urban Infrastructures (Water, Energy, Heat)</li> <li>Environmental Technologies (Solid Waste Disposal, Air Quality Control, Wastewater Treatement, etc.)</li> </ul>   |
| Educational Objectives                    | After taking part successfully, students have reached the following learning results   |
| Professional Competence                   |  |
|   | The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.  The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. |
|   | Scientific work techniques that are used can be described and critically reviewed.   |
| Skills                                    | The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.   |
| Personal Competence                       |  |
| Social Competence                         | The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.  |
| Autonomy                                  | The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.  |
| Workload in Hours                         | Independent Study Time 180, Study Time in Lecture 0  |
| Credit points                             |  |
| Course achievement                        |  |
| Examination                               |  |
| Examination duration and scale            |  |
| Assignment for the<br>Following Curricula | Water and Environmental Engineering: Specialisation Cities: Compulsory   |

| Module M0949: Rural            | <b>Development and Resources Oriented</b>  | Sanitation for diffe            | erent Climate Zon           | es                   |
|--------------------------------|--|---------------------------------|-----------------------------|----------------------|
|                                |  |                                 |                             |                      |
| Courses                        |  |                                 |                             |                      |
| Title                          |  | Тур                             | Hrs/wk                      | СР                   |
| ·                              | Oriented Sanitation for different Climate Zones (L0942)  | Seminar                         | 2                           | 3                    |
| ·                              | Oriented Sanitation for different Climate Zones (L0941)  | Lecture                         | 2                           | 3                    |
| Module Responsible             | Prof. Ralf Otterpohl   |                                 |                             |                      |
| Admission Requirements         |  |                                 |                             |                      |
| Recommended Previous           | Basic knowledge of the global situation with rising pover  | ty, soil degradation, lack of w | ater resources and sanita   | tion                 |
| Knowledge                      |  |                                 |                             |                      |
| Educational Objectives         | After taking part successfully, students have reached the  | following learning results      |                             |                      |
| <b>Professional Competence</b> |  |                                 |                             |                      |
| Knowledge                      | Students can describe resources oriented wastewater s  | systems mainly based on so      | urce control in detail. The | ey can comment on    |
|                                | techniques designed for reuse of water, nutrients and so   | il conditioners.                |                             |                      |
|                                | Students are able to discuss a wide range of proven app  | roaches in Rural Developmen     | nt from and for many regio  | ons of the world     |
|                                | state his are able to alseass a wide range of proven app   | ouches in Rulai Bevelopinei     | ic from and for many regio  | ins of the world.    |
|                                |  |                                 |                             |                      |
| Skills                         | Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the |                                 | s, measures for the         |                      |
|                                | rehabilitation of top soil quality combined with food and  | water security. Students can    | consult on the basics of s  | oil building through |
|                                | "Holisitc Planned Grazing" as developed by Allan Savory  | •                               |                             |                      |
| Personal Competence            |  |                                 |                             |                      |
| •                              | The students are able to develop a specific topic in a tea   | m and to work out milestone     | s according to a given pla  | n                    |
| Social competence              | The stadents are able to develop a specific topic in a tea   | and to work out innestone       | o according to a given pia  |                      |
| Autonomy                       | Students are in a position to work on a subject and to   | o organize their work flow in   | ndependently. They can a    | Ilso present on this |
|                                | subject.   |                                 |                             |                      |
| Workload in Hours              | Independent Study Time 124, Study Time in Lecture 56   |                                 |                             |                      |
| Credit points                  | , ,  |                                 |                             |                      |
| Course achievement             |  |                                 |                             |                      |
| Examination                    |  |                                 |                             |                      |
| Examination duration and       | During the course of the semester, the students work to  | wards mile stones. The worl     | k includes presentations a  | and papers. Detailed |
| scale                          | information will be provided at the beginning of the sme   |                                 | k melades presentations o   | ma papers. Detanea   |
| Assignment for the             | Civil Engineering: Specialisation Water and Traffic: Electi  |                                 |                             |                      |
| Following Curricula            | Bioprocess Engineering: Specialisation A - General Biopro  |                                 | ompulsory                   |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation Gel  |                                 |                             |                      |
|                                | Environmental Engineering: Specialisation Water: Electiv   |                                 |                             |                      |
|                                | International Management and Engineering: Specialisation   | . ,                             | tal Engineering: Elective ( | Compulsory           |
|                                | Joint European Master in Environmental Studies - Cities a  | • •                             |                             |                      |
|                                | Process Engineering: Specialisation Environmental Proce  |                                 | ·                           | ,                    |
|                                | Process Engineering: Specialisation Process Engineering:   |                                 | -                           |                      |
|                                | Water and Environmental Engineering: Specialisation Wa   | ter: Elective Compulsory        |                             |                      |
|                                | Water and Environmental Engineering: Specialisation En   | vironment: Elective Compuls     | ory                         |                      |
|                                | Water and Environmental Engineering: Specialisation Cit  | ies: Elective Compulsory        |                             |                      |

| Тур               | Seminar   |
|-------------------|---|
| Hrs/wk            | 2   |
| СР                | 3   |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer          | Prof. Ralf Otterpohl  |
| Language          | EN  |
| Cycle             | WiSe  |
| Content           | <ul> <li>Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on ar interview with a target audience, practitioners or scientists.</li> <li>The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.</li> </ul>   |
| Literature        | <ul> <li>J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHF Bibliothek)</li> <li>Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)</li> <li>Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys</li> </ul> |

|                   | ment and Resources Oriented Sanitation for different Climate Zones   |
|-------------------|--|
|                   | Lecture  |
| Hrs/wk            | 2  |
| СР                | 3  |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer          | Prof. Ralf Otterpohl   |
| Language          | EN   |
| Cycle             | WiSe   |
| Content           | <ul> <li>Living Soil - THE key element of Rural Development</li> <li>Participatory Approaches</li> <li>Rainwater Harvesting</li> <li>Ecological Sanitation Principles and practical examples</li> <li>Permaculture Principles of Rural Development</li> <li>Performance and Resilience of Organic Small Farms</li> <li>Going Further: The TUHH Toolbox for Rural Development</li> <li>EMAS Technologies, Low cost drinking water supply</li> </ul> |
| Literature        | <ul> <li>Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk</li> <li>Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> </ul>  |

| nurses                                 |   |
|--|---|
| ourses                                 | T   |
| itle peration of Public Transportation | Typ Hrs/wk CP Systems (L1179) Project-/problem-based Learning 4 6   |
| Module Responsible                     |   |
| Admission Requirements                 |   |
|  | some knowledge of transport planning, e.g. through taking the undergraduate class "Transport Planning and Traffic Engineering |
| Knowledge                              |   |
|  |   |
| Educational Objectives                 | After taking part successfully, students have reached the following learning results  |
| Professional Competence                |   |
|  | Students are able to:   |
|  |   |
|  | describe public transport (PT) systems in technical language.   |
|  | outline the entire PT system including the interdependencies of the different elements.                                       |
|  | explain the requirements for a PT system from different perspectives.   |
|  | explain the role of PT in the transport system.   |
| Skills                                 | Students are able to:   |
|  |   |
|  | systematically develop a public transport system when there are no clear cut correct or incorrect approaches.                 |
|  | cope with imprecise and incomplete data.  |
|  | develop and appraise alternative solutions.   |
|  | distinguish or develop appropriate methods of analysis and modes of presentation.   |
|  | reflect and evaluate their own transport concept, considering competing requirements.   |
| Personal Competence                    |   |
|  | Students are able to:   |
|  |   |
|  | carry out and complete a group project, inclusive of an appropriate allocation of tasks.                                      |
|  | constructively provide and accept feedback.   |
|  | present their own results to others.  |
| 4                                      |   |
| Autonomy                               | independently develop a bus PT concept within a given framework.  |
|  | determine and justify the focus of their work.  |
|  | organize and follow their work process regarding time and content.  |
|  | independently author a written report.  |
|  | assess the consequences of the solutions they develop.  |
|  |   |
| Workload in Hours                      | Independent Study Time 124, Study Time in Lecture 56  |
| Credit points                          | 6   |
| Course achievement                     | None  |
| Examination                            | Written elaboration   |
| Examination duration and               |   |
| scale                                  |   |
| Assignment for the                     |   |
| Following Curricula                    | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory   |

| Course L1179: Operation of Public Transportation Systems |  |
|--|--|
| Тур  | Project-/problem-based Learning  |
| Hrs/wk   | 4  |
| СР   | 6  |
| Workload in Hours  | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer   | Prof. Carsten Gertz  |
| Language   | DE   |
| Cycle  | WiSe   |
| Content  | The course primarily deals with the planning and operational challenges of public transport systems. A bus-system is the example for studying these problems in depth. The following topics and systemic elements are covered:  • PT network planning • timetabling • operational concepts   |
|  | <ul> <li>requirements for vehicle technology and operation</li> <li>infrastructural requirements</li> <li>inter- and multimodal connections</li> <li>financing and competition</li> <li>organisational structures</li> </ul> The topics are discussed with guests lecturers from the public transport sector and are considered in practice during an excursion.   |
| Literature   | Verband Deutscher Verkehrsunternehmen / VDV-Förderkreis (Hrsg.) (2010) Nachhaltiger Nahverkehr. Köln. (2 Bände)  Wuppertal Institut (2009) Handbuch zur Planung flexibler Bedienungsformen im ÖPNV: ein Beitrag zur Sicherung der Daseinsvorsorge in nachfrageschwachen Räumen. Bundesministerium für Verkehr, Bau und Stadtentwicklung / Bundesinstitut für Bau-, Stadt- und Raumforschung. Bonn.  Forschungsgesellschaft für Straßen- und Verkehrswesen (2009) HVÖ - Hinweise für den Entwurf von Verknüpfungsanlagen des öffentlichen Personennahverkehrs. FGSV Verlag. Köln.  Kirchhoff, Peter (2002) Städtische Verkehrsplanung – Konzepte, Verfahren, Maßnahmen. Vieweg+Teubner Verlag. Wiesbaden.  Kirchhoff, Peter & Tsakarestos, Antonius (2007) Planung des ÖPNV in ländlichen Räumen, Ziele – Entwurf- Realisierung. Vieweg+Teubner Verlag. Wiesbaden  Forschungsgesellschaft für Straßen- und Verkehrswesen (2008) Richtlinien für integrierte Netzgestaltung: RIN. FGSV-Verlag. Köln. |

| Module M1505: Adapt                | tation to Climate Change in Hyd  | raulic Engineering (AKWAS)                               |                  |                    |
|------------------------------------|--|--|------------------|--------------------|
| Courses                            |  |  |                  |                    |
| Title                              |  | Time   | Hwa hude         | CD                 |
| Adaptation to climate change in hy | draulic engineering (L2291)  | <b>Typ</b><br>Project-/problem-based Learning            | Hrs/wk<br>4      | <b>CP</b><br>6     |
| Module Responsible                 |  | . roject /prosiem suseu zeuming                          |                  |                    |
| Admission Requirements             |  |  |                  |                    |
| Recommended Previous               | None   |  |                  |                    |
| Knowledge                          | Hydrology, Hydraulic Engineering   |  |                  |                    |
|                                    | Hydromechanic, Hydraulics  |  |                  |                    |
|                                    | Fundamentals of Coastal Engineering, C   | oastal- and Flood Protection                             |                  |                    |
|                                    | Hydrological Systems   |  |                  |                    |
| <b>Educational Objectives</b>      | After taking part successfully, students have re   | eached the following learning results                    |                  |                    |
| <b>Professional Competence</b>     |  |  |                  |                    |
| Knowledge                          |  |  |                  |                    |
|                                    | <ul> <li>Climate protection and climate adaptation</li> <li>Insights into climate change and its region</li> </ul> | on<br>onal characteristics - fundamentals, climate model | ling / climate   | models             |
|                                    | Impacts of climate change on the compo   |  | iiig / ciiiilate | models             |
|                                    | Fundamentals of analysis of climate data   |  |                  |                    |
|                                    | Consequences of the impact of the clima  |  |                  |                    |
|                                    | Measures for climate adaptation  | -  |                  |                    |
|                                    | <ul> <li>Assessment, prioritization and communi</li> </ul>   | cation of adaptation measures                            |                  |                    |
|                                    | <ul> <li>Fundamentals of the analysis of hydrom</li> </ul>   | eteorological and hydrological data                      |                  |                    |
| Skills                             |  |  |                  |                    |
| SKIIIS                             | <ul> <li>Critical thinking: analysis of processes a</li> </ul>   | nd relations, assessment of needs for action             |                  |                    |
|                                    | <ul> <li>Creative thinking: development of adapt</li> </ul>  | ation strategies and adaptation measures                 |                  |                    |
|                                    | <ul> <li>Practical thinking: inclusion of restricti</li> </ul>   | ons, application of calculation approaches, meth         | ods, numeric     | al models, plannir |
|                                    | methods  |  |                  |                    |
|                                    | Consideration of complex tasks   |  |                  |                    |
| Personal Competence                |  |  |                  |                    |
| Social Competence                  |  |  |                  |                    |
| Social competence                  | Working in heterogenous groups   |  |                  |                    |
|                                    | Working with different scientific / non-sc   | ientific disciplines                                     |                  |                    |
|                                    | Self reflection  |  |                  |                    |
| Autonomy                           |  |  |                  |                    |
|                                    | Application oriented use of knowledge a  | nd skills  |                  |                    |
|                                    | Autonomous work on complex tasks   |  |                  |                    |
| Workload in Hours                  | Independent Study Time 124, Study Time in Le   | cture 56   |                  |                    |
| Credit points                      | 6  |  |                  |                    |
| Course achievement                 | None   |  |                  |                    |
| Examination                        | Written elaboration  |  |                  |                    |
|                                    | Preparation of a written report and a presentat  | ion of a complex task.                                   |                  |                    |
| scale                              |  |  |                  |                    |
| •                                  | Civil Engineering: Specialisation Coastal Engine   | • •  |                  |                    |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical E   |  |                  |                    |
|                                    | Civil Engineering: Specialisation Structural Eng   |  |                  |                    |
|                                    | Civil Engineering: Specialisation Water and Tra  | • •  |                  |                    |
|                                    | Water and Environmental Engineering: Special<br>Water and Environmental Engineering: Special                       |  |                  |                    |
|                                    | Water and Environmental Engineering: Special Water and Environmental Engineering: Special                          |  |                  |                    |
|                                    | vvater and Environmental Engineering. Special  | Bation water. Liective Compuisory                        |                  |                    |

| Course L2291: Adaptation to | climate change in hydraulic engineering  |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 4  |
| СР                          | 6  |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                    | Prof. Peter Fröhle   |
| Language                    | DE   |
| Cycle                       | WiSe   |
| Content                     | <ul> <li>Climate protection and climate adaptation</li> <li>Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>Fundamentals of the analysis of climate data</li> <li>Concequences of the impacts of climate change (ingenieering science view)</li> <li>Measures for climate change adaptation</li> <li>Assessment, prioritization and communication of measures</li> <li>Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul> |
| Literature                  | Bereitgestellte eLearning Plattform  |

| Module M1718: Multip               | phase Flow in Porous Media                           |                                      |        |    |
|------------------------------------|--|--------------------------------------|--------|----|
|                                    |  |                                      |        |    |
| Courses                            |  |                                      |        |    |
| Title                              |  | Тур                                  | Hrs/wk | СР |
| Advanced Modeling Techniques for   | Multiphase Flow in Porous Media (L2738)              | Recitation Section (small)           | 2      | 2  |
| Fundamentals of Multiphase Flow in | n Porous Media (L2736)                               | Lecture                              | 2      | 2  |
| Fundamentals of Multiphase Flow in | n Porous Media (L2737)                               | Recitation Section (large)           | 2      | 2  |
| Module Responsible                 | Prof. Nima Shokri                                    |                                      |        |    |
| Admission Requirements             | None   |                                      |        |    |
| Recommended Previous               |  |                                      |        |    |
| Knowledge                          |  |                                      |        |    |
| <b>Educational Objectives</b>      | After taking part successfully, students have reach  | ed the following learning results    |        |    |
| Professional Competence            |  |                                      |        |    |
| Knowledge                          |  |                                      |        |    |
| Skills                             |  |                                      |        |    |
| Personal Competence                |  |                                      |        |    |
| Social Competence                  |  |                                      |        |    |
| Autonomy                           |  |                                      |        |    |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84  |                                      |        |    |
| Credit points                      | 6  |                                      |        |    |
| Course achievement                 | None   |                                      |        |    |
| Examination                        | Written exam   |                                      |        |    |
| Examination duration and           | 90 min   |                                      |        |    |
| scale                              |  |                                      |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: | Elective Compulsory                  |        |    |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engi  | neering: Elective Compulsory         |        |    |
|                                    | Civil Engineering: Specialisation Geotechnical Engi  | neering: Elective Compulsory         |        |    |
|                                    | Civil Engineering: Specialisation Water and Traffic: | Elective Compulsory                  |        |    |
|                                    | Environmental Engineering: Specialisation Water: I   | Elective Compulsory                  |        |    |
|                                    | Environmental Engineering: Specialisation Water: I   | Elective Compulsory                  |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Cities: Elective Compulsory      |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Cities: Elective Compulsory      |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Environment: Elective Compulsory |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Environment: Elective Compulsory |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Water: Elective Compulsory       |        |    |
|                                    | Water and Environmental Engineering: Specialisati    | ion Water: Elective Compulsory       |        |    |

| Course L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media |   |  |
|--|---|--|
| Тур  | Recitation Section (small)                          |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer   | Prof. Nima Shokri                                   |  |
| Language   | EN  |  |
| Cycle  | SoSe  |  |
| Content  |   |  |
| Literature   |   |  |

| Course L2736: Fundamentals | ourse L2736: Fundamentals of Multiphase Flow in Porous Media |  |  |
|----------------------------|--|--|--|
| Тур                        | Lecture  |  |  |
| Hrs/wk                     | 2  |  |  |
| СР                         | 2  |  |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28          |  |  |
| Lecturer                   | Prof. Nima Shokri  |  |  |
| Language                   | EN   |  |  |
| Cycle                      | SoSe   |  |  |
| Content                    |  |  |  |
| Literature                 |  |  |  |

| Course L2737: Fundamentals | ourse L2737: Fundamentals of Multiphase Flow in Porous Media |  |  |
|----------------------------|--|--|--|
| Тур                        | Recitation Section (large)                                   |  |  |
| Hrs/wk                     | 2  |  |  |
| СР                         | 2  |  |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28          |  |  |
| Lecturer                   | Hannes Nevermann   |  |  |
| Language                   | EN   |  |  |
| Cycle                      | SoSe   |  |  |
| Content                    | See interlocking course                                      |  |  |
| Literature                 | See interlocking course                                      |  |  |

| Module M1721: Wate                | r and Environment: Theory and Application                           |                                 |        |    |
|-----------------------------------|---|---------------------------------|--------|----|
| Courses                           |   |                                 |        |    |
| Γitle                             |   | Тур                             | Hrs/wk | СР |
| Water and Environment: Applicatio |   | Project-/problem-based Learning | 3      | 4  |
| Nater and Environment: Theory (L  | 2753)   | Lecture                         | 1      | 2  |
| Module Responsible                | Prof. Nima Shokri   |                                 |        |    |
| Admission Requirements            | None  |                                 |        |    |
| Recommended Previous              |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| <b>Educational Objectives</b>     | After taking part successfully, students have reached the following | g learning results              |        |    |
| <b>Professional Competence</b>    |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| Skills                            |   |                                 |        |    |
| Personal Competence               |   |                                 |        |    |
| Social Competence                 |   |                                 |        |    |
| Autonomy                          |   |                                 |        |    |
| Workload in Hours                 | Independent Study Time 124, Study Time in Lecture 56                |                                 |        |    |
| Credit points                     | 6   |                                 |        |    |
| Course achievement                | None  |                                 |        |    |
| Examination                       | Written elaboration   |                                 |        |    |
| Examination duration and          | Report (about 5-10 pages) and Presentation (about 15 min)           |                                 |        |    |
| scale                             |   |                                 |        |    |
| Assignment for the                | Civil Engineering: Specialisation Coastal Engineering: Elective Cor | mpulsory                        |        |    |
| Following Curricula               | Civil Engineering: Specialisation Water and Traffic: Elective Comp  | ulsory                          |        |    |
|                                   | Civil Engineering: Specialisation Coastal Engineering: Elective Cor | npulsory                        |        |    |
|                                   | Civil Engineering: Specialisation Water and Traffic: Elective Comp  | ulsory                          |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective Compu     | lsory                           |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective Compu     | Isory                           |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities: Elect   | ive Compulsory                  |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities: Elect   | ive Compulsory                  |        |    |
|                                   | Water and Environmental Engineering: Specialisation Environmen      | t: Elective Compulsory          |        |    |
|                                   | Water and Environmental Engineering: Specialisation Environmen      |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water: Elect    | • •                             |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water: Elect    | tive Compulsory                 |        |    |

| Course L2754: Water and En | urse L2754: Water and Environment: Application and Field Work |  |  |
|----------------------------|---|--|--|
| Тур                        | Project-/problem-based Learning                               |  |  |
| Hrs/wk                     | 3   |  |  |
| СР                         | 4   |  |  |
| Workload in Hours          | Independent Study Time 78, Study Time in Lecture 42           |  |  |
| Lecturer                   | Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni      |  |  |
| Language                   | EN  |  |  |
| Cycle                      | SoSe  |  |  |
| Content                    |   |  |  |
| Literature                 |   |  |  |

| Course L2753: Water and Environment: Theory |   |
|---|---|
| Тур   | Lecture   |
| Hrs/wk                                      | 1   |
| СР  | 2   |
| Workload in Hours                           | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                    | Prof. Nima Shokri                                   |
| Language                                    | EN  |
| Cycle                                       | SoSe  |
| Content                                     |   |
| Literature                                  |   |

| Engineering                                  |   |   |        |    |
|--|---|---|--------|----|
| Module M1717: Advanced Vadose Zone Hydrology |   |   |        |    |
| Courses                                      |   |   |        |    |
| Title  |   | Тур                                       | Hrs/wk | СР |
| Modeling Processes in Vadose Zone            | e (L2734)   | Lecture                                   | 1      | 1  |
| Modeling Processes in Vadose Zone            | e (L2735)   | Recitation Section (small)                | 1      | 1  |
| Vadose Zone Hydrology (L2732)                |   | Lecture                                   | 2      | 2  |
| Vadose Zone Hydrology (L2733)                |   | Recitation Section (large)                | 2      | 2  |
| Module Responsible                           | Prof. Nima Shokri                                   |   |        |    |
| Admission Requirements                       | None  |   |        |    |
| Recommended Previous                         |   |   |        |    |
| Knowledge                                    |   |   |        |    |
| <b>Educational Objectives</b>                | After taking part successfully, students have r     | reached the following learning results    |        |    |
| Professional Competence                      |   |   |        |    |
| Knowledge                                    |   |   |        |    |
| Skills                                       |   |   |        |    |
| Personal Competence                          |   |   |        |    |
| Social Competence                            |   |   |        |    |
| Autonomy                                     |   |   |        |    |
| Workload in Hours                            | Independent Study Time 96, Study Time in Lecture 84 |   |        |    |
| Credit points                                | 6   |   |        |    |
| Course achievement                           | None  |   |        |    |
| Examination                                  | Written exam  |   |        |    |
| Examination duration and                     | 90 min  |   |        |    |
| scale  |   |   |        |    |
| Assignment for the                           | Civil Engineering: Specialisation Water and Tr      | affic: Elective Compulsory                |        |    |
| Following Curricula                          | Civil Engineering: Specialisation Water and Tr      | affic: Elective Compulsory                |        |    |
|  | Environmental Engineering: Specialisation Wa        | ter: Elective Compulsory                  |        |    |
|  | Environmental Engineering: Specialisation Wa        | iter: Elective Compulsory                 |        |    |
|  | Water and Environmental Engineering: Specia         | lisation Water: Elective Compulsory       |        |    |
|  | Water and Environmental Engineering: Specia         | lisation Environment: Elective Compulsory |        |    |
|  | Water and Environmental Engineering: Specia         | llisation Cities: Elective Compulsory     |        |    |
|  | Water and Environmental Engineering: Specia         | llisation Cities: Elective Compulsory     |        |    |
|  | Water and Environmental Engineering: Specia         | lisation Environment: Elective Compulsory |        |    |
|  | Water and Environmental Engineering: Specia         | lisation Water: Elective Compulsory       |        |    |

| Course L2734: Modeling Prod | ourse L2734: Modeling Processes in Vadose Zone      |  |  |
|-----------------------------|---|--|--|
| Тур                         | Lecture   |  |  |
| Hrs/wk                      | 1   |  |  |
| СР                          | 1   |  |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |  |
| Lecturer                    | Hannes Nevermann, Prof. Nima Shokri                 |  |  |
| Language                    | EN  |  |  |
| Cycle                       | SoSe  |  |  |
| Content                     |   |  |  |
| Literature                  |   |  |  |

| Course L2735: Modeling Pro | Course L2735: Modeling Processes in Vadose Zone     |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (small)                          |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 1   |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14 |  |  |
| Lecturer                   | Hannes Nevermann                                    |  |  |
| Language                   | EN  |  |  |
| Cycle                      | SoSe  |  |  |
| Content                    | See interlocking course                             |  |  |
| Literature                 | See interlocking course                             |  |  |

| Course L2732: Vadose Zone Hydrology |   |
|-------------------------------------|---|
| Тур                                 | Lecture   |
| Hrs/wk                              | 2   |
| СР                                  | 2   |
| Workload in Hours                   | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer                            | Prof. Nima Shokri                                   |
| Language                            | EN  |
| Cycle                               | SoSe  |
| Content                             |   |
| Literature                          |   |

| Course L2733: Vadose Zone | ourse L2733: Vadose Zone Hydrology                  |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (large)                          |  |
| Hrs/wk                    | 2   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                  | Prof. Nima Shokri                                   |  |
| Language                  | EN  |  |
| Cycle                     | SoSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Engineering              |   |                                 |                    |                        |
|--------------------------|---|---------------------------------|--------------------|------------------------|
| Module M1724: Smar       | t Monitoring  |                                 |                    |                        |
|                          |   |                                 |                    |                        |
| Courses                  |   |                                 |                    |                        |
| Title                    |   | Тур                             | Hrs/wk             | СР                     |
| Smart Monitoring (L2762) |   | Integrated Lecture              | 2                  | 2                      |
| Smart Monitoring (L2763) |   | Recitation Section (small)      | 2                  | 4                      |
| Module Responsible       | Prof. Kay Smarsly   |                                 |                    |                        |
| Admission Requirements   | None  |                                 |                    |                        |
|                          | Basic knowledge or interest in object-oriented modeling, progr      | ramming, and sensor technol     | ogies are helpful  | . Interest in modern   |
|                          | research and teaching areas, such as Internet of Things, Indus      | •                               |                    |                        |
|                          | skills of scientific working, are required. Basic knowledge in scie |                                 |                    | ·                      |
|                          |   |                                 |                    |                        |
| Educational Objectives   | After taking part successfully, students have reached the follow    | ing learning results            |                    |                        |
| Professional Competence  |   |                                 |                    |                        |
| Knowledge                | The students will become familiar with the principles and pro-      | actices of smart monitoring.    | The students wi    | I be able to design    |
|                          | decentralized smart systems to be applied for continuous (          | (remote) monitoring of syste    | ms in the built    | and in the natural     |
|                          | environment. In addition, the students will learn to design and     | to implement intelligent senso  | or systems using   | state-of-the-art data  |
|                          | analysis techniques, modern software design concepts, and em        | bedded computing methodolo      | gies. Besides lect | ures, project work is  |
|                          | also part of this module. In small groups, the students wil         | I design smart monitoring s     | ystems that inte   | grate a number of      |
|                          | "intelligent" sensors to be implemented by the students. Sp         | pecific focus will be put on    | the application of | of machine learning    |
|                          | techniques. The smart monitoring systems will be mounted on         | real-world (built or natural) s | stems, such as l   | oridges or slopes, or  |
|                          | on scaled lab structures for validation purposes. The outcome       | of every group will be docum    | ented in a paper   | . All students of this |
|                          | module will "automatically" participate with their smart moni       |                                 |                    | •                      |
|                          | written papers and oral examinations form the final grades. The     | module will be taught in Engl   | ish. Limited enrol | lment.                 |
| Skills                   |   |                                 |                    |                        |
| Personal Competence      |   |                                 |                    |                        |
| Social Competence        |   |                                 |                    |                        |
| Autonomy                 |   |                                 |                    |                        |
|                          | Independent Study Time 124, Study Time in Lecture 56                |                                 |                    |                        |
| Credit points            |   |                                 |                    |                        |
| Course achievement       |   |                                 |                    |                        |
|                          | Written elaboration   |                                 |                    |                        |
|                          | 10 pages of work with 15-minute oral presentation                   |                                 |                    |                        |
| scale                    | 10 pages of work with 13-minute oral presentation                   |                                 |                    |                        |
|                          | Civil Engineering: Specialisation Water and Traffic: Elective Com   | nulsory                         |                    |                        |
| •                        | Civil Engineering: Specialisation Water and Trantc. Elective Con-   |                                 |                    |                        |
| Tollowing Curricula      | Civil Engineering: Specialisation Coastal Engineering: Elective C   |                                 |                    |                        |
|                          | Civil Engineering: Specialisation Structural Engineering: Elective  | , ,                             |                    |                        |
|                          | Civil Engineering: Specialisation Coastal Engineering: Elective C   |                                 |                    |                        |
|                          | Civil Engineering: Specialisation Geotechnical Engineering: Elec-   |                                 |                    |                        |
|                          | Civil Engineering: Specialisation Structural Engineering: Elective  |                                 |                    |                        |
|                          | Civil Engineering: Specialisation Water and Traffic: Elective Com   | npulsory                        |                    |                        |
|                          | Environmental Engineering: Specialisation Waste and Energy: E       | lective Compulsory              |                    |                        |
|                          | Environmental Engineering: Specialisation Biotechnology: Electi     | ve Compulsory                   |                    |                        |
|                          | Environmental Engineering: Specialisation Water: Elective Comp      |                                 |                    |                        |
|                          | Environmental Engineering: Specialisation Waste and Energy: E       | lective Compulsory              |                    |                        |
|                          | Environmental Engineering: Specialisation Biotechnology: Electi     |                                 |                    |                        |
|                          | Environmental Engineering: Specialisation Water: Elective Comp      | oulsory                         |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Cities: Ele     | ctive Compulsory                |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Cities: Ele     | ctive Compulsory                |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Environme       | ent: Elective Compulsory        |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Environme       | ent: Elective Compulsory        |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Water: Ele      | ective Compulsory               |                    |                        |
|                          | Water and Environmental Engineering: Specialisation Water: Ele      | ective Compulsory               |                    |                        |

| Course L2762: Smart Monito | ring   |
|----------------------------|--|
| Тур                        | Integrated Lecture   |
| Hrs/wk                     | 2  |
| СР                         | 2  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                   | Prof. Kay Smarsly  |
| Language                   | EN   |
| Cycle                      | WiSe/SoSe  |
| Content                    | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| Literature                 |  |

| Course L2763: Smart Monitoring |  |  |
|--------------------------------|--|--|
|                                |  |  |
| Тур                            | Recitation Section (small)   |  |
| Hrs/wk                         | 2  |  |
| СР                             | 4  |  |
| Workload in Hours              | Independent Study Time 92, Study Time in Lecture 28  |  |
| Lecturer                       | Prof. Kay Smarsly  |  |
| Language                       | EN   |  |
| Cycle                          | WiSe/SoSe  |  |
| Content                        | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which |  |
|                                | will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be   |  |
|                                | tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the "Smart        |  |
|                                | Monitoring" competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to         |  |
|                                | contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as    |  |
|                                | well as through external sources, such as video tutorials and literature.  |  |
|                                |  |  |
| Literature                     |  |  |

### **Specialization Environment**

| Module M0830: Environmental Protection and Management |  |                                      |                       |                       |
|---|--|--------------------------------------|-----------------------|-----------------------|
| Courses   |  |                                      |                       |                       |
| Title   |  | Тур                                  | Hrs/wk                | СР                    |
| Integrated Pollution Control (L0502                   | )  | Lecture                              | 2                     | 2                     |
| Health, Safety and Environmental M                    | Management (L0387)   | Lecture                              | 2                     | 3                     |
| Health, Safety and Environmental N                    | Management (L0388)   | Recitation Section (small)           | 1                     | 1                     |
| Module Responsible                                    | Prof. Ralf Otterpohl   |                                      |                       |                       |
| Admission Requirements                                | None   |                                      |                       |                       |
| Recommended Previous                                  |  |                                      |                       |                       |
| Knowledge   | Good knowledge in Technologies for Environmen  |                                      | d solutions)          |                       |
|   | Good knowledge of the relevant Environmental L   | •                                    |                       |                       |
|   | Basic knowledge of instruments for Environment   | al Assessment                        |                       |                       |
| Educational Objectives                                | After taking part successfully, students have reached the  | ne following learning results        |                       |                       |
| Professional Competence                               |  |                                      |                       |                       |
| Knowledge   | The students are able to describe the basics of regu   | lations, economic instruments, volu  | ntary initiatives, fu | undamentals of HSE    |
| -   | legislation ISO 14001, EMAS and Responsible Care ISO   |                                      |                       |                       |
|   | substance cycles and approaches from end-of-pipe   |                                      |                       | -                     |
|   | knowledge of complex industry related problems. The  | y are able to judge environmental is | ssues and to widel    | ly consider, apply or |
|   | carry out innovative technical solutions, remediation  | measures and further interventions   | as well as concept    | tual problem solving  |
|   | approaches in the full range of problems in different ind  | lustrial sectors.                    |                       |                       |
|   |  |                                      |                       |                       |
|   |  |                                      |                       |                       |
| Skills  | Students are able to assess current problems and situ  | ations in the field of environmental | protection. They ca   | an consider the best  |
|   | available techniques and to plan and suggest concrete  |                                      |                       |                       |
|   | solve problems on a technical, administrative and legis  | ative level.                         |                       |                       |
|   |  |                                      |                       |                       |
|   |  |                                      |                       |                       |
| Personal Competence                                   |  |                                      |                       |                       |
| Social Competence                                     | The students can work together in international groups   |                                      |                       |                       |
| ,   |  |                                      |                       |                       |
|   |  |                                      |                       |                       |
| Autonomy  | Students are able to organize their work flow to prepa   | re themselves for presentations and  | contributions to the  | he discussions. They  |
| ,   | can acquire appropriate knowledge by making enquirie   |                                      |                       | ,                     |
|   |  | ,                                    |                       |                       |
|   |  |                                      |                       |                       |
| Workload in Hours                                     | Independent Study Time 110, Study Time in Lecture 70   |                                      |                       |                       |
| Credit points   |  |                                      |                       |                       |
| Course achievement                                    |  |                                      |                       |                       |
| Examination   |  |                                      |                       |                       |
| Examination duration and                              |  |                                      |                       |                       |
| scale   | 30 111111  |                                      |                       |                       |
|   | Civil Engineering: Specialisation Water and Traffic: Flec  | tive Compulsory                      |                       |                       |
| •   | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory  Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective   |                                      |                       |                       |
| Tollowing Curricula                                   | Compulsory   | The Process Engineering, Focus is    | ianagement and        | controlling. Licetive |
|   | Energy and Environmental Engineering: Specialisation I   | Environmental Engineering: Elective  | Compulsory            |                       |
|   | Environmental Engineering: Core Qualification: Compul  | • •                                  |                       |                       |
|   | Joint European Master in Environmental Studies - Cities  | •                                    | iter: Elective Comp   | oulsory               |
|   | Joint European Master in Environmental Studies - Cities  | • •                                  |                       | •                     |
|   | Product Development, Materials and Production: Specia  | , ,                                  | 3,                    |                       |
|   | Product Development, Materials and Production: Specia  |                                      |                       |                       |
|   | Product Development, Materials and Production: Specia  | ·                                    | -                     |                       |
|   | Water and Environmental Engineering: Specialisation E  |                                      |                       |                       |
|   | Water and Environmental Engineering: Specialisation C  |                                      |                       |                       |
|   | and the second s | >                                    |                       |                       |

| Course L0502: Integrated Po | Ilution Control   |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 2   |
| СР                          | 2   |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     | The lecture focusses on:  |
|                             | <ul> <li>The Regulatory Framework</li> <li>Pollution &amp; Impacts, Characteristics of Pollutants</li> <li>Approaches of Integrated Pollution Control</li> <li>Sevilla Process, Best Available Technologies &amp; BREF Documents</li> <li>Case Studies: paper industry, cement industry, automotive industry</li> <li>Field Trip</li> </ul> |
| Literature                  | Förstner, Ulrich (1998): Integrated Pollution Control, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-80313-0  Shen, Thomas T. (1999): Industrial Pollution Prevention, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-65208-3  |

| Course L0387: Health, Safety | y and Environmental Management  |
|------------------------------|---|
| Тур                          | Lecture   |
| Hrs/wk                       | 2   |
| СР                           | 3   |
| Workload in Hours            | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                     | Hans-Joachim Nau  |
| Language                     | EN  |
| Cycle                        | WiSe  |
| Content                      | <ul> <li>Objectives of and benefit from HSE management</li> <li>From dilution and end-of-pipe technology to eco-efficiency and eco-effectiveness Behaviour control: regulations, economic instruments and voluntary initiatives</li> <li>Fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements Environmental performance evaluation Risk management: hazard, risk and safety Health and safety at the workplace</li> <li>Crisis management</li> </ul> |
| Literature                   | C. Stephan: Industrial Health, Safety and Environmental Management, MV-Verlag, Münster, 2007/2012 (can be found in the library under GTG 315)  Exercises can be downloaded from StudIP  |

| Course L0388: Health, Safety and Environmental Management |   |
|---|---|
| Тур   | Recitation Section (small)                          |
| Hrs/wk  | 1   |
| СР  | 1   |
| Workload in Hours   | Independent Study Time 16, Study Time in Lecture 14 |
| Lecturer  | Hans-Joachim Nau                                    |
| Language  | EN  |
| Cycle   | WiSe  |
| Content   | See interlocking course                             |
| Literature  | See interlocking course                             |

| Liigineeriiig                     |   |  |                         |         |
|-----------------------------------|---|--|-------------------------|---------|
| Module M0902: Wasto               | ewater Treatment and Air Po   | llution Abatement  |                         |         |
| Courses                           |   |  |                         |         |
| itle                              |   | Тур  | Hrs/wk                  | СР      |
| iological Wastewater Treatment (l | .0517)  | Lecture  | 2                       | 3       |
| ir Pollution Abatement (L0203)    |   | Lecture  | 2                       | 3       |
| Module Responsible                | Dr. Swantje Pietsch-Braune  |  |                         |         |
| Admission Requirements            | None  |  |                         |         |
| Recommended Previous              | Basic knowledge of biology and chemistry  | ,  |                         |         |
| Knowledge                         | harded and harden of call to a constant   | . A constant of the state of th |                         |         |
|                                   | basic knowledge of solids process enginee   | ering and separation technology  |                         |         |
|                                   |   |  |                         |         |
| Educational Objectives            | After taking part suggestibly students ba   | ave reached the following learning results   |                         |         |
| Educational Objectives            | After taking part successfully, students ha   | ave reactied the following learning results  |                         |         |
| Professional Competence           | After suggestful completion of the module   | students are able to   |                         |         |
| Kriowieuge                        | After successful completion of the module   | e students are able to   |                         |         |
|                                   | <ul> <li>name and explain biological proces</li> </ul>  | sses for waste water treatment,  |                         |         |
|                                   | <ul> <li>characterize waste water and sewa</li> </ul>   | ige sludge   |                         |         |
|                                   | <ul> <li>discuss legal regulations in the area</li> </ul>   | a of emissions and air quality   |                         |         |
|                                   | <ul> <li>classify off gas tretament processes</li> </ul>  | s and to define their area of application  |                         |         |
| Skills                            | Students are able to  |  |                         |         |
|                                   |   |  |                         |         |
|                                   |   | for the biological waste water treatment   | . d in the cases        |         |
|                                   | combine processes for cleaning of cle | off-gases depending on the pollutants containe   | ed in the gases         |         |
| Personal Competence               |   |  |                         |         |
| Social Competence                 |   |  |                         |         |
| Autonomy                          |   |  |                         |         |
| Workload in Hours                 | Independent Study Time 124, Study Time  | in Lecture 56  |                         |         |
| Credit points                     | 6   |  |                         |         |
| Course achievement                | None  |  |                         |         |
| Examination                       | Written exam  |  |                         |         |
| Examination duration and          | 90 min  |  |                         |         |
| scale                             |   |  |                         |         |
| Assignment for the                | Civil Engineering: Specialisation Water and   | d Traffic: Elective Compulsory   |                         |         |
| Following Curricula               |   | General Bioprocess Engineering: Elective Com   |                         |         |
|                                   |   | ecialisation General Process Engineering: Elect  |                         |         |
|                                   |   | pecialisation Environmental Engineering: Elect   | ive Compulsory          |         |
|                                   | Environmental Engineering: Specialisation   |  | Endougle Electric       | S I     |
|                                   |   | ng: Specialisation II. Energy and Environmental  |                         |         |
|                                   | Renewable Energies: Specialisation Bioen  | tudies - Cities and Sustainability: Specialisation   | i water: Elective Compi | uis01 y |
|                                   | ,   | ergy Systems: Elective Compulsory<br>Inmental Process Engineering: Elective Compu  | lsony                   |         |
|                                   | Process Engineering: Specialisation Process   |  | isoi y                  |         |
|                                   |   | aa Engineeriiig, Elective Cullibulbulv   |                         |         |
|                                   |   |  |                         |         |
|                                   | Water and Environmental Engineering: Sp<br>Water and Environmental Engineering: Sp  | ecialisation Water: Elective Compulsory  |                         |         |

| Тур               | Lecture   |
|-------------------|---|
| Hrs/wk            |   |
| СР                | 3   |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28 |
| Lecturer          | Dr. Joachim Behrendt                                |
| Language          | DE/EN   |
| Cycle             | WiSe  |
| Content           | Charaterisation of Wastewater                       |
|                   | Metobolism of Microorganisms                        |
|                   | Kinetic of mirobiotic processes                     |
|                   | Calculation of bioreactor for wastewater treatment  |
|                   | Concepts of Wastewater treatment                    |
|                   | Design of WWTP                                      |
|                   | Excursion to a WWTP                                 |
|                   | Biofilms  |
|                   | Biofim Reactors                                     |
|                   | Anaerobic Wastewater and sldge treatment            |
|                   | resources oriented sanitation technology            |
|                   | Future challenges of wastewater treatment           |

| Literature | Gujer, Willi   |
|------------|--|
|            | Siedlungswasserwirtschaft : mit 84 Tabellen  |
|            | ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?    |
|            | id=2842122&prov=M&dok_var=1&dok_ext=htm  |
|            | Berlin [u.a.] : Springer, 2007   |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Wastewater treatment : biological and chemical processes   |
|            | ISBN: 3540422285 (Pp.)   |
|            | Berlin [u.a.] : Springer, 2002   |
|            | TUB_HH_Katalog   |
|            | Imhoff, Karl (Imhoff, Klaus R.;)   |
|            | Taschenbuch der Stadtentwässerung : mit 10 Tafeln  |
|            | ISBN: 3486263331 ((Gb.))   |
|            | München [u.a.]: Oldenbourg, 1999   |
|            | TUB_HH_Katalog   |
|            | Lange, Jörg (Otterpohl, Ralf; Steger-Hartmann, Thomas;)  |
|            | Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft  |
|            | ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334          |
|            | Donaueschingen-Pfohren: Mall-Beton-Verl., 2000   |
|            | TUB_HH_Katalog   |
|            | Mudrack, Klaus (Kunst, Sabine;)  |
|            | Biologie der Abwasserreinigung : 18 Tabellen   |
|            | ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903                  |
|            | Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003  |
|            | TUB_HH_Katalog   |
|            | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)  |
|            | Wastewater engineering : treatment and reuse   |
|            | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))  |
|            | Boston [u.a.] : McGraw-Hill, 2003  |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Activated sludge models ASM1, ASM2, ASM2d and ASM3   |
|            | ISBN: 1900222248   |
|            | London: IWA Publ., 2002  |
|            | TUB_HH_Katalog   |
|            | Kunz, Peter  |
|            | Umwelt-Bioverfahrenstechnik  |
|            | Vieweg, 1992   |
|            | Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt (Deutsche Vereinigung für                |
|            | Wasserwirtschaft, Abwasser und Abfall, ;)  |
|            | Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe |
|            | aus der Abwasserbehandlung, Kleinkläranlagen   |
|            | ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL:  |
|            | http://www.gbv.de/dms/weimar/abs/513989765 abs.pdf   |
|            | Weimar: Universitätsverl, 2006   |
|            | TUB HH Katalog   |
|            | Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall   |
|            | DWA-Regelwerk  |
|            | Hennef: DWA, 2004  |
|            | TUB HH Katalog   |
|            | Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)  |
|            | Fundamentals of biological wastewater treatment  |
|            |  |
|            | ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm              |
|            | Weinheim: WILEY-VCH, 2007  |
|            | TUB_HH_Katalog   |
|            |  |

| Course L0203: Air Pollution | ourse L0203: Air Pollution Abatement   |  |  |
|-----------------------------|--|--|--|
| Тур                         | Lecture  |  |  |
| Hrs/wk                      | 2  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |  |  |
| Lecturer                    | Dr. Swantje Pietsch-Braune, Christian Eichler  |  |  |
| Language                    | EN   |  |  |
| Cycle                       | WiSe   |  |  |
| Content                     | In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators. |  |  |
| Literature                  | Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls 2. ed London [u.a.] : Spon, 2002   |  |  |

| Module M1403: Const                | ruction and Simulatio   | n of Sewerage Sy  | /stems   |   |                    |
|------------------------------------|---|---|--|---|--------------------|
| Courses                            |   |   |  |   |                    |
| Title                              |   |   | Тур  | Hrs/wk  | СР                 |
| Construction and renovation of urb | -   |   | Seminar  | 3   | 3                  |
| Simulation of sewerage systems (L  | 2006)   |   | Seminar  | 3   | 3                  |
| Module Responsible                 | Prof. Ralf Otterpohl  |   |  |   |                    |
| Admission Requirements             | None  |   |  |   |                    |
| Recommended Previous<br>Knowledge  | <ul> <li>Hydraulics in pipes and g</li> <li>Mechanics</li> <li>Soil mechanics and found</li> <li>Knowledge about urban s</li> </ul>   | dation engineering  | ster management  |   |                    |
| Educational Objectives             | After taking part successfully, s   | tudents have reached the  | following learning results   |   |                    |
| Professional Competence            |   |   |  |   |                    |
|                                    | Students can describe urban wa<br>and weak point analyzes. In add<br>to comprehend flow events in g<br>Students have knowledge of st<br>knowledge regarding different r   | dition, they can analyze t<br>ravity-sewers based on that<br>atic and structural requine<br>renovation technologies for | ne hydraulic effects quantitati<br>ne St. Venant equations.<br>rements of the sewer system.<br>or sewer systems is acquired. | vely. Furthermore, they be cases of damage are in | nave the knowledge |
| Skills                             | The students can simulate different run-off events in sewer systems and are able to dimension the sewer systems accordingly. Moreover, they can determine suitable construction materials and static requirements for different cases of application. |   |  |   |                    |
| Personal Competence                |   |   |  |   |                    |
| Social Competence                  | Students are able to apply the a  | acquired skills in a team a   | nd can impart this knowledge   |   |                    |
| Autonomy                           | Students can solve problems in the field of wastewater systems independently, concerning in particular dimensioning and simulation of sewer systems. Furthermore, they are able to present and justify their solutions.                               |   |  |   |                    |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84   |   |  |   |                    |
| Credit points                      | 6   |   |  |   |                    |
| Course achievement                 | CompulsoryBonusFormNo20 %Presenta   | <b>D</b> escri  | ption  |   |                    |
| Examination                        | Written elaboration   |   |  |   |                    |
| Examination duration and           | nach Absprache  |   |  |   |                    |
| scale                              |   |   |  |   |                    |
| Assignment for the                 | Civil Engineering: Specialisation   | Water and Traffic: Comp   | ulsory   |   |                    |
| Following Curricula                | Water and Environmental Engin   | eering: Specialisation Wa   | ter: Compulsory  |   |                    |
|                                    | Water and Environmental Engin   | eering: Specialisation En   | vironment: Elective Compulsor  | гу  |                    |

| Course L1998: Construction | and renovation of urban sewer systems                          |  |  |
|----------------------------|--|--|--|
| Тур                        | Seminar  |  |  |
| Hrs/wk                     |  |  |  |
| СР                         |  |  |  |
|                            | Independent Study Time 48, Study Time in Lecture 42            |  |  |
|                            | Prof. Ingo Weidlich  |  |  |
|                            |  |  |  |
| Language                   |  |  |  |
| Cycle                      |  |  |  |
| Content                    | The lecture focusses on construction and renovation of urban s | ewer pipelines.  |  |
|                            | Construction:  |  |  |
|                            | Pipe materials, types and joint technology                     |  |  |
|                            | Open trenches  |  |  |
|                            | Trenchless technologies  |  |  |
|                            | Dina Statica   |  |  |
|                            | Pipe Statics:  |  |  |
|                            | <ul> <li>Design of sewers according to ATV A 127</li> </ul>    |  |  |
|                            | Earth pressure on pipes, pipe deformation, cutting forces      |  |  |
|                            | Comparison with other international calculation approach       | hes  |  |
|                            | Renovation:  |  |  |
|                            | Failure case study   |  |  |
|                            | Overview on the different renovation technologies              |  |  |
|                            | Liner design according to DWA-A 143                            |  |  |
|                            |  |  |  |
| Literature                 |  | Titel  |  |
|                            | 1  | ATV A 127, Abwassertechnische Vereinigung e.V., Arbeitsblatt A                               |  |
|                            |  | 127, Regelwerk Abwasser-Abfall, Vertrieb: GFA, DK 628.22 (083),A 127, 2000                   |  |
|                            | 2  | DIN EN 1610, Verlegung und Prüfung von Abwasserleitungen und                                 |  |
|                            |  | -kanälen, Beuth Verlag, Berlin, 1997   |  |
|                            | 3  | Arbeitsblatt DWA-A 143-1, Sanierung von  |  |
|                            |  | Entwässerungssystemen außerhalb von Gebäuden, Teil 1:  |  |
|                            |  | Planung und Überwachung von Sanierungsmaßnahmen Februar                                      |  |
|                            |  | 2015   |  |
|                            | 4  | Arbeitsblatt DWA-A 143-2, Sanierung von Entwässerungssystemen außerhalb von Gebäuden Teil 2: |  |
|                            |  | Statische Berechnung zur Sanierung von Abwasserleitungen und                                 |  |
|                            |  | -kanälen mit Lining und Montageverfahren, Juli 2015  |  |
|                            | 5  | DIN EN 752:2008, 2008: Entwässerungssysteme außerhalb von                                    |  |
|                            |  | Gebäuden - Kanalmanagement.  |  |
|                            | 6  | Zeitschrift 3R, Fachzeitschrift für sichere und effiziente                                   |  |
|                            | 7  | Rohrleitungssysteme  |  |
|                            | 7  | Handbuch für den Rohrleitungsbau Band 1 und 2, 4. Auflage,<br>Günter Wossog, 2015            |  |
|                            | 8  | Rohrleitungstechnik, Walter Wagner, Vogel Buchverlag, 2006                                   |  |
|                            | 9  | Stein D., Stein R., "Instandhaltung von Kanalisationen", 1008 S.,                            |  |
|                            |  | ISBN 978-3-9810648-4-1   Verlag Prof. DrIng. Stein & Partner                                 |  |
|                            |  | GmbH, 2014   |  |
|                            | 10   | Stein, D., "Grabenloser Leitungsbau", 1. Auflage, Gebundene                                  |  |
|                            |  | Ausgabe - 1166 Seiten, Ernst & Sohn Verlag, 2003, ISBN:                                      |  |
|                            | 11   | 3433017786 Willoughby D:A: "Horizontal Directional Drilling: Utility and                     |  |
|                            | <del>* *</del>   | Pipeline Applications" Digital Engineering Library @ McGraw-Hill -                           |  |
|                            |  | The McGraw-Hill Companies, Inc., 2005  |  |
|                            | 12   | Weidlich I., "Erddruck auf Rohre", 1. Auflage, ISBN 3-89999-027-                             |  |
|                            |  | 7, 227 Seiten, 2012  |  |

| Course L2006: Simulation of | sewerage systems   |
|-----------------------------|--|
| Тур                         | Seminar  |
| Hrs/wk                      | 3  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42  |
| Lecturer                    | Prof. Ralf Otterpohl   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | Modeling of sewer systems:   |
|                             | <ul> <li>Modeling approaches in wastewater management, especially approaches to integrated modeling</li> <li>Planning processes, calculations and design approaches for elements of gravity-sewers</li> <li>Model setup</li> <li>St. Venant equation and simplifications of models (kinematic wave etc.)</li> <li>Calculation &amp; modeling of solids transport (advection, diffusion, dispersion and sales processes)</li> <li>Examples for modeling with SWMM (EPA, USA)</li> </ul> |
| Literature                  |  |

| Engineering"                                       |  |  |                       |                   |
|--|--|--|-----------------------|-------------------|
| Module M0581: Wate                                 | r Protection   |  |                       |                   |
| Courses  |  |  |                       |                   |
| Title  |  | Тур  | Hrs/wk                | СР                |
| Water Protection and Wastewater Management (L0226) |  | Lecture                                    | 3                     | 3                 |
| Water Protection and Wastewater                    | Management (L2008)   | Project Seminar                            | 3                     | 3                 |
| Module Responsible                                 | Prof. Ralf Otterpohl   |  |                       |                   |
| Admission Requirements                             | None   |  |                       |                   |
| Recommended Previous                               | • Pacia knowledge in water management  |  |                       |                   |
| Knowledge  | <ul><li>Basic knowledge in water management;</li><li>Good knowledge in urban drainage;</li></ul> |  |                       |                   |
|  | Good knowledge in diban dramage,     Good knowledge of wastewater treatmen                       | t techniques:                              |                       |                   |
|  | Good knowledge of pollutants (e.g. COD,  | ,  |                       |                   |
|  | 2 dood knowledge of politicality (e.g. eob,  | bob, 13, 14, 17 and then properties,       |                       |                   |
| <b>Educational Objectives</b>                      | After taking part successfully, students have rea  | sched the following learning results       |                       |                   |
| <b>Professional Competence</b>                     |  |  |                       |                   |
| Knowledge  | The students can describe the basic principles of  | f the regulatory framework related to the  | international and Eu  | ropean water sect |
|  | They can explain limnological processes, subs  | tance cycles and water morphology in       | detail. They are able | e to assess compl |
|  | problems related to water protection, such as  | ecosystem service and wastewater treat     | ment with a special   | focus on innovati |
|  | solutions, remediation measures as well as cond  | eptual approaches.                         |                       |                   |
| Skills   | Students can accurately assess current problen   | ns and situations in a country-specific or | local context. They o | an suggest concre |
|  | actions to contribute to the planning of tomo  |  |                       |                   |
|  | administrative and legislative solutions to solve  |  | .,                    | ., .,             |
|  |  |  |                       |                   |
| Personal Competence                                |  |  |                       |                   |
| Social Competence                                  | The students can work together in international groups.  |  |                       |                   |
|  |  |  |                       |                   |
|  |  |  |                       |                   |
|  |  |  |                       |                   |
| Autonomy   | Students are able to erganize their work flow to   | a property proceedations and discussions   | Thou can acquire an   | propriato knowlod |
| Autonomy   | Students are able to organize their work flow to<br>by making enquiries independently.           | prepare presentations and discussions.     | mey can acquire ap    | propriate knowled |
|  | zy making enquires macpendently.   |  |                       |                   |
|  |  |  |                       |                   |
|  |  |  |                       |                   |
|  |  |  |                       |                   |
|  |  |  |                       |                   |
| Workload in Hours                                  | Independent Study Time 96, Study Time in Lect  | ure 84                                     |                       |                   |
| Credit points                                      |  |  |                       |                   |
| Course achievement                                 | None   |  |                       |                   |
| Examination  | Presentation   |  |                       |                   |
| Examination duration and                           | Term paper plus presentation   |  |                       |                   |
| scale  |  |  |                       |                   |
|  |  |  |                       |                   |
| Assignment for the                                 | Civil Engineering: Specialisation Structural Engir   | , ,  |                       |                   |
| Following Curricula                                | Civil Engineering: Specialisation Geotechnical En  | • • •                                      |                       |                   |
|  | Civil Engineering: Specialisation Coastal Enginee  | . ,  |                       |                   |
|  | Civil Engineering: Specialisation Water and Traff  |  |                       |                   |
|  | Environmental Engineering: Specialisation Wate   | , ,  |                       |                   |
|  | International Management and Engineering: Spe  | • •  |                       |                   |
|  | Joint European Master in Environmental Studies   | • •  | water: Elective Comp  | ouisory           |
|  | Water and Environmental Engineering: Specialis   |  |                       |                   |
|  | Water and Environmental Engineering: Specialis   | , , ,                                      |                       |                   |
|  | Water and Environmental Engineering: Specialis   | ation Environment: Compulsory              |                       |                   |

| Course L0226: Water Protect | tion and Wastewater Management  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 3   |
| СР                          | 3   |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     | The lecture focusses on:  Regulatory Framework (e.g. WFD)  Main instruments for the water management and protection  In depth knowledge of relevant measures of water pollution control  Urban drainage, treatment options in different regions on the world  Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration  Case Studies and Field Trips   |
| Literature                  | <ul> <li>The literature listed below is available in the library of the TUHH.</li> <li>Water and wastewater technology Hammer, M. J. 1., &amp; . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.</li> <li>Water and wastewater engineering: design principles and practice: Davis, M. L. 1. (2011). New York, NY: McGraw-Hill.</li> <li>Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.</li> </ul> |

| Course L2008: Water Protect | urse L2008: Water Protection and Wastewater Management |  |
|-----------------------------|--|--|
| Тур                         | Project Seminar  |  |
| Hrs/wk                      | 3  |  |
| СР                          | 3  |  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42    |  |
| Lecturer                    | Prof. Ralf Otterpohl                                   |  |
| Language                    | EN   |  |
| Cycle                       | WiSe   |  |
| Content                     |  |  |
| Literature                  |  |  |

| Engineering                        |  |  |                                       |                       |
|------------------------------------|--|--|---------------------------------------|-----------------------|
| Module M0511: Electr               | icity Generation from Wind and Hy  | dro Power                              |                                       |                       |
| Courses                            |  |  |                                       |                       |
| Title                              |  | Тур                                    | Hrs/wk                                | СР                    |
| Sustainability Management (L0007)  |  | Lecture                                | 2                                     | 1                     |
| Hydro Power Use (L0013)            |  | Lecture                                | 1                                     | 1                     |
| Wind Turbine Plants (L0011)        | 10012)   | Lecture                                | 2                                     | 3                     |
| Wind Energy Use - Focus Offshore ( |  | Lecture                                | 1                                     | 1                     |
| •                                  | Dr. Isabel Höfer   |  |                                       |                       |
| Admission Requirements             | None   |  |                                       |                       |
| Recommended Previous               | Module: Technical Thermodynamics I,  |  |                                       |                       |
| Knowledge                          | Module: Technical Thermodynamics II,   |  |                                       |                       |
|                                    | Module: Fundamentals of Fluid Machanics  |  |                                       |                       |
|                                    | Module: Fundamentals of Fluid Mechanics  |  |                                       |                       |
| <b>Educational Objectives</b>      | After taking part successfully, students have reache   | ed the following learning results      |                                       |                       |
| <b>Professional Competence</b>     |  |  |                                       |                       |
| Knowledge                          | By ending this module students can explain in de   | tail knowledge of wind turbines wi     | th a particular focus of              | wind energy use ir    |
|                                    | offshore conditions and can critical comment these   | e aspects in consideration of curren   | t developments. Furthe                | rmore, they are able  |
|                                    | to describe fundamentally the use of water power $\boldsymbol{t}$                                      | to generate electricity. The students  | reproduce and explain                 | the basic procedure   |
|                                    | in the implementation of renewable energy projects   | s in countries outside Europe.         |                                       |                       |
|                                    | Through active discussions of various topics withi   | in the seminar of the module. stu      | dents improve their un                | derstanding and the   |
|                                    | application of the theoretical background and are the  |  |                                       | acrotationing and the |
|                                    |  | ,,                                     | , , , , , , , , , , , , , , , , , , , |                       |
| Skills                             | Students are able to apply the acquired theoretic  |  |                                       |                       |
|                                    | assess technically the resulting relationships in the  |  | • •                                   | -                     |
|                                    | compare critically the special procedure for the imp   |  | •                                     | side Europe with the  |
|                                    | in principle applied approach in Europe and can app  | oly this procedure on exemplary the    | oretical projects.                    |                       |
|                                    |  |  |                                       |                       |
| Personal Competence                |  |  | !                                     |                       |
| Social Competence                  | Students can discuss scientific tasks subjet-specific  | ciy and multidiscipilnary within a sel | minar.                                |                       |
| Autonomy                           | Students can independently exploit sources in the  | context of the emphasis of the le      | octure material to clear              | the contents of the   |
| Autonomy                           | lecture and to acquire the particular knowledge abo  |  | cture material to clear               | the contents of the   |
|                                    | recture and to dequire the particular knowledge abo  | out the subject area.                  |                                       |                       |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture   | 84                                     |                                       |                       |
| Credit points                      | 6  |  |                                       |                       |
| Course achievement                 | None   |  |                                       |                       |
| Examination                        | Written exam   |  |                                       |                       |
| Examination duration and           | 2.5 hours written exam + Prensentation in sustaina   | bility management                      |                                       |                       |
| scale                              |  |  |                                       |                       |
| Assignment for the                 | Civil Engineering: Specialisation Structural Engineer  | ring: Elective Compulsory              |                                       |                       |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engin   | neering: Elective Compulsory           |                                       |                       |
|                                    | Civil Engineering: Specialisation Coastal Engineering  | g: Elective Compulsory                 |                                       |                       |
|                                    | Energy and Environmental Engineering: Specialisati   |  |                                       |                       |
|                                    | International Management and Engineering: Specia   | • •                                    |                                       |                       |
|                                    | International Management and Engineering: Specia   | • •                                    |                                       | Compulsory            |
|                                    | Product Development, Materials and Production: Sp  | •                                      |                                       |                       |
|                                    | Product Development, Materials and Production: Sp  |  |                                       |                       |
|                                    | Product Development, Materials and Production: Sp<br>Renewable Energies: Core Qualification: Compulsor |  | puis0i y                              |                       |
|                                    | Theoretical Mechanical Engineering: Technical Com  |  | ılsory                                |                       |
|                                    | Theoretical Mechanical Engineering: Specialisation   |  | •                                     |                       |
|                                    | Process Engineering: Specialisation Environmental  |  | •                                     |                       |
|                                    | Water and Environmental Engineering: Specialisation  |  |                                       |                       |
|                                    | Water and Environmental Engineering: Specialisation  |  |                                       |                       |
|                                    |  |  |                                       |                       |

| Course L0007: Sustainability | Management   |
|------------------------------|--|
| Тур                          | Lecture  |
| Hrs/wk                       | 2  |
| СР                           | 1  |
| Workload in Hours            | Independent Study Time 2, Study Time in Lecture 28   |
| Lecturer                     | Dr. Anne Rödl  |
| Language                     | DE   |
| Cycle                        | WiSe   |
| Content                      | The lecture sustainability management provide an insight into the various aspects and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples. |
|                              | Introduction to the topic of sustainability  Dimensions of sustainability:  cellogy ceconomics social  Transition from the environmental assessment for sustainability management Case Studies Excursion  Objective: The aim of the course is to learn methods for the assessment of sustainability aspects and apply for sustainability.  |
|                              | Objective: The aim of the course is to learn methods for the assessment of sustainability aspects and apply for sustainability management.   |
| Literature                   | Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in globaler Verantwortung. Wiesbaden: Gabler Verlag.  |

| Тур               |
|-------------------|
| Hrs/wk            |
| СР                |
| Workload in Hours |
| Lecturer          |
| Language          |
| Cycle             |
|                   |
| Literature        |

| Course L0011: Wind Turbine Plants |   |
|-----------------------------------|---|
| Тур                               | Lecture   |
| Hrs/wk                            | 2   |
| СР                                | 3   |
| Workload in Hours                 | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                          | Dr. Rudolf Zellermann, Dr. Jochen Oexmann   |
| Language                          | DE  |
| Cycle                             | SoSe  |
| Content                           | <ul> <li>Historical development</li> <li>Wind: origins, geographic and temporal distribution, locations</li> <li>Power coefficient, rotor thrust</li> <li>Aerodynamics of the rotor</li> <li>Operating performance</li> <li>Power limitation, partial load, pitch and stall control</li> <li>Plant selection, yield prediction, economy</li> <li>Excursion</li> </ul> |
| Literature                        | Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005   |

| Course L0012: Wind Energy | Lecture  |
|---------------------------|--|
| Тур                       |  |
| Hrs/wk                    |  |
| СР                        |  |
|                           | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Prof. Martin Skiba   |
| Language                  | DE   |
| Cycle                     | SoSe   |
| Content                   | <ul> <li>Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>Physical fundamentals for utilization of wind energy</li> <li>Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>Development and planning of offshore wind farms</li> <li>Operation and optimization of offshore wind farms</li> <li>Day excursion</li> </ul> |
| Literature                | <ul> <li>Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage</li> <li>Hau, E.: Windkraftanlagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage</li> <li>Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>  |

| Module M0703: Soil a              | and Groundwater Contaminatio  | n   |        |    |
|-----------------------------------|---|---|--------|----|
|                                   |   |   |        |    |
| Courses                           |   |   |        |    |
| Title                             |   | Тур   | Hrs/wk | CP |
| Contamination and Remediation (L  |   | Project Seminar                             | 3      | 3  |
| NAPL in Soil and Groundwater (L05 |   | Lecture                                     | 1      | 1  |
| NAPL in Soil and Groundwater (L05 | 1   | Recitation Section (small)                  | 2      | 2  |
| Module Responsible                |   |   |        |    |
| Admission Requirements            | None  |   |        |    |
| Recommended Previous<br>Knowledge | <ul><li> Ground water hydrology</li><li> Geohydraulic and solute transport</li><li> Hydromechanics</li></ul>  |   |        |    |
| <b>Educational Objectives</b>     | After taking part successfully, students have   | reached the following learning results      |        |    |
| Professional Competence           |   |   |        |    |
| Knowledge                         | The students are able to analyse contamination in soils and groundwater. They are able to create remediation concepts for LNAPI contamnations. They are faminilar with Monitored Natural Attenuation  |   |        |    |
| Skills                            | The students are able to analyse contaminations in soils and groundwater using special engineering methods. They can do transport modelling in the unsaturated zone, estimations of groundwater pollution and analyse the impacts of remediation measures. They can forecast die distribution, mobility and remediation of non aquaous phase liquids in soil and groundwater. |   |        |    |
| Personal Competence               |   |   |        |    |
| Social Competence                 | The students are able to prepare complex contamination issues in teamwork and are able to find remediation measures.  |   |        |    |
| Autonomy                          | None  |   |        |    |
| Workload in Hours                 | Independent Study Time 96, Study Time in L  | ecture 84                                   |        |    |
| Credit points                     | 6   |   |        |    |
| Course achievement                | None  |   |        |    |
| Examination                       | Written exam  |   |        |    |
| Examination duration and          | Klausur 60 min; Referat 15 min;   |   |        |    |
| scale                             |   |   |        |    |
| Assignment for the                | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory  |   |        |    |
| •                                 | Water and Environmental Engineering: Spec   | · ·   |        |    |
|                                   | Water and Environmental Engineering: Spec   | ialisation Environment: Elective Compulsory |        |    |
|                                   | Water and Environmental Engineering: Spec   | ialisation Cities: Elective Compulsory      |        |    |

| Course L0547: Contamination and Remediation |  |  |
|---|--|--|
| Тур   | Project Seminar  |  |
| Hrs/wk                                      | 3  |  |
| СР  | 3  |  |
| Workload in Hours                           | Independent Study Time 48, Study Time in Lecture 42  |  |
| Lecturer                                    | Prof. Nima Shokri, Hannes Nevermann  |  |
| Language                                    | EN   |  |
| Cycle                                       | SoSe   |  |
| Content                                     | Processing of a complex soil and groundwater contamination site. Students perform analyses of data to detect the contamination |  |
|   | and to analyse the groundwater hazard and to develop a concept for remediation of the damage.                                  |  |
| Literature                                  | entfällt   |  |

| Course L0545: NAPL in Soil and Groundwater |  |  |
|--|--|--|
| Тур  | Lecture  |  |
| Hrs/wk                                     | 1  |  |
| СР   | 1  |  |
| Workload in Hours                          | Independent Study Time 16, Study Time in Lecture 14  |  |
| Lecturer                                   | Prof. Nima Shokri  |  |
| Language                                   | EN   |  |
| Cycle                                      | SoSe   |  |
| Content                                    | concept of capillarity, multi phase distribution in poraus media, residual saturation, rellative permeability, infiltration of NAPL into |  |
|  | the subsurface, vertical distribution of LNAPL, specific volume  |  |
| Literature                                 | Charbeneau, R.J. (2000): Groundwater Hydraulics and pollutant Transport  |  |

| Course L0546: NAPL in Soil and Groundwater |   |
|--|---|
| Тур  | Recitation Section (small)                          |
| Hrs/wk                                     | 2   |
| СР   | 2   |
| Workload in Hours                          | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer                                   | Prof. Nima Shokri                                   |
| Language                                   | EN  |
| Cycle                                      | SoSe  |
| Content                                    | See interlocking course                             |
| Literature                                 | See interlocking course                             |

| Module M0513: Syste   | em Aspects of Renewable Energies   |   |                  |                     |
|---|--|---|------------------|---------------------|
| Courses   |  |   |                  |                     |
| Title Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021) |  | Typ Lecture Lecture                     | Hrs/wk<br>2<br>1 | <b>CP</b> 2 1       |
| Energy Trading (L0019)<br>Energy Trading (L0020)  |  | Recitation Section (small)              | 1                | 1                   |
| Deep Geothermal Energy (L0025)  |  | Lecture                                 | 2                | 2                   |
| Module Responsible  | Prof. Martin Kaltschmitt   |   |                  |                     |
| Admission Requirements  | None   |   |                  |                     |
| Recommended Previous  | Module: Technical Thermodynamics I   |   |                  |                     |
| Knowledge   | Module: Technical Thermodynamics II  |   |                  |                     |
| Educational Objectives  | After taking part successfully, students have reached the follo  | wing learning results                   |                  |                     |
| <b>Professional Competence</b>  |  |   |                  |                     |
| Knowledge   | Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy. |   |                  |                     |
| Skills  | Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.  |   |                  |                     |
|   | Furthermore, the students are able to explain the procedures other modules on renewable energy projects. In this context markets and energy trades.  |   |                  |                     |
| Personal Competence   |  |   |                  |                     |
| Social Competence   | Students are able to discuss issues in the thematic fields in th   | e renewable energy sector addre         | ssed within the  | module.             |
| Autonomy  | Students can independently exploit sources , acquire the paquestions.  | articular knowledge about the su        | bject area and   | transform it to new |
| Workload in Hours   | Independent Study Time 96, Study Time in Lecture 84  |   |                  |                     |
| Credit points   | 6  |   |                  |                     |
| Course achievement  | None   |   |                  |                     |
|   | Written exam   |   |                  |                     |
| Examination duration and  | 3 hours written exam   |   |                  |                     |
| scale   |  |   |                  |                     |
| _   | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory   |   |                  |                     |
| Following Curricula   | Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory   |   |                  |                     |
|   | International Management and Engineering: Specialisation II. International Management and Engineering: Specialisation II.  | • | -                | Compulsory          |
|   | International Management and Engineering: Specialisation II.   | •                                       | •                |                     |
|   | Renewable Energies: Core Qualification: Compulsory   | rocess Engineering and biotech          | iology. Liective | Compaisory          |
|   | Process Engineering: Specialisation Environmental Process En   | gineering: Elective Compulsorv          |                  |                     |
|   | Process Engineering: Specialisation Process Engineering: Elect   |   |                  |                     |
|   | Water and Environmental Engineering: Specialisation Water: E   | lective Compulsory                      |                  |                     |
|   | Water and Environmental Engineering: Specialisation Environ  | nent: Elective Compulsory               |                  |                     |

| Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage |  |  |
|---|--|--|
| Тур   | Lecture  |  |
| Hrs/wk  | 2  |  |
| СР  | 2  |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer  | Prof. Michael Fröba  |  |
| Language  | DE   |  |
| Cycle   | SoSe   |  |
| Content   | <ol> <li>Introduction to electrochemical energy conversion</li> <li>Function and structure of electrolyte</li> <li>Low-temperature fuel cell         <ul> <li>Types</li> <li>Thermodynamics of the PEM fuel cell</li> <li>Cooling and humidification strategy</li> </ul> </li> <li>High-temperature fuel cell         <ul> <li>The MCFC</li> <li>The SOFC</li> <li>Integration Strategies and partial reforming</li> </ul> </li> <li>Fuels         <ul> <li>Supply of fuel</li> <li>Reforming of natural gas and biogas</li> <li>Reforming of liquid hydrocarbons</li> </ul> </li> <li>Energetic Integration and control of fuel cell systems</li> </ol> |  |
| Literature  | Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003   |  |

| Course L0019: Energy Tradin | ıg   |
|-----------------------------|--|
| Тур                         | Lecture  |
| Hrs/wk                      | 1  |
| СР                          | 1  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                    | Michael Sagorje, Dr. Sven Orlowski   |
| Language                    | DE   |
| Cycle                       | SoSe   |
| Content                     | <ul> <li>Basic concepts and tradable products in energy markets</li> <li>Primary energy markets</li> <li>Electricity Markets</li> <li>European Emissions Trading Scheme</li> <li>Influence of renewable energy</li> <li>Real options</li> <li>Risk management</li> </ul> Within the exercise the various tasks are actively discussed and applied to various cases of application. |
| Literature                  |  |

| Course L0020: Energy Tradin | ourse L0020: Energy Trading                         |  |
|-----------------------------|---|--|
| Тур                         | Recitation Section (small)                          |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Michael Sagorje, Dr. Sven Orlowski                  |  |
| Language                    | DE  |  |
| Cycle                       | SoSe  |  |
| Content                     | See interlocking course                             |  |
| Literature                  | See interlocking course                             |  |

| Course L0025: Deep Geother | mal Energy  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Dr. Ben Norden  |
| Language                   | DE  |
| Cycle                      | SoSe  |
| Content                    | <ol> <li>Introduction to the deep geothermal use</li> <li>Geological Basics I</li> <li>Geology and thermal aspects</li> <li>Rock Physical Aspects</li> <li>Geochemical aspects</li> <li>Exploration of deep geothermal reservoirs</li> <li>Drilling technologies, piping and expansion</li> <li>Borehole Geophysics</li> <li>Underground system characterization and reservoir engineering</li> <li>Microbiology and Upper-day system components</li> <li>Adapted investment concepts, cost and environmental aspect</li> </ol>   |
| Literature                 | <ul> <li>Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)</li> <li>www.geo-energy.org</li> <li>Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.</li> <li>Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.</li> <li>Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)</li> <li>Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH &amp; Co. KGaA; Auflage: 1. Auflage (19. April 2010)</li> </ul> |

| Engineering                                |  |   |                       |                       |
|--|--|---|-----------------------|-----------------------|
| Module M0827: Mode                         | ling in Water Management   |   |                       |                       |
| Courses                                    |  |   |                       |                       |
| Title                                      |  | Typ                                     | Hrs/wk                | СР                    |
| Groundwater Modeling using Modflow (L0543) |  | <b>Typ</b><br>Lecture                   | 1                     | 1                     |
| Groundwater Modeling using Modfl           |  | Recitation Section (small)              | 2                     | 2                     |
| Modeling of Water Supply and Sew           |  | Project-/problem-based Learning         | 2                     | 3                     |
| Module Responsible                         | Dr. Klaus Johannsen  |   |                       |                       |
| Admission Requirements                     | None   |   |                       |                       |
| Recommended Previous                       | Groundwater  |   |                       |                       |
| Knowledge                                  | a groundwater budraulies and transport of substan  |   |                       |                       |
|  | <ul> <li>groundwater hydraulics and transport of substan</li> </ul>  | ces                                     |                       |                       |
|  | Pipe Systems   |   |                       |                       |
|  | . Knowledge on urban water infrastructures in  | particular dripking water systems and u | rhan drainag          | a systems including   |
|  | <ul> <li>Knowledge on urban water infrastructures, in<br/>special structures</li> </ul>  | particular drinking water systemsand d  | ibali uralliay        | e systems including   |
|  | <ul> <li>Hydraulics of drinking water supply systems and</li> </ul>  | sawar systams                           |                       |                       |
|  | Basic knowledge on water management  | sewer systems                           |                       |                       |
|  | pasie knomeage on mater management   |   |                       |                       |
| Educational Objectives                     | After taking part successfully, students have reached the  | ne following learning results           |                       |                       |
| Professional Competence                    |  |   |                       |                       |
| Knowledge                                  | The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can |   |                       |                       |
|  | carry out systems analyses and can detect technical a  |   | ems in case s         | studies. Besides they |
|  | are able to analyse interdependencies of hydraulic and   | toxic phenomena in soil and water.      |                       |                       |
|  |  |   |                       |                       |
|  |  |   |                       |                       |
| Skills                                     | The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios     |   |                       |                       |
|  | and can compare or assess different solutions for existing problems by application of selected software products. The students a   |   | cts. The students are |                       |
|  | able to use different software solutions (e.g. EPANET, E   | PA-SWMM).                               |                       |                       |
|  |  |   |                       |                       |
|  |  |   |                       |                       |
|  |  |   |                       |                       |
| Personal Competence                        |  |   |                       |                       |
| Social Competence                          | Wird nicht vermittelt.   |   |                       |                       |
| <i>i.</i> .                                | Marine in the community of   |   |                       |                       |
| Autonomy                                   | Wird nicht vermittelt.   |   |                       |                       |
| Workload in Hours                          | Independent Study Time 110, Study Time in Lecture 70   |   |                       |                       |
| Credit points                              | 6  |   |                       |                       |
| Course achievement                         | None   |   |                       |                       |
| Examination                                | Oral exam  |   |                       |                       |
| Examination duration and                   | 20 min   |   |                       |                       |
| scale                                      |  |   |                       |                       |
| Assignment for the                         | Civil Engineering: Specialisation Structural Engineering   |   |                       |                       |
| Following Curricula                        | Civil Engineering: Specialisation Geotechnical Engineer  | • •                                     |                       |                       |
|  | Civil Engineering: Specialisation Coastal Engineering: E   |   |                       |                       |
|  | Civil Engineering: Specialisation Water and Traffic: Elec  |   |                       |                       |
|  | Water and Environmental Engineering: Specialisation W  | ' '                                     |                       |                       |
|  | Water and Environmental Engineering: Specialisation E  |   |                       |                       |
|  | Water and Environmental Engineering: Specialisation C  | ities: Elective Compulsory              |                       |                       |

| Course L0543: Groundwater | Modeling using Modflow   |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Sonja Götz   |
| Language                  | DE/EN  |
| Cycle                     | SoSe   |
| Content                   | Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work |
|                           | with the model PMWIN for practical case studies.   |
| Literature                | MODFLOW-Handbuch   |
|                           | Chiang, Wen Hsien: PMWIN   |
|                           |  |

| Course L0544: Groundwater | Course L0544: Groundwater Modeling using Modflow    |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (small)                          |  |
| Hrs/wk                    | 2   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                  | Sonja Götz  |  |
| Language                  | DE/EN   |  |
| Cycle                     | SoSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| ourse L0875: Modeling of Water Supply and Sewer Network |  |  |
|---|--|--|
| Тур   | Project-/problem-based Learning  |  |
| Hrs/wk  | 2  |  |
| СР  | 3  |  |
| Workload in Hours                                       | Independent Study Time 62, Study Time in Lecture 28  |  |
| Lecturer  | Dr. Klaus Johannsen, Weitere Mitarbeiter   |  |
| Language  | DE   |  |
| Cycle   | SoSe   |  |
| Content   |  |  |
| Literature  | Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014. |  |

| Module M0749: Waste Treatment and Solid Matter Process Technology  |           |
|--|-----------|
| Courses  |           |
| Title Typ Hrs/wk CP  |           |
| Solid Matter Process Technology for Biomass (L0052) Lecture 2 2  | ļ         |
| Thermal Waste Treatment (L0320) Lecture 2 2  | ļ         |
| Thermal Waste Treatment (L1177) Recitation Section (large) 1 2   |           |
| Module Responsible Prof. Kerstin Kuchta  |           |
| Admission Requirements None  |           |
| Recommended Previous Basics of   |           |
| Knowledge  • thermo dynamics   |           |
| fluid dynamics   |           |
| • chemistry  | ļ         |
| , and the second |           |
| Educational Objectives After taking part successfully, students have reached the following learning results  |           |
| Professional Competence  |           |
| Knowledge The students can name, describe current issue and problems in the field of thermal waste treatment and particle engineering and contemplate them in the context of their field.  | process   |
| The industrial application of unit operations as part of process engineering is explained by actual examples of waste inc  | ineration |
| technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglome  |           |
| renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, p   |           |
| and refining edible oils, electricity , heat and mineral recyclables.  |           |
|  |           |
| Skills The students are able to select suitable processes for the treatment of wastes or raw material with respect to their chara  |           |
| and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment co  | incepts.  |
| Personal Competence  |           |
| Social Competence Students can   |           |
| respectfully work together as a team and discuss technical tasks   |           |
| participate in subject-specific and interdisciplinary discussions,   | ļ         |
| develop cooperated solutions   | ļ         |
| <ul> <li>promote the scientific development and accept professional constructive criticism.</li> </ul>   |           |
|  |           |
| Autonomy Students can independently tap knowledge of the subject area and transform it to new questions. They are ca   |           |
| consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can  |           |
| targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impa  | ict.      |
| Workload in Hours Independent Study Time 110, Study Time in Lecture 70   |           |
| Credit points 6  |           |
| Course achievement None  |           |
| Examination Written exam   |           |
| Examination duration and 120 min   |           |
| scale  |           |
| Assignment for the Civil Engineering: Specialisation Water and Traffic: Elective Compulsory  |           |
| Following Curricula Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory   |           |
| Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory   |           |
| International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory  | 1         |
| International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory   | ļ         |
| Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory  |           |
| Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory  |           |
| Process Engineering: Specialisation Process Engineering: Elective Compulsory   | ļ         |
| Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory   | ļ         |
|  |           |
| Water and Environmental Engineering: Specialisation Environment: Compulsory  Water and Environmental Engineering: Specialisation Cities: Elective Compulsory   | į         |

| Course L0052: Solid Matter Process Technology for Biomass |  |  |
|---|--|--|
| Тур   | Lecture  |  |
| Hrs/wk  | 2  |  |
| СР  | 2  |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer  | Prof. Werner Sitzmann  |  |
| Language  | DE   |  |
| Cycle   | SoSe   |  |
| Content   | The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture. |  |
| Literature  | Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4  Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe,  Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de  Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175  |  |

| Course L0320: Thermal Wast | te Treatment  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Prof. Kerstin Kuchta  |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | <ul> <li>Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals</li> <li>basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition</li> <li>Incineration techniques: grate firing, ash transfer, boiler</li> <li>Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination</li> <li>Ash treatment: Mass, quality, treatment concepts, recycling, disposal</li> </ul> |
| Literature                 | Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.   |

| Course L1177: Thermal Waste Treatment |   |  |
|---------------------------------------|---|--|
| Тур                                   | Recitation Section (large)                          |  |
| Hrs/wk                                | 1   |  |
| СР                                    | 2   |  |
| Workload in Hours                     | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                              | Prof. Kerstin Kuchta                                |  |
| Language                              | EN  |  |
| Cycle                                 | SoSe  |  |
| Content                               | See interlocking course                             |  |
| Literature                            | See interlocking course                             |  |

| Linginicering                           |  |                  |                       |
|---|--|------------------|-----------------------|
| Module M0828: Urbai                     | n Environmental Management   |                  |                       |
|   |  |                  |                       |
| Courses                                 |  |                  |                       |
| Title                                   | Тур  | Hrs/wk           | СР                    |
| Noise Protection (L1109)                | Lecture  | 2                | 2                     |
| Urban Infrastructures (L0874)           | Project-/problem-based Lear  | ning 2           | 4                     |
| Module Responsible                      |  |                  |                       |
| Admission Requirements                  |  |                  |                       |
| Recommended Previous                    | Knowledge on Urban planning  |                  |                       |
| Knowledge                               | Knowledge on measures for climate protection   |                  |                       |
|   | General knowledge of scientific writing/working  |                  |                       |
|   | J. J   |                  |                       |
| Educational Objectives                  | After taking part successfully, students have reached the following learning results             |                  |                       |
| <b>Professional Competence</b>          |  |                  |                       |
| Knowledge                               | Students can describe urban development corridors as well as current and future urban en         | vironmental prob | ems. They are able to |
|   | explain the causes of environmental problems (like noise).                                       |                  |                       |
|   | Students can specify applications for various technical innovations and explain why these        | ontribute to the | improvement of urba   |
|   | life. They can, for example, derive and discuss measures for effective noise abatement.          |                  |                       |
| Skills                                  | Students are able to develop specific solutions for correcting existing or future er             | vironment-relate | d problems of urba    |
| Skills                                  | development. They can define a range of conceptual and technical solutions for environme         |                  | •                     |
|   | paths. To solve specific urban environmental problems they can select technical innovati         |                  | ·                     |
|   | context.   | nis and meegrate |                       |
| Personal Competence                     |  |                  |                       |
|   | The students can work together in international groups.  |                  |                       |
| ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | 3  |                  |                       |
| Autonomy                                | 1  | contributions to | the discussions. The  |
|   | can acquire appropriate knowledge by making enquiries independently.                             |                  |                       |
| Workload in Hours                       | Independent Study Time 124, Study Time in Lecture 56   |                  |                       |
| Credit points                           | 6  |                  |                       |
| Course achievement                      | None   |                  |                       |
| Examination                             | Written elaboration  |                  |                       |
| Examination duration and                | Written Report plus oral Presentation  |                  |                       |
| scale                                   |  |                  |                       |
| Assignment for the                      | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory                    |                  |                       |
| Following Curricula                     |  |                  |                       |
|   | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory                       |                  |                       |
|   | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory                         |                  |                       |
|   | Environmental Engineering: Core Qualification: Elective Compulsory                               |                  |                       |
|   | Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualificatio    | n: Compulsory    |                       |
|   | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Col | npulsory         |                       |
|   | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory             |                  |                       |
|   | Water and Environmental Engineering: Specialisation Cities: Compulsory                           |                  |                       |

| Course L1109: Noise Protection |  |  |
|--------------------------------|--|--|
| Тур                            | Lecture  |  |
| Hrs/wk                         | 2  |  |
| СР                             | 2  |  |
| Workload in Hours              | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer                       | Prof. Martin Jäschke   |  |
| Language                       | EN   |  |
| Cycle                          | SoSe   |  |
| Content                        |  |  |
| Literature                     | 1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German)                                   |  |
|                                | 2) WHO (1999): Guidelines for Community Noise  |  |
|                                | 3) Environmental Noise Directive 2002/49/EG  |  |
|                                | 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation |  |

| Course L0874: Urban Infrastructures |   |  |
|-------------------------------------|---|--|
| Тур                                 | Project-/problem-based Learning   |  |
| Hrs/wk                              | 2   |  |
| СР                                  | 4   |  |
| Workload in Hours                   | Independent Study Time 92, Study Time in Lecture 28   |  |
| Lecturer                            | Dr. Dorothea Rechtenbach  |  |
| Language                            | EN  |  |
| Cycle                               | SoSe  |  |
| Content                             | Problem Based Learning  Main topics are:  Central vs. Decentral Wastewater Treatment. Compaction of Cities. Car Free Cities. Multifunctional Places in Cities. The Sustainability of Freight Transport in Cities. |  |
| Literature                          | Depends on chosen topic.  |  |

| Engineering                        |   |   |                    |                       |
|------------------------------------|---|---|--------------------|-----------------------|
| Module M0857: Geoch                | hemical Engineering   |   |                    |                       |
| Courses                            |   |   |                    |                       |
| Title                              |   | Тур   | Hrs/wk             | СР                    |
| Contaminated Sites and Landfilling | (L0906)   | Lecture                                     | 2                  | 2                     |
| Contaminated Sites and Landfilling | (L0907)   | Recitation Section (large)                  | 1                  | 2                     |
| Geochemical Engineering (L0904)    |   | Lecture                                     | 2                  | 2                     |
| Module Responsible                 | Dr. Marco Ritzkowski  |   |                    |                       |
| Admission Requirements             | None  |   |                    |                       |
| Recommended Previous               | Module: General and Inorganic Chemistry,  |   |                    |                       |
| Knowledge                          | Module:Organic Chemistry,   |   |                    |                       |
|                                    | Biology (Basic Knowledge)   |   |                    |                       |
|                                    |   |   |                    |                       |
|                                    |   |   |                    |                       |
| Educational Objectives             | After taking part successfully, students have reache  | ed the following learning results           |                    |                       |
| Professional Competence            |   |   |                    |                       |
| Knowledge                          | With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in |   |                    |                       |
|                                    | soil and groundwater, and techniques to deposit co  | ntaminated waste material. They are able    | to describe in pri | inciple the behaviour |
|                                    | of chemicals in the environment. Students can expl  | ain and report the approach to remediate    | contaminated sit   | es.                   |
| Skills                             | With the completion of this module students can   | apply the acquired theoretical knowledge    | to model cases     | of site pollution and |
| Skiiis                             | critically assess the situation technically and conce   |   |                    | ·                     |
|                                    | and techniques. Model projects can be devised and   |   | on amerene re      | mediation strategies  |
|                                    | and teeningles. Model projects can be devised and   | treated.                                    |                    |                       |
| Personal Competence                |   |   |                    |                       |
| Social Competence                  | Students can discuss technical and scientific tasks   | within a seminar subject specific and inter | disciplinary .     |                       |
| Autonomy                           | Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.    |   |                    |                       |
| Workload in Hours                  | Independent Study Time 110, Study Time in Lecture   | e 70  |                    |                       |
| Credit points                      | 6   |   |                    |                       |
| Course achievement                 | None  |   |                    |                       |
| Examination                        | Written exam  |   |                    |                       |
| Examination duration and           | 2 hours   |   |                    |                       |
| scale                              |   |   |                    |                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic:  | Elective Compulsory                         |                    |                       |
| Following Curricula                | Environmental Engineering: Core Qualification: Elec   | ctive Compulsory                            |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation   | on Water: Elective Compulsory               |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation   | on Environment: Elective Compulsory         |                    |                       |
|                                    | Water and Environmental Engineering: Specialisation   | on Cities: Elective Compulsory              |                    |                       |

| Course L0906: Contaminated | Sites and Landfilling   |  |
|----------------------------|---|--|
| Тур                        | Lecture   |  |
| Hrs/wk                     | 2   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer                   | Dr. Marco Ritzkowski, Dr. Joachim Gerth   |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    | The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects.  The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare. |  |
| Literature                 | 1) Waste Management. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105, Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) Solid Waste Technology and Management. Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3, Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) Natural attenuation of fuels and chlorinated solvents in the subsurface. Todd H. Wiedemeier(Ed.), ISBN: 0471197491  Lesesaal 2: US - Umweltschutz, Signatur USH-844  |  |

| Course L0907: Contaminated Sites and Landfilling |   |  |
|--|---|--|
| Тур  | Recitation Section (large)                          |  |
| Hrs/wk   | 1   |  |
| СР   | 2   |  |
| Workload in Hours                                | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer   | Dr. Marco Ritzkowski, Dr. Joachim Gerth             |  |
| Language   | EN  |  |
| Cycle  | SoSe  |  |
| Content  | See interlocking course                             |  |
| Literature                                       | See interlocking course                             |  |

| Course L0904: Geochemical |  |  |  |
|---------------------------|--|--|--|
| Тур                       | Lecture  |  |  |
| Hrs/wk                    | 2  |  |  |
| СР                        | 2  |  |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28  |  |  |
| Lecturer                  | Dr. Joachim Gerth  |  |  |
| Language                  | EN   |  |  |
| Cycle                     | SoSe   |  |  |
|                           | As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment. |  |  |
| Literature                | Geochemistry, groundwater and pollution. C. A. J. Appelo; D. Postma  Leiden [u.a.] Balkema 2005  Lehrbuchsammlung der TUB, Signatur GWC-515  |  |  |

| Module M0870: Mana  | gement of Surface Water   |                                     |                   |                     |  |
|---|---|-------------------------------------|-------------------|---------------------|--|
| Courses   |   |                                     |                   |                     |  |
| Title   |   | Тур                                 | Hrs/wk            | СР                  |  |
|   |   | Lecture                             | 3                 | 4                   |  |
| Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961) |   | Project-/problem-based Learning     | 2                 | 2                   |  |
| Module Responsible  | Prof. Peter Fröhle  |                                     |                   |                     |  |
| Admission Requirements  | None  |                                     |                   |                     |  |
| Recommended Previous  | Fundamentals of Hydromechanics, Hydraulics, Hydrology and           | Hydraulic Engineering; Hydrau       | ılic Engineering  | I and Hydraulic     |  |
| Knowledge   | Engineering II  |                                     |                   |                     |  |
| <b>Educational Objectives</b>   | After taking part successfully, students have reached the following | ng learning results                 |                   |                     |  |
| Professional Competence   |   |                                     |                   |                     |  |
| Knowledge   | Students are able to define in detail the basic processes that      | are related to the modelling of     | of flows in hydr  | aulic engineering.  |  |
|   | Besides, they can describe the basic aspects of numerical mode      | elling and actual numerical mode    | els for the simul | lation of flows and |  |
|   | waves. They can also depict the concepts of nature oriented hyd     | raulic engineering.                 |                   |                     |  |
| a   |   |                                     |                   |                     |  |
| Skills  | Students are able to apply hydrodynamic-numerical models to pr      |                                     |                   |                     |  |
|   | able to set up flood-risk management concepts and are able to a     | pply basic concepts of renaturati   | on to practical p | problems.           |  |
| Personal Competence   |   |                                     |                   |                     |  |
| Social Competence   | The students are able to deploy their gained knowledge in appl      | ied problems of the practical na    | ture-based hydr   | raulic engineering. |  |
|   | Additionaly, they will be able to work in team with engineers of o  | ther disciplines.                   |                   |                     |  |
| Autonomy  | The students will be able to independently extend their knowledg    | ge and apply it to new problems.    |                   |                     |  |
| Workload in Hours   | Independent Study Time 110, Study Time in Lecture 70                |                                     |                   |                     |  |
| Credit points   |   |                                     |                   |                     |  |
| Course achievement  |   |                                     |                   |                     |  |
| Examination   | Written exam  |                                     |                   |                     |  |
| Examination duration and  | The duration of the examination is 150 min. The examination         | includes tasks with respect to t    | the general und   | derstanding of the  |  |
| scale   | lecture contents and calculations tasks.                            |                                     |                   |                     |  |
| Assignment for the  | Civil Engineering: Specialisation Water and Traffic: Compulsory     |                                     |                   |                     |  |
| Following Curricula   | Environmental Engineering: Core Qualification: Elective Compuls     | ory                                 |                   |                     |  |
|   | Joint European Master in Environmental Studies - Cities and Susta   | ainability: Core Qualification: Cor | npulsory          |                     |  |
|   | Water and Environmental Engineering: Specialisation Water: Con      | npulsory                            |                   |                     |  |
|   | Water and Environmental Engineering: Specialisation Environmen      | nt: Compulsory                      |                   |                     |  |
|   | Water and Environmental Engineering: Specialisation Cities: Elec    | tive Compulsory                     |                   |                     |  |
|   |   |                                     |                   |                     |  |

| qyT               | Lecture  |
|-------------------|--|
| Hrs/wk            |  |
| CP                |  |
| Workload in Hours | Independent Study Time 78, Study Time in Lecture 42  |
|                   | Dr. Edgar Nehlsen, Prof. Peter Fröhle  |
| Language          | DE/EN  |
| Cycle             | SoSe   |
| Content           | Basics of numerial models / application of models  |
|                   | <ul> <li>classification of models</li> <li>model concept</li> <li>modelling</li> <li>1D Working Equation</li> <li>Mathematical description of physical processes</li> <li>Equation of motions</li> <li>o conservation of mass</li> <li>conservation of momentum</li> <li>Initial conditions and boundary conditions</li> </ul> |
|                   | Numerical Methods  • Time step procedure  • Finite differences  • Finite volumes   |
| Litoratura        | Vorlesungsskript   |

| Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection |   |  |
|---|---|--|
| Тур   | Project-/problem-based Learning   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer  | Dr. Natasa Manojlovic, Prof. Peter Fröhle   |  |
| Language  | DE/EN   |  |
| Cycle   | SoSe  |  |
| Content   | <ul> <li>Regime-Theory and application for the development of environmental guiding priciples of rivers</li> <li>Engineering - biological measures for the stabilization of rivers</li> <li>Risk management in flood protection</li> <li>Design techniques in technical flood protection</li> <li>Methods for the assessment of flood caused damages</li> </ul> |  |
| Literature  | Vorlesungsumdruck   |  |

| Module M0871: Hydro                | ological Systems   |  |                 |                       |
|------------------------------------|--|--|-----------------|-----------------------|
| Courses                            |  |  |                 |                       |
| Title                              |  | Тур  | Hrs/wk          | СР                    |
| Applied Surface Hydrology (L0289)  |  | Lecture  | 2               | 2                     |
| Applied Surface Hydrology (L1412)  |  | Project-/problem-based Learning                | 1               | 2                     |
| Interaction Water - Environment in | Fluvial Areas (L0295)  | Project-/problem-based Learning                | 1               | 2                     |
| Module Responsible                 | Prof. Peter Fröhle   |  |                 |                       |
| Admission Requirements             | None   |  |                 |                       |
| Recommended Previous               | Fundamentals of Hydromechanics and Hydraulic Engin                       | eering: Hydraulic Engineering I and Hydra      | ulic Engineerir | ng II                 |
| Knowledge                          |  |  |                 |                       |
| Educational Objectives             | After taking part successfully, students have reached t                  | he following learning results                  |                 |                       |
| Professional Competence            |  |  |                 |                       |
| Knowledge                          | The students are able to define the basic concepts of                    | hydrology and water management. They           | are able to d   | escribe and quantify  |
|                                    | the relevant processes of the hydrological water cycle                   | Besides, the students know the main asp        | ects of rainfa  | ll-run-off-models and |
|                                    | are able to theoretically derive established reservoir / s               | storage models and a unit-hydrograph.          |                 |                       |
| Skills                             | The students are able to use the basic hydrological                      | concepts and approaches and are able to        | o theoreticall  | v dorivo ostablishod  |
| Skilis                             | reservoir / storage models or a unit-hydrograph as the                   |  |                 | -                     |
|                                    | concepts of measurements of hydrological and hydrol                      |  |                 | *                     |
|                                    | assess these measurements. Furthermore, they are ab                      |  | •               | -                     |
|                                    | assess these measurements. Furthermore, they are up                      | ic to apply a flyarological filoder to basic f | iyarological pi | obicitis.             |
| Personal Competence                |  |  |                 |                       |
| Social Competence                  | The students are able to deploy their gained knowledg                    | e in applied problems of the hydrology an      | d water mana    | gement. Additionaly,  |
|                                    | they will be able to work in team with engineers of other                | er disciplines.                                |                 |                       |
| Autonomy                           | The students will be able to independently extend their                  | knowledge and apply it to new problems         |                 |                       |
| Workload in Hours                  | Independent Study Time 124, Study Time in Lecture 56                     | 5  |                 |                       |
| Credit points                      | 6  |  |                 |                       |
| Course achievement                 | None   |  |                 |                       |
| Examination                        | Written exam   |  |                 |                       |
| Examination duration and           | The duration of the examination is 90 min. The examin                    | ation includes tasks with respect to the ge    | eneral underst  | anding of the lecture |
| scale                              | contents and calculations tasks.   |  |                 |                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory |  |                 |                       |
| Following Curricula                | Environmental Engineering: Core Qualification: Elective                  | e Compulsory                                   |                 |                       |
|                                    | Joint European Master in Environmental Studies - Cities                  | and Sustainability: Core Qualification: Co     | mpulsory        |                       |
|                                    | Water and Environmental Engineering: Specialisation V                    | Vater: Elective Compulsory                     |                 |                       |
|                                    | Water and Environmental Engineering: Specialisation E                    | nvironment: Elective Compulsory                |                 |                       |
|                                    | Water and Environmental Engineering: Specialisation C                    | Cities: Elective Compulsory                    |                 |                       |

| Course L0289: Applied Surfa | ce Hydrology  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 2   |
| СР                          | 2   |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                    | Prof. Peter Fröhle  |
| Language                    | DE/EN   |
| Cycle                       | SoSe  |
| Content                     | Basics of hydrology:  |
|                             | <ul> <li>Hydrological cycle</li> <li>Data acquisition</li> <li>Data analyses and statistical assessment</li> <li>Statistics of extremes</li> <li>Regionalization methods for hydrological values</li> <li>Rainfall-run-off modelling on the basis of a unit hydrograph conceps</li> <li>Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul> |
| Literature                  | http://de.wikipedia.org/wiki/Kalypso_(Software)   |
|                             | http://kalypso.bjoernsen.de/  |
|                             | http://sourceforge.net/projects/kalypso/  |
|                             |   |

| Course L1412: Applied Surface Hydrology |   |
|---|---|
| Тур                                     | Project-/problem-based Learning                     |
| Hrs/wk                                  | 1   |
| СР                                      | 2   |
| Workload in Hours                       | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                | Prof. Peter Fröhle                                  |
| Language                                | DE/EN   |
| Cycle                                   | SoSe  |
| Content                                 | See interlocking course                             |
| Literature                              | See interlocking course                             |

| Course L0295: Interaction W | Course L0295: Interaction Water - Environment in Fluvial Areas   |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project-/problem-based Learning  |  |  |
| Hrs/wk                      | 1  |  |  |
| СР                          | 2  |  |  |
| Workload in Hours           | Independent Study Time 46, Study Time in Lecture 14  |  |  |
| Lecturer                    | Prof. Peter Fröhle   |  |  |
| Language                    | DE/EN  |  |  |
| Cycle                       | SoSe   |  |  |
| Content                     | A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester. |  |  |
| Literature                  | -  |  |  |

| Module M0874: Waste                | ewater Systems  |                                      |                   |                           |
|------------------------------------|---|--------------------------------------|-------------------|---------------------------|
| Courses                            |   |                                      |                   |                           |
| Title                              |   | Тур                                  | Hrs/wk            | СР                        |
| Wastewater Systems - Collection, T | reatment and Reuse (L0934)                                  | Lecture                              | 2                 | 2                         |
| Wastewater Systems - Collection, T | reatment and Reuse (L0943)                                  | Recitation Section (large)           | 1                 | 1                         |
| Advanced Wastewater Treatment (    | L0357)  | Lecture                              | 2                 | 2                         |
| Advanced Wastewater Treatment (    | L0358)  | Recitation Section (large)           | 1                 | 1                         |
| Module Responsible                 | Prof. Ralf Otterpohl  |                                      |                   |                           |
| Admission Requirements             | None  |                                      |                   |                           |
| Recommended Previous               | Knowledge of wastewater management and the key proc         | esses involved in wastewater treatm  | nent.             |                           |
| Knowledge                          |   |                                      |                   |                           |
| <b>Educational Objectives</b>      | After taking part successfully, students have reached the   | following learning results           |                   |                           |
| <b>Professional Competence</b>     |   |                                      |                   |                           |
| Knowledge                          | Students are able to outline key areas of the full range o  | f treatment systems in waste water   | management, as    | well as their mutual      |
|                                    | dependence for sustainable water protection. They can d     | escribe relevant economic, environn  | nental and social | factors.                  |
| GL W.                              |   |                                      |                   | Called a contraction of a |
| SKIIIS                             | Students are able to pre-design and explain the availab     | le wastewater treatment processes    | and the scope o   | t their application in    |
|                                    | municipal and for some industrial treatment plants.         |                                      |                   |                           |
| Personal Competence                |   |                                      |                   |                           |
| Social Competence                  | Social skills are not targeted in this module.              |                                      |                   |                           |
|                                    |   |                                      |                   |                           |
| Autonomy                           | Students are in a position to work on a subject and to      | organize their work flow independ    | dently. They can  | also present on this      |
|                                    | subject.  |                                      |                   |                           |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84         |                                      |                   |                           |
| Credit points                      | 6   |                                      |                   |                           |
| Course achievement                 | None  |                                      |                   |                           |
| Examination                        | Written exam  |                                      |                   |                           |
| Examination duration and           | 120 min   |                                      |                   |                           |
| scale                              |   |                                      |                   |                           |
| Assignment for the                 | Civil Engineering: Specialisation Structural Engineering: E | lective Compulsory                   |                   |                           |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engineering  | g: Elective Compulsory               |                   |                           |
|                                    | Civil Engineering: Specialisation Coastal Engineering: Elec | ctive Compulsory                     |                   |                           |
|                                    | Civil Engineering: Specialisation Water and Traffic: Comp   | ulsory                               |                   |                           |
|                                    | Bioprocess Engineering: Specialisation A - General Biopro   | cess Engineering: Elective Compulso  | ory               |                           |
|                                    | Energy and Environmental Engineering: Specialisation En     | vironmental Engineering: Elective C  | ompulsory         |                           |
|                                    | Environmental Engineering: Specialisation Water: Elective   | e Compulsory                         |                   |                           |
|                                    | International Management and Engineering: Specialisatio     | n II. Energy and Environmental Engi  | neering: Elective | Compulsory                |
|                                    | International Management and Engineering: Specialisatio     | n II. Process Engineering and Biotec | hnology: Elective | Compulsory                |
|                                    | Process Engineering: Specialisation Environmental Proces    | ss Engineering: Elective Compulsory  |                   |                           |
|                                    | Process Engineering: Specialisation Process Engineering:    | Elective Compulsory                  |                   |                           |
|                                    | Water and Environmental Engineering: Specialisation Water   | ter: Compulsory                      |                   |                           |
|                                    | Water and Environmental Engineering: Specialisation Env     |                                      |                   |                           |
|                                    | Water and Environmental Engineering: Specialisation Citi    | es: Compulsory                       |                   |                           |

| Course L0934: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|--|--|--|
| Тур  | ecture   |  |
| Hrs/wk   | 2  |  |
| СР   | 2  |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer   | Prof. Ralf Otterpohl   |  |
| Language   | EN   |  |
| Cycle  | SoSe   |  |
| Content  | •Understanding the global situation with water and wastewater  |  |
|  | •Regional planning and decentralised systems   |  |
|  | Overview on innovative approaches  |  |
|  | •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse |  |
|  | Mathematical Modelling of Nitrogen Removal   |  |
|  | •Exercises with calculations and design  |  |
| Literature   | Henze, Mogens:   |  |
|  | Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages                                |  |
|  | George Tchobanoglous, Franklin L. Burton, H. David Stensel:  |  |
|  | Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy  |  |
|  | McGraw-Hill, 2004 - 1819 pages   |  |

| Course L0943: Wastewater S | urse L0943: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|----------------------------|--|--|--|
| Тур                        | Recitation Section (large)                                       |  |  |
| Hrs/wk                     | 1  |  |  |
| СР                         | 1  |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14              |  |  |
| Lecturer                   | Prof. Ralf Otterpohl   |  |  |
| Language                   | EN   |  |  |
| Cycle                      | SoSe   |  |  |
| Content                    | See interlocking course  |  |  |
| Literature                 | See interlocking course  |  |  |

| Course L0357: Advanced Wa | stewater Treatment  |
|---------------------------|---|
| Тур                       | Lecture   |
| Hrs/wk                    | 2   |
| СР                        | 2   |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                  | Dr. Joachim Behrendt  |
| Language                  | EN  |
| Cycle                     | SoSe  |
| Content                   | Survey on advanced wastewater treatment   |
|                           | reuse of reclaimed municipal wastewater   |
|                           | Precipitation   |
|                           | Flocculation  |
|                           | Depth filtration  |
|                           | Membrane Processes  |
|                           | Activated carbon adsorption   |
|                           | Ozonation   |
|                           | "Advanced Oxidation Processes"  |
|                           | Disinfection  |
| Literature                | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003   |
|                           | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987  |
|                           | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007  |
|                           | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung,<br>Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |
|                           | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003  |

| Course L0358: Advanced Wa | stewater Treatment   |
|---------------------------|--|
| Тур                       | Recitation Section (large)   |
| Hrs/wk                    | 1  |
| СР                        | 1  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                  | Dr. Joachim Behrendt   |
| Language                  | EN   |
| Cycle                     | SoSe   |
| Content                   | Aggregate organic compounds (sum parameters)   |
|                           | Industrial wastewater  |
|                           | Processes for industrial wastewater treatment  |
|                           | Precipitation  |
|                           | Flocculation   |
|                           | Activated carbon adsorption  |
|                           | Recalcitrant organic compounds   |
|                           |  |
| Literature                | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003  |
|                           | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987   |
|                           | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007   |
|                           | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |
|                           | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003   |

| Module M0875: Nexus                | s Engineering - Water, Soil, Food an                                 | d Energy                           |                            |                      |
|------------------------------------|--|------------------------------------|----------------------------|----------------------|
| Courses                            |  |                                    |                            |                      |
| Title                              |  | Тур                                | Hrs/wk                     | СР                   |
| Ecological Town Design - Water, En |  | Seminar                            | 2                          | 2                    |
| Water & Wastewater Systems in a    | Global Context (L0939)   | Lecture                            | 2                          | 4                    |
| Module Responsible                 | Prof. Ralf Otterpohl   |                                    |                            |                      |
| Admission Requirements             | None   |                                    |                            |                      |
| Recommended Previous               | Basic knowledge of the global situation with rising                  | poverty, soil degradation, migra   | ition to cities, lack of v | vater resources and  |
| Knowledge                          | sanitation   |                                    |                            |                      |
| Educational Objectives             | After taking part successfully, students have reached                | d the following learning results   |                            |                      |
| Professional Competence            |  |                                    |                            |                      |
| Knowledge                          | Students can describe the facets of the global water                 | situation. Students can judge the  | enormous potential of th   | e implementation of  |
|                                    | synergistic systems in Water, Soil, Food and Energy s                | supply.                            |                            |                      |
| Ckilla                             | Students are able to design application attlements                   | for different goographic and cocie | oconomic conditions fo     | r the main climates  |
| SKIIIS                             | Students are able to design ecological settlements around the world. | for different geographic and socio | r-economic conditions to   | ir the main climates |
|                                    | around the world.  |                                    |                            |                      |
| Personal Competence                |  |                                    |                            |                      |
| Social Competence                  | The students are able to develop a specific topic in a               | team and to work out milestones    | according to a given pla   | n.                   |
| Autonomy                           | Students are in a position to work on a subject an                   | nd to organize their work flow inc | dependently They can a     | also present on this |
| Autonomy                           | subject.   | id to organize their work now me   | rependently. They can t    | nso present on this  |
|                                    | Subject.   |                                    |                            |                      |
| Workload in Hours                  | Independent Study Time 124, Study Time in Lecture                    | 56                                 |                            |                      |
| Credit points                      | 6  |                                    |                            |                      |
| Course achievement                 | None   |                                    |                            |                      |
| Examination                        | Subject theoretical and practical work                               |                                    |                            |                      |
| Examination duration and           | During the course of the semester, the students wo                   | rk towards mile stones. The work   | includes presentations a   | and papers. Detailed |
| scale                              | information can be found at the beginning of the sme                 | ester in the StudIP course module  | handbook.                  |                      |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: El              | lective Compulsory                 |                            |                      |
| Following Curricula                | Bioprocess Engineering: Specialisation A - General Bi                | ioprocess Engineering: Elective Co | mpulsory                   |                      |
|                                    | Chemical and Bioprocess Engineering: Specialisation                  | General Process Engineering: Elec  | ctive Compulsory           |                      |
|                                    | Environmental Engineering: Core Qualification: Electi                | ive Compulsory                     |                            |                      |
|                                    | Joint European Master in Environmental Studies - Citi                | •                                  |                            |                      |
|                                    | Process Engineering: Specialisation Environmental Pr                 |                                    | ulsory                     |                      |
|                                    | Process Engineering: Specialisation Process Engineer                 |                                    |                            |                      |
|                                    | Water and Environmental Engineering: Specialisation                  |                                    |                            |                      |
|                                    | Water and Environmental Engineering: Specialisation                  |                                    | У                          |                      |
|                                    | Water and Environmental Engineering: Specialisation                  | Cities: Elective Compulsory        |                            |                      |

| Course L1229: Ecological Tov | vn Design - Water, Energy, Soil and Food Nexus   |
|------------------------------|--|
| Тур                          | Seminar  |
| Hrs/wk                       | 2  |
| СР                           | 2  |
| Workload in Hours            | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                     | Prof. Ralf Otterpohl   |
| Language                     | EN   |
| Cycle                        | SoSe   |
| Content                      | <ul> <li>Participants Workshop: Design of the most attractive productive Town</li> <li>Keynote lecture and video</li> <li>The limits of Urbanization / Green Cities</li> <li>The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>Global Ecovillage Network: Upsides and Downsides around the World</li> <li>Visit of an Ecovillage</li> <li>Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion</li> <li>TUHH Rural Development Toolbox</li> <li>Integrated New Town Development</li> <li>Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>Outreach: Participants campaign</li> <li>City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul> |
| Literature                   | <ul> <li>Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in "Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU</li> </ul>  |

| Course L0939: Water & Wastewater Systems in a Global Context |   |  |  |
|--|---|--|--|
| Тур  | Lecture   |  |  |
| Hrs/wk   | 2   |  |  |
| СР   | 4   |  |  |
| Workload in Hours  | Independent Study Time 92, Study Time in Lecture 28   |  |  |
| Lecturer   | Prof. Ralf Otterpohl  |  |  |
| Language   | EN  |  |  |
| Cycle  | SoSe  |  |  |
| Content  |   |  |  |
|  | <ul> <li>Keynote lecture and video</li> <li>Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>Water and it's utilization, Integrated Urban Water Management</li> <li>Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>Rehearsal session, Q&amp;A</li> </ul> |  |  |
| Literature   | <ul> <li>Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>  |  |  |

| Module M0922: City F                  | Planning   |
|---------------------------------------|--|
| Courses                               |  |
| Title                                 | Typ Hrs/wk CP  |
| City Planning (L1066)                 | Project-/problem-based Learning 4 6  |
| Module Responsible                    |  |
| Admission Requirements                | None   |
| Recommended Previous                  | for "Principles of Urban Planning": none   |
| Knowledge                             | for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class "Tran<br>Planning and Traffic Engineering"   |
| <b>Educational Objectives</b>         | After taking part successfully, students have reached the following learning results   |
| <b>Professional Competence</b>        |  |
| Knowledge                             | Students are able to:  |
|                                       | use technical terms of urban planning.   |
|                                       | describe the main determinants of urban development.   |
|                                       | explain and compare different possibilities of how urban development can be influenced.  |
|                                       | discuss requirements for public streetscapes.  |
|                                       | explain the importance of street design.   |
| Skille                                | Students are able to:  |
| SKIIIS                                | stadens are able to.   |
|                                       | read and analyze urban development concepts and designs for streetscapes   |
|                                       | appraise such concepts in the context of competing requirements.   |
|                                       | design, justify and reflect their own solutions for concrete examples.   |
| Personal Competence Social Competence | Students are able to:  • discuss intermediate results with each other.  • constructively accept feedback on their own work.  • provide constructive feedback to others.  |
| Autonomy                              | Students are able to:  • independently complete a written report including drawings following a broadly pre-defined process.  • assess the consequences of their proposed solutions.  • independently acquire knowledge and apply this to new issues or problem areas. |
| Workload in Hours                     | Independent Study Time 124, Study Time in Lecture 56   |
| Credit points                         | 6  |
| Course achievement                    | None   |
| Examination                           | Written elaboration  |
| Examination duration and scale        | written assignment, designwork during the semester   |
| Assignment for the                    | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |
| Following Curricula                   |  |
| . Showing curricula                   | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |
|                                       | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |
|                                       | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory  |
|                                       | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   |
|                                       | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |
|                                       | Water and Environmental Engineering: Specialisation Cities: Compulsory   |

| Course L1066: City Planning |   |
|-----------------------------|---|
| Тур                         | Project-/problem-based Learning   |
| Hrs/wk                      | 4   |
| СР                          | 6   |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56  |
| Lecturer                    | Prof. Carsten Gertz   |
| Language                    | DE  |
| Cycle                       | SoSe  |
| Content                     | "Principles of Urban Planning" deals with the determinants of urban development and their interactions. Topics include:   |
|                             | <ul> <li>legal framework,</li> <li>instruments and methods of planning,</li> <li>functional requirements,</li> <li>stakeholders and actors</li> <li>basic design requirements</li> <li>different planning levels and</li> <li>historical contexts.</li> </ul> The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign. |
| Literature                  | Albers, Gerd; Wekel, Julian (2009) Stadtplanung: Eine illustrierte Einführung. Primus Verlag. Darmstadt.  Frick, Dieter (2008) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. Wasmuth-Verlag. Tübingen  Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen  Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.   |
|                             |   |

| Module M0663: Marir                | ne Geotechnics                               |   |        |    |
|------------------------------------|--|---|--------|----|
| Courses                            |  |   |        |    |
| Title                              |  | Тур   | Hrs/wk | СР |
| Marine Geotechnics (L0548)         |  | Lecture   | 1      | 2  |
| Marine Geotechnics (L0549)         |  | Recitation Section (large)                        | 2      | 2  |
| Steel Structures in Foundation and | Hydraulic Engineering (L1146)                | Lecture   | 2      | 2  |
| Module Responsible                 | Prof. Jürgen Grabe                           |   |        |    |
| Admission Requirements             | None   |   |        |    |
| Recommended Previous               | complete modules: Geotechnics I-III, Mathe   | ematics I-III                                     |        |    |
| Knowledge                          | G. T. I. |   |        |    |
|                                    | courses: Soil laboratory course              |   |        |    |
| <b>Educational Objectives</b>      | After taking part successfully, students ha  | ve reached the following learning results         |        |    |
| Professional Competence            |  |   |        |    |
| Knowledge                          |  |   |        |    |
| Skills                             |  |   |        |    |
| Personal Competence                |  |   |        |    |
| Social Competence                  |  |   |        |    |
| Autonomy                           |  |   |        |    |
| Workload in Hours                  | Independent Study Time 110, Study Time       | in Lecture 70                                     |        |    |
| Credit points                      | 6  |   |        |    |
| Course achievement                 | None   |   |        |    |
| Examination                        | Written exam                                 |   |        |    |
| Examination duration and           | 90 min                                       |   |        |    |
| scale                              |  |   |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Geotechni  | ical Engineering: Compulsory                      |        |    |
| Following Curricula                | Civil Engineering: Specialisation Structural | Engineering: Elective Compulsory                  |        |    |
|                                    | Civil Engineering: Specialisation Coastal Er | ngineering: Compulsory                            |        |    |
|                                    | Theoretical Mechanical Engineering: Speci    | alisation Maritime Technology: Elective Compulsor | у      |    |
|                                    | Theoretical Mechanical Engineering: Techr    | nical Complementary Course: Elective Compulsory   |        |    |
|                                    | Water and Environmental Engineering: Spe     | ecialisation Cities: Elective Compulsory          |        |    |
|                                    | Water and Environmental Engineering: Spe     | ecialisation Environment: Elective Compulsory     |        |    |
|                                    | Water and Environmental Engineering: Spe     | ecialisation Water: Elective Compulsory           |        |    |

| Course L0548: Marine Geotechnics |  |  |
|----------------------------------|--|--|
| Тур                              | Lecture  |  |
| Hrs/wk                           | 1  |  |
| СР                               | 2  |  |
| Workload in Hours                | Independent Study Time 46, Study Time in Lecture 14  |  |
| Lecturer                         | Prof. Jürgen Grabe   |  |
| Language                         | DE   |  |
| Cycle                            | SoSe   |  |
| Content                          | Geotechnical investigation an description of the seabed Foundations of Offshore-Constructions CCliff erosion Sea dikes Port structures Flood protection structures   |  |
| Literature                       | <ul> <li>EAK (2002): Empfehlungen für Küstenschutzbauwerke</li> <li>EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke</li> <li>Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst &amp; Sohn, Berlin</li> </ul> |  |

| Course L0549: Marine Geote | ourse L0549: Marine Geotechnics                     |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)                          |  |  |
| Hrs/wk                     | 2   |  |  |
| СР                         | 2   |  |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28 |  |  |
| Lecturer                   | Prof. Jürgen Grabe                                  |  |  |
| Language                   | DE  |  |  |
| Cycle                      | SoSe  |  |  |
| Content                    | See interlocking course                             |  |  |
| Literature                 | See interlocking course                             |  |  |

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| Course L1146: Steel Structur | Course L1146: Steel Structures in Foundation and Hydraulic Engineering                                  |  |  |
|------------------------------|---|--|--|
| Тур                          | Lecture   |  |  |
| Hrs/wk                       | 2   |  |  |
| СР                           | 2   |  |  |
| Workload in Hours            | Independent Study Time 32, Study Time in Lecture 28   |  |  |
| Lecturer                     | Frank Feindt  |  |  |
| Language                     | DE  |  |  |
| Cycle                        | SoSe  |  |  |
| Content                      | Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue |  |  |
| Literature                   | EAU 2012, EA-Pfähle, EAB  |  |  |

| ted Topics in Environmental Engineering                       |  |  |   |
|---|--|--|---|
|   |  |  |   |
| Title   |  | Hrs/wk   | СР  |
| 1444)   | Lecture  | 2  | 3   |
| Delivery (L2387)  | Integrated Lecture   | 2  | 2   |
|   | Lecture  | 2  | 3   |
| )   | Lecture  | 2  | 2   |
|   | Recitation Section (small)   | 1  | 1   |
| Prof. Mathias Ernst   |  |  |   |
| None  |  |  |   |
|   |  |  |   |
|   |  |  |   |
| After taking part successfully, students have reached the fol | lowing learning results  |  |   |
|   |  |  |   |
|   |  |  |   |
|   |  |  |   |
|   |  |  |   |
|   |  |  |   |
|   |  |  |   |
| Depends on choice of courses                                  |  |  |   |
| 6   |  |  |   |
| Environmental Engineering: Core Qualification: Elective Com   | pulsory  |  |   |
| Water and Environmental Engineering: Specialisation Cities:   | Elective Compulsory  |  |   |
| Water and Environmental Engineering: Specialisation Enviro    | nment: Elective Compulsory   |  |   |
| Water and Environmental Engineering: Specialisation Water     | Elective Compulsory  |  |   |
|   | 1444) relivery (L2387)  Prof. Mathias Ernst  None  After taking part successfully, students have reached the fol  Depends on choice of courses 6  Environmental Engineering: Core Qualification: Elective Com Water and Environmental Engineering: Specialisation Cities: Water and Environmental Engineering: Specialisation Enviro | Typ  1444) Lecture lelivery (L2387) Integrated Lecture Lecture Lecture Recitation Section (small)  Prof. Mathias Ernst  None  After taking part successfully, students have reached the following learning results  Depends on choice of courses | Typ Hrs/wk  1444) Lecture 2 Integrated Lecture 2 Lecture 2 Lecture 2 Recitation Section (small) 1  Prof. Mathias Ernst  None  After taking part successfully, students have reached the following learning results  Depends on choice of courses  Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L1444: Environmenta | ll Aquatic Chemistry  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28   |
| Examination Form           | Klausur   |
| Examination duration and   | 60 min  |
| scale                      |   |
| Lecturer                   | Dr. Klaus Johannsen   |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | <ul> <li>Concentration and activity</li> <li>Gas-water partitioning</li> <li>Acid/base equilibria</li> <li>Alkalinity and acidity</li> <li>Precipitation/dissolution equilibria</li> <li>Redox equilibria</li> <li>Complex formation</li> <li>Sorption</li> </ul> |
| Literature                 | Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015   |

| Course L2387: Excellence in International Project Delivery |   |  |
|--|---|--|
| Тур  | Integrated Lecture                                  |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28 |  |
| Examination Form   | laut FSPO   |  |
| Examination duration and                                   | wird zu Beginn der Lehrveranstaltung festgelegt     |  |
| scale  |   |  |
| Lecturer   | Dr. Jens Huckfeldt                                  |  |
| Language   | EN  |  |
| Cycle  | SoSe  |  |
| Content  |   |  |
| Literature   |   |  |

| Course L0520: Sludge Treatment |   |  |  |
|--------------------------------|---|--|--|
| Тур                            | Lecture   |  |  |
| Hrs/wk                         | 2   |  |  |
| СР                             | 3   |  |  |
| Workload in Hours              | Independent Study Time 62, Study Time in Lecture 28                 |  |  |
| Examination Form               | Klausur   |  |  |
| Examination duration and       | 60 min  |  |  |
| scale                          |   |  |  |
| Lecturer                       | Dr. Joachim Behrendt  |  |  |
| Language                       | EN  |  |  |
| Cycle                          | SoSe  |  |  |
| Content                        | Sedimentation characteristic and thickening,                        |  |  |
|                                | Centrifugation,   |  |  |
|                                | Flotation,  |  |  |
|                                | Filtration,   |  |  |
|                                | Aerobic sludge stabilisation,                                       |  |  |
|                                | Sludge Digestion,   |  |  |
|                                | Sludge Disintegration,  |  |  |
|                                | Sludge Dewatering,  |  |  |
|                                | Natural Processes for Sludge Treatment,                             |  |  |
|                                | Nutrient Recovery from Sludge,                                      |  |  |
|                                | Thermal Processes and Incineration.                                 |  |  |
| Literature                     | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)                     |  |  |
|                                | Wastewater engineering : treatment and reuse                        |  |  |
|                                | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))         |  |  |
|                                | Boston [u.a.] : McGraw-Hill, 2003                                   |  |  |
|                                | TUB_HH_Katalog  |  |  |
|                                | Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes |  |  |
|                                | Sludge Treatment and Disposal                                       |  |  |
|                                | ISBN 9781843391661  |  |  |
|                                | IWA Publishing, 2007  |  |  |
|                                |   |  |  |

| Course L1767: Thermal Biomass Utilization |  |  |  |
|---|--|--|--|
| Тур                                       | Lecture  |  |  |
| Hrs/wk                                    | 2  |  |  |
| СР  | 2  |  |  |
| Workload in Hours                         | Independent Study Time 32, Study Time in Lecture 28  |  |  |
| Examination Form                          | Klausur  |  |  |
| Examination duration and                  | 60 min   |  |  |
| scale                                     |  |  |  |
| Lecturer                                  | Prof. Martin Kaltschmitt   |  |  |
| Language                                  | DE   |  |  |
| Cycle                                     | WiSe   |  |  |
| Content                                   | Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.  |  |  |
|   | The course is structured as follows:  • Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course   |  |  |
|   | <ul> <li>Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>Thermo-chemical conversion of solid biofuels</li> </ul>  |  |  |
|   | <ul> <li>Basics of thermo-chemical conversion</li> <li>Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use</li> <li>Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> </ul>   |  |  |
|   | <ul> <li>Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material</li> <li>Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)</li> <li>Bio-chemical conversion of biomass</li> </ul> |  |  |
|   | <ul> <li>Basics of bio-chemical conversion</li> <li>Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry</li> <li>Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage</li> </ul>  |  |  |
| Literature                                | Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage  |  |  |

| Course L1768: Thermal Biomass Utilization |   |  |
|---|---|--|
| Тур                                       | Recitation Section (small)                          |  |
| Hrs/wk                                    | 1   |  |
| СР  | 1   |  |
| Workload in Hours                         | Independent Study Time 16, Study Time in Lecture 14 |  |
| Examination Form                          | Klausur   |  |
| Examination duration and                  | 60 min  |  |
| scale                                     |   |  |
| Lecturer                                  | Prof. Martin Kaltschmitt                            |  |
| Language                                  | DE  |  |
| Cycle                                     | WiSe  |  |
| Content                                   | See interlocking course                             |  |
| Literature                                | See interlocking course                             |  |

| Module M1716: Subst              | urface Processes                                     |  |        |    |  |
|----------------------------------|--|--|--------|----|--|
|                                  |  |  |        |    |  |
| Courses                          |  |  |        |    |  |
| Title                            |  | Тур                                      | Hrs/wk | СР |  |
| Modeling of Subsurface Processes | (L2730)  | Lecture                                  | 2      | 2  |  |
| Modeling of Subsurface Processes | (L2731)  | Recitation Section (small)               | 1      | 1  |  |
| Modern Techniques for Subsurface | •  | Lecture                                  | 2      | 2  |  |
| Modern Techniques for Subsurface | Solute Transport (L2729)                             | Recitation Section (large)               | 1      | 1  |  |
| Module Responsible               | Prof. Nima Shokri                                    |  |        |    |  |
| Admission Requirements           | None   |  |        |    |  |
| Recommended Previous             |  |  |        |    |  |
| Knowledge                        |  |  |        |    |  |
| <b>Educational Objectives</b>    | After taking part successfully, students have reach  | ed the following learning results        |        |    |  |
| Professional Competence          |  |  |        |    |  |
| Knowledge                        |  |  |        |    |  |
| Skills                           |  |  |        |    |  |
| Personal Competence              |  |  |        |    |  |
| Social Competence                |  |  |        |    |  |
| Autonomy                         |  |  |        |    |  |
| Workload in Hours                | ndependent Study Time 96, Study Time in Lecture 84   |  |        |    |  |
| Credit points                    | 6  |  |        |    |  |
| Course achievement               | None   |  |        |    |  |
| Examination                      | Written exam   |  |        |    |  |
| Examination duration and         | 90 min   |  |        |    |  |
| scale                            |  |  |        |    |  |
| Assignment for the               | Civil Engineering: Specialisation Structural Enginee | ring: Elective Compulsory                |        |    |  |
| Following Curricula              | Civil Engineering: Specialisation Geotechnical Engir | neering: Elective Compulsory             |        |    |  |
|                                  | Civil Engineering: Specialisation Coastal Engineerin | g: Elective Compulsory                   |        |    |  |
|                                  | Civil Engineering: Specialisation Water and Traffic: | Elective Compulsory                      |        |    |  |
|                                  | Process Engineering: Specialisation Environmental    | Process Engineering: Elective Compulsory |        |    |  |
|                                  | Process Engineering: Specialisation Process Engine   | ering: Elective Compulsory               |        |    |  |
|                                  | Water and Environmental Engineering: Specialisation  | on Water: Compulsory                     |        |    |  |
|                                  | Water and Environmental Engineering: Specialisation  | on Environment: Elective Compulsory      |        |    |  |
|                                  | Water and Environmental Engineering: Specialisation  | on Cities: Elective Compulsory           |        |    |  |

| Course L2730: Modeling of Subsurface Processes |   |  |
|--|---|--|
| Тур  | Lecture   |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours                              | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                                       | Sonja Götz  |  |
| Language                                       | EN  |  |
| Cycle  | WiSe  |  |
| Content  |   |  |
| Literature                                     |   |  |

| Course L2731: Modeling of Subsurface Processes |   |  |
|--|---|--|
| Тур  | Recitation Section (small)                          |  |
| Hrs/wk   | 1   |  |
| СР   | 1   |  |
| Workload in Hours                              | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                                       | Sonja Götz  |  |
| Language                                       | EN  |  |
| Cycle  | WiSe  |  |
| Content  | See interlocking course                             |  |
| Literature                                     | See interlocking course                             |  |

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| Course L2728: Modern Techniques for Subsurface Solute Transport |   |  |
|---|---|--|
| Тур   | Lecture   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer  | Prof. Nima Shokri                                   |  |
| Language  | EN  |  |
| Cycle   | WiSe  |  |
| Content   |   |  |
| Literature  |   |  |

| Course L2729: Modern Techr | ourse L2729: Modern Techniques for Subsurface Solute Transport |  |  |
|----------------------------|--|--|--|
| Тур                        | Recitation Section (large)                                     |  |  |
| Hrs/wk                     | 1  |  |  |
| СР                         | 1  |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14            |  |  |
| Lecturer                   | Hannes Nevermann   |  |  |
| Language                   | EN   |  |  |
| Cycle                      | WiSe   |  |  |
| Content                    | See interlocking course  |  |  |
| Literature                 | See interlocking course  |  |  |

| Module M1720: Emer                 | ging Trends in Environmental E                  | ngineering                                |        |    |
|------------------------------------|---|---|--------|----|
|                                    |   |   |        |    |
| Courses                            |   |   |        |    |
| Title                              |   | Тур                                       | Hrs/wk | CP |
| Microplastics in Environment (L275 |   | Integrated Lecture                        | 2      | 2  |
| Research Methods for Energy-Wate   |   | Lecture                                   | 1      | 2  |
| Research Trends in Energy-Water-   |   | Seminar                                   | 2      | 2  |
| Module Responsible                 | Prof. Nima Shokri                               |   |        |    |
| Admission Requirements             | None  |   |        |    |
| Recommended Previous               |   |   |        |    |
| Knowledge                          |   |   |        |    |
| <b>Educational Objectives</b>      | After taking part successfully, students have r | eached the following learning results     |        |    |
| <b>Professional Competence</b>     |   |   |        |    |
| Knowledge                          |   |   |        |    |
| Skills                             |   |   |        |    |
| Personal Competence                |   |   |        |    |
| Social Competence                  |   |   |        |    |
| Autonomy                           |   |   |        |    |
| Workload in Hours                  | Independent Study Time 110, Study Time in Lo    | ecture 70                                 |        |    |
| Credit points                      | 6   |   |        |    |
| Course achievement                 | None  |   |        |    |
| Examination                        | Written elaboration                             |   |        |    |
| Examination duration and           | Report (about 5-10 pages) and Presentation (a   | about 15 min)                             |        |    |
| scale                              |   |   |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Water and Tra | affic: Elective Compulsory                |        |    |
| Following Curricula                | Environmental Engineering: Specialisation Wa    | ter: Elective Compulsory                  |        |    |
|                                    | Environmental Engineering: Specialisation Wa    | ste and Energy: Elective Compulsory       |        |    |
|                                    | Environmental Engineering: Specialisation Bio   | technology: Elective Compulsory           |        |    |
|                                    | Water and Environmental Engineering: Specia     | lisation Cities: Elective Compulsory      |        |    |
|                                    | Water and Environmental Engineering: Specia     | lisation Environment: Elective Compulsory |        |    |
|                                    | Water and Environmental Engineering: Specia     | lisation Water: Elective Compulsory       |        |    |

| Course L2750: Microplastics | urse L2750: Microplastics in Environment            |  |  |
|-----------------------------|---|--|--|
| Тур                         | Integrated Lecture                                  |  |  |
| Hrs/wk                      | 2   |  |  |
| СР                          | 2   |  |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28 |  |  |
| Lecturer                    | Prof. Nima Shokri                                   |  |  |
| Language                    | EN  |  |  |
| Cycle                       | WiSe  |  |  |
| Content                     |   |  |  |
| Literature                  |   |  |  |

| Course L2751: Research Met | urse L2751: Research Methods for Energy-Water-Soil-Climate Nexus |  |  |
|----------------------------|--|--|--|
| Тур                        | Lecture  |  |  |
| Hrs/wk                     | 1  |  |  |
| СР                         | 2  |  |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14              |  |  |
| Lecturer                   | Prof. Nima Shokri  |  |  |
| Language                   | EN   |  |  |
| Cycle                      | WiSe   |  |  |
| Content                    |  |  |  |
| Literature                 |  |  |  |

| Course L2752: Research Tren | ourse L2752: Research Trends in Energy-Water-Soil-Climate Nexus |  |  |
|-----------------------------|---|--|--|
| Тур                         | Seminar   |  |  |
| Hrs/wk                      | 2   |  |  |
| СР                          | 2   |  |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28             |  |  |
| Lecturer                    | Dr. Salome Shokri-Kuehni  |  |  |
| Language                    | EN  |  |  |
| Cycle                       | WiSe  |  |  |
| Content                     |   |  |  |
| Literature                  |   |  |  |

| Module M0620: Speci                       | al Aspects of W   | aste Resource M              | anagement            |  |                 |                     |
|---|---|------------------------------|----------------------|--|-----------------|---------------------|
| Courses                                   |   |                              |                      |  |                 |                     |
| Title                                     | Title   |                              |                      | Тур  | Hrs/wk          | СР                  |
| Advanced Topics in Waste Resourc          |   |                              |                      | Project-/problem-based Learning  | 3               | 3                   |
| International Waste Management (          | I   |                              |                      | Project-/problem-based Learning  | 2               | 3                   |
| Module Responsible                        |   |                              |                      |  |                 |                     |
| Admission Requirements                    |   | nent technologies            |                      |  |                 |                     |
| Recommended Previous  Knowledge           | basics in waste treati  | nent technologies            |                      |  |                 |                     |
| Educational Objectives                    | After taking part succ  | essfully, students have re   | ached the followi    | ng learning results  |                 |                     |
| Professional Competence                   | Arter taking part sace  | essiany, stadents have re    | deried the followin  | ng rearring results  |                 |                     |
| · ·                                       | The students are able   | e to describe waste as a     | esource as well      | as advanced technologies for re  | cycling and re  | covery of resources |
|   | from waste in detail.   | This covers collection, trar | sport, treatment     | and disposal in national and inte                                      | ernational cont | exts.               |
| Ckilla                                    | Students are able to  | rolast suitable prosesses f  | or the treatment     | with respect to the national or s                                      | ultural and day | alanmantal contaut  |
| SKIIIS                                    |   |                              |                      | with respect to the national or co<br>of different technologies and ma |                 | ·                   |
|   | They can evaluate the   | e ecological impact and th   | e tecililical ellort | or different technologies and me                                       | anagement sys   | items.              |
| Personal Competence                       |   |                              |                      |  |                 |                     |
| Social Competence                         | Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop                           |                              |                      |  |                 |                     |
|   | ·   |                              |                      | t of others and promote the sci  | entific develop | ment of colleagues. |
|   | Furthermore, they ca  | n give and accept professi   | onal constructive    | CHUCISMS.  |                 |                     |
| Autonomy                                  | Students can indepe   | ndently gain additional k    | nowledge of the      | subject area and apply it in so  | olving the give | n course tasks and  |
|   | projects.   |                              |                      |  |                 |                     |
| Workload in Hours                         | Independent Study Ti  | me 110, Study Time in Le     | cture 70             |  |                 |                     |
| Credit points                             | 6   | ·                            |                      |  |                 |                     |
| Course achievement                        | Compulsory Bonus  | Form                         | Description          |  |                 |                     |
|   | Yes 20 %  | Written elaboration          |                      |  |                 |                     |
| Examination                               | Presentation  |                              |                      |  |                 |                     |
| Examination duration and .                | PowerPoint presentat  | ion (10-15 minutes)          |                      |  |                 |                     |
| scale                                     | Civil Familian dia Con  | sistination Water and Traf   | fi Fl - +i C         |  |                 |                     |
| Assignment for the<br>Following Curricula | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory  Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory |                              |                      |  |                 |                     |
| ronowing curricula                        | _   | • .                          |                      | ainability: Specialisation Energy:                                     | Elective Comr   | oulsorv             |
|   |   | ntal Engineering: Speciali   |                      |  |                 | ,                   |
|   | Water and Environme   | ntal Engineering: Speciali   | sation Environme     | nt: Elective Compulsory  |                 |                     |
|   | Water and Environme   | ntal Engineering: Speciali   | sation Cities: Elec  | tive Compulsory  |                 |                     |

| Course L1055: Advanced Top | oics in Waste Resource Management   |
|----------------------------|---|
| Тур                        | Project-/problem-based Learning   |
| Hrs/wk                     | 3   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 48, Study Time in Lecture 42   |
| Lecturer                   | Prof. Rüdiger Siechau   |
| Language                   | EN  |
| Cycle                      | WiSe  |
| Content                    | Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management            |
|                            | - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste |
|                            | collection systems).  |
|                            | The course is split into two parts:   |
|                            | 1. part: "Conventional" lecture (development of waste management, legislation, collection, transportation and organisation of           |
|                            | waste management, costs, fees and revenues).  |
|                            | 2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work    |
|                            | out the project were given before during the conventional lecture. Course documents are published in StudIP and communication           |
|                            | during project work takes place via StudIP.   |
|                            | The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the   |
|                            | presentation.   |
|                            |   |
|                            |   |
| Literature                 | Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010                          |
|                            | PowerPoint slides in Stud IP  |
|                            |   |

| Course L0317: International | Waste Management   |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 2  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                    | Prof. Kerstin Kuchta   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics ( Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented.  Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves  Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries.  Single national projects and studies will be prepared and presented by students |
| Literature                  | Basel convention   |

| Module M0801: Water                | r Resources and -Supply  |                                     |                   |            |
|------------------------------------|--|-------------------------------------|-------------------|------------|
| Courses                            |  |                                     |                   |            |
| Title                              |  | Тур                                 | Hrs/wk            | СР         |
| Chemistry of Drinking Water Treatr | ment (L0311)   | Lecture                             | 2                 | 1          |
| Chemistry of Drinking Water Treatr | ment (L0312)   | Recitation Section (large)          | 1                 | 2          |
| Water Resource Management (L04)    |  | Lecture                             | 2                 | 2          |
| Water Resource Management (L04)    |  | Recitation Section (small)          | 1                 | 1          |
| Module Responsible                 |  |                                     |                   |            |
| Admission Requirements             | None   |                                     |                   |            |
| Recommended Previous               | Knowledge of water management and the key processes  | involved in water treatment.        |                   |            |
| Knowledge                          |  |                                     |                   |            |
| Educational Objectives             | After taking part successfully, students have reached the  | following learning results          |                   |            |
| Professional Competence            |  |                                     |                   |            |
| Knowledge                          | Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application. |                                     |                   |            |
| Skills                             | Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.                |                                     |                   |            |
| Personal Competence                |  |                                     |                   |            |
| Social Competence                  | Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.  |                                     |                   |            |
| Autonomy                           | Students will be in a position to work on a subject independently and present on this subject.   |                                     |                   |            |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84  |                                     |                   |            |
| Credit points                      | 6  |                                     |                   |            |
| Course achievement                 | None   |                                     |                   |            |
| Examination                        | Written exam   |                                     |                   |            |
| Examination duration and           | 60 min (chemistry) + presentation  |                                     |                   |            |
| scale                              |  |                                     |                   |            |
| Assignment for the                 | Civil Engineering: Specialisation Structural Engineering: E  | lective Compulsory                  |                   |            |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Engineering   | g: Elective Compulsory              |                   |            |
|                                    | Civil Engineering: Specialisation Water and Traffic: Comp  | ulsory                              |                   |            |
|                                    | Civil Engineering: Specialisation Coastal Engineering: Elec  | ctive Compulsory                    |                   |            |
|                                    | International Management and Engineering: Specialisatio  | n II. Energy and Environmental Engi | neering: Elective | Compulsory |
|                                    | Water and Environmental Engineering: Specialisation Water  | ter: Compulsory                     |                   |            |
|                                    | Water and Environmental Engineering: Specialisation Env  | ironment: Elective Compulsory       |                   |            |
|                                    | Water and Environmental Engineering: Specialisation Citi   | es: Elective Compulsory             |                   |            |

| Course L0311: Chemistry of | Drinking Water Treatment  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 1   |
| Workload in Hours          | Independent Study Time 2, Study Time in Lecture 28  |
| Lecturer                   | Dr. Klaus Johannsen   |
| Language                   | DE  |
| Cycle                      | WiSe  |
| Content                    | The topic of this course is water chemistry with respect to drinking water treatment and water distribution   |
|                            | Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).  Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.  Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester. |
| Literature                 | MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.  DVGW (Hrsg.): Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.  Jensen, J. N.: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.   |

| Course L0312: Chemistry of | ourse L0312: Chemistry of Drinking Water Treatment  |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)                          |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 2   |  |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14 |  |  |
| Lecturer                   | Dr. Klaus Johannsen                                 |  |  |
| Language                   | DE  |  |  |
| Cycle                      | WiSe  |  |  |
| Content                    | See interlocking course                             |  |  |
| Literature                 | See interlocking course                             |  |  |

| Course L0402: Water Resour | rce Management  |
|----------------------------|---|
|                            | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Prof. Mathias Ernst   |
| Language                   | DE  |
| Cycle                      | WiSe  |
| Content                    | The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview:  • Current situation of global water resources  - User and Stakeholder conflicts  - Wasserressourcenmanagement in urbane Gebieten  - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.  - Ökobilanzierung, Benchmarking in der Wasserversorgung |
| Literature                 | <ul> <li>Aktuelle UN World Water Development Reports</li> <li>Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>Ppt der Vorlesung</li> </ul>  |

## Module Manual M.Sc. "Water and Environmental Engineering"

| Course L0403: Water Resour | Course L0403: Water Resource Management             |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (small)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 1   |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                   | Prof. Mathias Ernst                                 |  |
| Language                   | DE  |  |
| Cycle                      | WiSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| Module M0822: Proce                | ss Modeling in Water Technology  |   |                |                       |
|------------------------------------|--|---|----------------|-----------------------|
| Courses                            |  |   |                |                       |
| Title                              |  | Тур   | Hrs/wk         | СР                    |
| Process Modelling of Wastewater Tr |  | Project-/problem-based Learning             | 2              | 3                     |
| Process Modeling in Drinking Water | Treatment (L0314)  | Project-/problem-based Learning             | 2              | 3                     |
| Module Responsible                 | Dr. Klaus Johannsen  |   |                |                       |
| Admission Requirements             | None   |   |                |                       |
|                                    | Knowledge of the most important processes in drinking  | water and waste water treatment.            |                |                       |
| Knowledge                          |  |   |                |                       |
| Educational Objectives             | After taking part successfully, students have reached th   | e following learning results                |                |                       |
| Professional Competence            |  |   |                |                       |
| Knowledge                          | Students are able to explain selected processes of drin  | •   | n detail. The  | y are able to explain |
|                                    | basics as well as possibilities and limitations of dynamic   | modeling.                                   |                |                       |
| Skills                             | Students are able to use the most important features   | Modelica offers. They are able to transpo   | se selected    | processes in drinking |
|                                    | water and waste water treatment into a mathematical  | model in Modelica with respect to equilib   | rium, kinetics | s and mass balances.  |
|                                    | They are able to set up and apply models and assess th   | eir possibilities and limitations.          |                |                       |
|                                    |  |   |                |                       |
|                                    |  |   |                |                       |
| Personal Competence                |  |   |                |                       |
| Social Competence                  | Students are able to solve problems and document solutions in a group with members of different technical background. They are |   |                |                       |
|                                    | able to give appropriate feedback and can work constru   | ctively with feedback concerning their wo   | ork.           |                       |
|                                    |  |   |                |                       |
|                                    |  |   |                |                       |
| Autonomy                           | Students are able to define a problem, gain the required   | I knowledge and set up a model.             |                |                       |
|                                    |  |   |                |                       |
| Workload in Hours                  | Independent Study Time 124, Study Time in Lecture 56   |   |                |                       |
|                                    | 6  |   |                |                       |
| -                                  | None   |   |                |                       |
| Examination                        | Written exam   |   |                |                       |
| Examination duration and           | 1,5 hours  |   |                |                       |
| scale                              |  |   |                |                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: Elect   | ive Compulsory                              |                |                       |
| Following Curricula                | Environmental Engineering: Specialisation Water: Election  | ve Compulsory                               |                |                       |
|                                    | Joint European Master in Environmental Studies - Cities  | and Sustainability: Specialisation Water: I | Elective Comp  | oulsory               |
|                                    | Process Engineering: Specialisation Environmental Proce  | ess Engineering: Elective Compulsory        |                |                       |
|                                    | Process Engineering: Specialisation Process Engineering  | : Elective Compulsory                       |                |                       |
|                                    | Water and Environmental Engineering: Specialisation W  | ater: Elective Compulsory                   |                |                       |
|                                    | Water and Environmental Engineering: Specialisation Er   | vironment: Elective Compulsory              |                |                       |
|                                    | Water and Environmental Engineering: Specialisation Ci   | ties: Elective Compulsory                   |                |                       |

| Course L0522: Process Mode | lling of Wastewater Treatment   |
|----------------------------|---|
| Тур                        | Project-/problem-based Learning   |
| Hrs/wk                     | 2   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                   | Dr. Joachim Behrendt  |
| Language                   | DE/EN   |
| Cycle                      | WiSe  |
| Content                    | Mass and energy balances  |
|                            | Tracer modelling  |
|                            | Activated Sludge Model  |
|                            | Activated Studge Model  |
|                            | Wastewater Treatment Plant Modelling (continously and SBR)  |
|                            | Sludge Treatment (ADM, aerobic autothermal)   |
|                            | Biofilm Modelling   |
| Literature                 | Henze, Mogens (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;)                    |
|                            | Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated |
|                            | Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001   |
|                            | ISBN: 1843394146  |
|                            | [London] : IWA Publ., 2002  |
|                            | TUB_HH_Katalog  |
|                            | Henze, Mogens   |
|                            | Activated sludge models ASM1, ASM2, ASM2d and ASM3  |
|                            | ISBN: 1900222248  |
|                            | London: IWA Publ., 2002   |
|                            | TUB_HH_Katalog  |
|                            | Henze, Mogens   |
|                            | Wastewater treatment : biological and chemical processes  |
|                            | ISBN: 3540422285 (Pp.)  |
|                            | Berlin [u.a.] : Springer, 2002  |
|                            | TUB_HH_Katalog  |
|                            | Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)   |
|                            | Fundamentals of biological wastewater treatment   |
|                            | ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm                       |
|                            | Weinheim: WILEY-VCH, 2007   |
|                            | TUB_HH_Katalog  |
|                            |   |

| Course L0314: Process Mode | ling in Drinking Water Treatment   |
|----------------------------|--|
| Тур                        | Project-/problem-based Learning  |
| Hrs/wk                     | 2  |
| СР                         | 3  |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                   | Dr. Klaus Johannsen  |
| Language                   | DE/EN  |
| Cycle                      | WiSe   |
| Content                    | In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica.                                     |
|                            | In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam. |
| Literature                 | OpenModelica: https://openmodelica.org/index.php/download/download-windows   |
|                            | OpenModelica - Modelica Tutorial: https://openmodelica.org/index.php/useresresources/userdocumentation   |
|                            | OpenModelica - Users Guide: https://openmodelica.org/index.php/useresresources/userdocumentation   |
|                            | Peter Fritzson: Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.  |
|                            | MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  |
|                            | Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.   |
|                            | <b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.  |
|                            |  |

| Module M0802: Memi                                      | orane Technology   |  |                    |                         |
|---|--|--|--------------------|-------------------------|
| Courses   |  |  |                    |                         |
| Courses   |  |  |                    |                         |
| Title   |  | Тур  | Hrs/wk             | СР                      |
| Membrane Technology (L0399) Membrane Technology (L0400) |  | Lecture  Recitation Section (small)          | 2<br>1             | 3<br>2                  |
| Membrane Technology (L0401)                             |  | Practical Course                             | 1                  | 1                       |
| Module Responsible                                      | Prof. Mathias Ernst  |  |                    |                         |
| Admission Requirements                                  |  |  |                    |                         |
| Recommended Previous                                    |  | ne core processes involved in water, gas a   | and steam treatn   | nent                    |
| Knowledge   | Judic Michiga of Mater enember, Michiga of the   | ie este processes inverted in mater, gas i   | and Securit a cuti |                         |
| Educational Objectives                                  | After taking part successfully, students have reached  | the following learning results               |                    |                         |
| Professional Competence                                 | The taking part succession, state in a verteather  | tile telletting teathing testine             |                    |                         |
| •   | Students will be able to rank the technical application  | ns of industrially important membrane p      | rocesses They w    | vill he able to explain |
| Knowledge   | the different driving forces behind existing membra  |  |                    |                         |
|   | membrane filtration and their advantages and disac   |  |                    |                         |
|   | membranes in water, other liquid media, gases and in   |  | an the key ame     | c.rees iii eile ase s   |
|   |  |  |                    |                         |
| Skills  | Students will be able to prepare mathematical equa   |  |                    |                         |
|   | calculate key parameters in the membrane separation  | •  |                    |                         |
|   | available boundary data and provide recommendat  | ·  |                    | -                       |
|   | experiments, students will be able to classify the   |  |                    |                         |
|   | membrane materials. Students will be able to charact   | terise the formation of the fouling layer in | n different water  | s and apply technica    |
|   | measures to control this.  |  |                    |                         |
| Personal Competence                                     |  |  |                    |                         |
| Social Competence                                       | Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions |  |                    |                         |
|   | within their group on laboratory experiments to be ur  |  |                    |                         |
|   |  |  |                    |                         |
| Autonomy  | Students will be in a position to solve homework or  | n the topic of membrane technology inc       | dependently. The   | y will be capable of    |
|   | finding creative solutions to technical questions.   |  |                    |                         |
| Workload in Hours                                       | Independent Study Time 124, Study Time in Lecture  | 56   |                    |                         |
| Credit points   | 6  |  |                    |                         |
| Course achievement                                      | None   |  |                    |                         |
| Examination   | Written exam   |  |                    |                         |
| <b>Examination duration and</b>                         | 90 min   |  |                    |                         |
| scale   |  |  |                    |                         |
| Assignment for the                                      | Civil Engineering: Specialisation Water and Traffic: Ele   | ective Compulsory                            |                    |                         |
| Following Curricula                                     | Bioprocess Engineering: Specialisation A - General Bio   | oprocess Engineering: Elective Compulso      | ry                 |                         |
|   | Bioprocess Engineering: Specialisation B - Industrial E  | Bioprocess Engineering: Elective Compuls     | sory               |                         |
|   | Chemical and Bioprocess Engineering: Specialisation  | Chemical Process Engineering: Elective (     | Compulsory         |                         |
|   | Chemical and Bioprocess Engineering: Specialisation  | General Process Engineering: Elective Co     | ompulsory          |                         |
|   | Energy and Environmental Engineering: Specialisation   | 3, 3   | : Elective Compu   | llsory                  |
|   | Environmental Engineering: Specialisation Water: Ele   | , ,  |                    |                         |
|   | Joint European Master in Environmental Studies - Citie   | es and Sustainability: Specialisation Wate   | er: Elective Comp  | oulsory                 |
|   | Process Engineering: Specialisation Process Engineer   | ing: Elective Compulsory                     |                    |                         |
|   | Process Engineering: Specialisation Environmental Pr   | ocess Engineering: Elective Compulsory       |                    |                         |
|   | Water and Environmental Engineering: Specialisation  | · ·  |                    |                         |
|   | Water and Environmental Engineering: Specialisation  | Environment: Elective Compulsory             |                    |                         |
|   | Water and Environmental Engineering: Specialisation  | Cities: Elective Compulsory                  |                    |                         |

| Course L0399: Membrane Te | chnology   |
|---------------------------|--|
| Тур                       | Lecture  |
| Hrs/wk                    | 2  |
| СР                        | 3  |
| Workload in Hours         | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                  | Prof. Mathias Ernst  |
| Language                  | EN   |
| Cycle                     | WiSe   |
|                           | The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well.  Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis.  The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice. |
| Literature                | <ul> <li>T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage),<br/>Springer-Verlag, Berlin 2004.</li> <li>Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>   |

| Course L0400: Membrane Te | Course L0400: Membrane Technology                   |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (small)                          |  |
| Hrs/wk                    | 1   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                  | Prof. Mathias Ernst                                 |  |
| Language                  | EN  |  |
| Cycle                     | WiSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Course L0401: Membrane Technology |   |  |
|-----------------------------------|---|--|
| Тур                               | Practical Course                                    |  |
| Hrs/wk                            | 1   |  |
| СР                                | 1   |  |
| Workload in Hours                 | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                          | Prof. Mathias Ernst                                 |  |
| Language                          | EN  |  |
| Cycle                             | WiSe  |  |
| Content                           | See interlocking course                             |  |
| Literature                        | See interlocking course                             |  |

| Module M0864: Pract                | ical Course in Water and Was   | tewater Technology                            |                     |                        |
|------------------------------------|--|---|---------------------|------------------------|
| Courses                            |  |   |                     |                        |
| Title                              |  | Тур   | Hrs/wk              | СР                     |
| Practical Course in Water and Wast | ewater Technology I (L0503)  | Practical Course                              | 2                   | 3                      |
| Practicle Course of Wastewater Tec | hnology II (L0607)   | Practical Course                              | 3                   | 3                      |
| Module Responsible                 | Dr. Dorothea Rechtenbach   |   |                     |                        |
| Admission Requirements             | None   |   |                     |                        |
| Recommended Previous               | Basic knowledge in chemistry and physics   | (knowledge acquired at school)                |                     |                        |
| Knowledge                          |  |   |                     |                        |
| Educational Objectives             | After taking part successfully, students have  | ve reached the following learning results     |                     |                        |
| Professional Competence            |  |   |                     |                        |
| Knowledge                          | The students know basic analytical proce   | dures for evaluating the quality of water and | wastewater. They ha | ave knowledge about    |
|                                    | fundamental process engineering features   | of important water and wastewater treatment   | technologies.       |                        |
| Skills                             | The students are able to understand and  | to practically apply methodologies for waste  | water analysis as w | ell as descriptions of |
|                                    | experiments and experimental setups in wastewater technology.  |   |                     |                        |
| Personal Competence                |  |   |                     |                        |
| Social Competence                  |  |   |                     |                        |
| Autonomy                           | The students are able to conduct experiments following written procedures without external assistance. |   |                     |                        |
| Workload in Hours                  | Independent Study Time 110, Study Time   | in Lecture 70                                 |                     |                        |
| Credit points                      | 6  |   |                     |                        |
| Course achievement                 | None   |   |                     |                        |
| Examination                        | Written elaboration  |   |                     |                        |
| Examination duration and           | ca. 5 Stunden  |   |                     |                        |
| scale                              |  |   |                     |                        |
| Assignment for the                 | Civil Engineering: Specialisation Water and  | Traffic: Elective Compulsory                  |                     |                        |
| Following Curricula                | Water and Environmental Engineering: Spe   | ecialisation Water: Elective Compulsory       |                     |                        |
|                                    | Water and Environmental Engineering: Spe   | ecialisation Environment: Elective Compulsory |                     |                        |
|                                    | Water and Environmental Engineering: Spe   | ecialisation Cities: Elective Compulsory      |                     |                        |

| Course L0503: Practical Course in Water and Wastewater Technology I |  |  |
|---|--|--|
| Тур   | Practical Course   |  |
| Hrs/wk  | 2  |  |
| СР  | 3  |  |
| Workload in Hours   | Independent Study Time 62, Study Time in Lecture 28                                    |  |
| Lecturer  | Dr. Dorothea Rechtenbach   |  |
| Language  | EN   |  |
| Cycle   | WiSe   |  |
| Content   | - Impact of pretreatment of wastewater samples on analytical results                   |  |
|   | - Analysis of nutrients in wastewater samples (different methods for nitrate analysis) |  |
|   | - Alkalinity   |  |
|   | - TOC, COD   |  |
|   | - microscopic analysis of microorganisms relevant in wastewater treatment              |  |
| Literature  | Skript auf StudIP  |  |

| Course L0607: Practicle Course of Wastewater Technology II |   |  |
|--|---|--|
| Тур  | Practical Course                                    |  |
| Hrs/wk   | 3   |  |
| СР   | 3   |  |
| Workload in Hours  | Independent Study Time 48, Study Time in Lecture 42 |  |
| Lecturer   | Dr. Joachim Behrendt                                |  |
| Language   | DE/EN   |  |
| Cycle  | WiSe  |  |
| Content  | Experiments:  |  |
|  | Oxygen transfer                                     |  |
|  | Oxygen Uptake rate                                  |  |
|  | Sludge dewatering                                   |  |
|  | Tracer  |  |
|  | Flocculation  |  |
| Literature   | Skript/Script                                       |  |

| Module M0923: Integ               | rated Transportation Planning   |
|-----------------------------------|---|
| Courses                           |   |
| Title                             | Typ Hrs/wk CP   |
| ntegrated Transportation Planning |   |
| Module Responsible                |   |
| Admission Requirements            |   |
|                                   | some knowledge of transport planning, e.g. through taking the undergraduate class "Transport Planning and Traffic Engineerin              |
| Knowledge                         | some morreage or campore planning, e.g. amough taking the anaclighadade class #.campore.com   |
|                                   | After taking part successfully, students have reached the following learning results  |
| Professional Competence           |   |
| -                                 | Students are able to:   |
| 3.13                              |   |
|                                   | describe interdependencies between land-use/location choice and transportation/mobility behaviour   |
|                                   | explain and evaluate the social, ecological and economic effects of transport and land-use policy measures.                               |
|                                   | <ul> <li>relate current issues in the area of integrated transport planning and formulate an opinion on them.</li> </ul>                  |
|                                   |   |
|                                   |   |
| Skills                            | Students are able to:   |
|                                   | • quantify important parameters, which influence travel demand or are influenced by it.   |
|                                   | <ul> <li>comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document t</li> </ul> |
|                                   | results in accordance with scientific conventions.  |
|                                   |   |
|                                   |   |
| Personal Competence               |   |
| Social Competence                 | Students are able to:   |
|                                   |   |
|                                   | provide feedback on topical contents and their teaching.  |
|                                   | constructively handle feedback on their own work.   |
|                                   | produce results in group work and document these.   |
|                                   |   |
| Autonomy                          | Students are able to:   |
|                                   | assess potential consequences of their future professional activities   |
|                                   | • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means                    |
|                                   | its execution.  |
|                                   |   |
|                                   |   |
| Workload in Hours                 | Independent Study Time 124, Study Time in Lecture 56  |
| Credit points                     | 6   |
| Course achievement                | None  |
| Examination                       | Written elaboration   |
| Examination duration and          | written assignment with presentation during the semester  |
| scale                             |   |
| Assignment for the                | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory   |
| Following Curricula               | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory   |
| -                                 | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory  |
|                                   | Civil Engineering: Specialisation Water and Traffic: Compulsory   |
|                                   | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory                                   |
|                                   | Water and Environmental Engineering: Specialisation Water: Elective Compulsory  |
|                                   |   |
|                                   | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory  |

| Course L1068: Integrated Tr | ansportation Planning  |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 4  |
| СР                          | 6  |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                    | Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß   |
| Language                    | DE   |
| Cycle                       | WiSe   |
| Content                     | The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.:  • interactions between transport and the environment and consequent limitations  • characteristics of integrated planning  • complex planning processes  • interdependencies of location choice and mobility behaviour  • transport and land-use policies  • project on current issues in transportation studies |
| Literature                  | Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin.  Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin,  Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)  |

| Module M0949: Rural            | <b>Development and Resources Oriented</b>   | Sanitation for diffe           | erent Climate Zon          | ies                   |  |
|--------------------------------|---|--------------------------------|----------------------------|-----------------------|--|
| Courses                        |   |                                |                            |                       |  |
| Title                          |   | Тур                            | Hrs/wk                     | СР                    |  |
|                                | Oriented Sanitation for different Climate Zones (L0942)   | Seminar                        | 2                          | 3                     |  |
| ·                              | Oriented Sanitation for different Climate Zones (L0941)   | Lecture                        | 2                          | 3                     |  |
| Module Responsible             | Prof. Ralf Otterpohl  |                                |                            |                       |  |
| Admission Requirements         | None  |                                |                            |                       |  |
| Recommended Previous           | Basic knowledge of the global situation with rising pover   | y, soil degradation, lack of w | rater resources and sanita | ation                 |  |
| Knowledge                      |   |                                |                            |                       |  |
| <b>Educational Objectives</b>  | After taking part successfully, students have reached the   | following learning results     |                            |                       |  |
| <b>Professional Competence</b> |   |                                |                            |                       |  |
| Knowledge                      | Students can describe resources oriented wastewater s   | ystems mainly based on sou     | urce control in detail. Th | ey can comment on     |  |
|                                | techniques designed for reuse of water, nutrients and so  | l conditioners.                |                            |                       |  |
|                                | Students are able to discuss a wide range of proven app   | naches in Rural Develonmen     | t from and for many regi   | ons of the world      |  |
|                                | students are usic to discuss a wide range of proven appli   | odenes in Narai Developmen     | c from and for many regi   | ons of the world.     |  |
|                                |   |                                |                            |                       |  |
| Skills                         | Students are able to design low-tech/low-cost sanitation  | on, rural water supply, rainv  | water harvesting system    | s, measures for the   |  |
|                                | rehabilitation of top soil quality combined with food and   | water security. Students can   | consult on the basics of   | soil building through |  |
|                                | "Holisitc Planned Grazing" as developed by Allan Savory.  |                                |                            |                       |  |
| Personal Competence            |   |                                |                            |                       |  |
| •                              | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |                                |                            |                       |  |
|                                |   |                                |                            |                       |  |
| Autonomy                       | Students are in a position to work on a subject and to  | organize their work flow in    | ndependently. They can     | also present on this  |  |
|                                | subject.  |                                |                            |                       |  |
| Workload in Hours              | Independent Study Time 124, Study Time in Lecture 56  |                                |                            |                       |  |
| Credit points                  | 6   |                                |                            |                       |  |
| Course achievement             | None  |                                |                            |                       |  |
| Examination                    | Subject theoretical and practical work  |                                |                            |                       |  |
| Examination duration and       | During the course of the semester, the students work to   | wards mile stones. The work    | c includes presentations   | and papers. Detailed  |  |
| scale                          | information will be provided at the beginning of the sme  | ster.                          |                            |                       |  |
| Assignment for the             | Civil Engineering: Specialisation Water and Traffic: Electi   | ve Compulsory                  |                            |                       |  |
| Following Curricula            | Bioprocess Engineering: Specialisation A - General Biopro   | ocess Engineering: Elective Co | ompulsory                  |                       |  |
|                                | Chemical and Bioprocess Engineering: Specialisation Ger   | neral Process Engineering: Ele | ective Compulsory          |                       |  |
|                                | Environmental Engineering: Specialisation Water: Electiv  | e Compulsory                   |                            |                       |  |
|                                | International Management and Engineering: Specialisation  | on II. Energy and Environmen   | tal Engineering: Elective  | Compulsory            |  |
|                                | Joint European Master in Environmental Studies - Cities a   | nd Sustainability: Specialisat | ion Water: Elective Comp   | oulsory               |  |
|                                | Process Engineering: Specialisation Environmental Proce   | ss Engineering: Elective Com   | pulsory                    |                       |  |
|                                | Process Engineering: Specialisation Process Engineering:  | Elective Compulsory            |                            |                       |  |
|                                | Water and Environmental Engineering: Specialisation Wa  | ter: Elective Compulsory       |                            |                       |  |
|                                | Water and Environmental Engineering: Specialisation En  | ·                              | ory                        |                       |  |
|                                | Water and Environmental Engineering: Specialisation Cit   | es: Elective Compulsory        |                            |                       |  |

| Course L0942: Rural Develop | oment and Resources Oriented Sanitation for different Climate Zones   |
|-----------------------------|---|
| Тур                         | Seminar   |
| Hrs/wk                      | 2   |
| СР                          | 3   |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     |   |
|                             | <ul> <li>Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists.</li> <li>The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.</li> </ul>   |
| Literature                  | <ul> <li>J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek)</li> <li>Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)</li> <li>Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys</li> </ul> |

| Course L0941: Rural Develop | ment and Resources Oriented Sanitation for different Climate Zones   |  |  |
|-----------------------------|--|--|--|
| Тур                         | ecture   |  |  |
| Hrs/wk                      | 2  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |  |  |
| Lecturer                    | Prof. Ralf Otterpohl   |  |  |
| Language                    | EN   |  |  |
| Cycle                       | WiSe   |  |  |
| Content                     | <ul> <li>Living Soil - THE key element of Rural Development</li> <li>Participatory Approaches</li> <li>Rainwater Harvesting</li> <li>Ecological Sanitation Principles and practical examples</li> <li>Permaculture Principles of Rural Development</li> <li>Performance and Resilience of Organic Small Farms</li> <li>Going Further: The TUHH Toolbox for Rural Development</li> <li>EMAS Technologies, Low cost drinking water supply</li> </ul> |  |  |
| Literature                  | Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk     Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press   |  |  |

| Module M0950: Study           | Work Environment  |
|-------------------------------|---|
| Courses                       |   |
| Title                         | Typ Hrs/wk CP   |
| Module Responsible            | Dozenten des SD B   |
| Admission Requirements        | None  |
| Recommended Previous          |   |
| Knowledge                     |   |
| <b>Educational Objectives</b> | After taking part successfully, students have reached the following learning results  |
| Professional Competence       |   |
| Knowledge                     | The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.   |
|                               | The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.   |
|                               | Scientific work techniques that are used can be described and critically reviewed.  |
| Skills                        | The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.  |
| Personal Competence           |   |
| -                             | The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.   |
| Autonomy                      | The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology. |
| Workload in Hours             | Independent Study Time 180, Study Time in Lecture 0   |
| Credit points                 | 6   |
| Course achievement            | None  |
| Examination                   | Study work  |
| Examination duration and      |   |
| scale                         |   |
| _                             | Water and Environmental Engineering: Specialisation Environment: Compulsory   |
| Following Curricula           |   |

| Module M0619: Wast   | e Treatment Tech  | nologies  |   |  |                  |                   |
|--|---|---|---|--|------------------|-------------------|
| Courses  |   |   |   |  |                  |                   |
|  |   |   |   | Tirm   | Hwa /wde         | CD                |
| <b>Fitle</b>   | n, (I 0220)   |   |   | <b>Typ</b> Practical Course  | Hrs/wk<br>2      | <b>CP</b> 2       |
| Waste and Environmental Chemist<br>Biological Waste Treatment (L0318 | -   |   |   | Project-/problem-based Learning  | 3                | 4                 |
| ·  |   |   |   | 110Ject-/problem-based Learning  | 3                | -                 |
| Module Responsible   |   |   |   |  |                  |                   |
| Admission Requirements   |   | h!  |   |  |                  |                   |
| Recommended Previous<br>Knowledge                                    | chemical and biological   | Dasics  |   |  |                  |                   |
|  | After telling ment access   | -£  |   |  |                  |                   |
| Educational Objectives   | After taking part success   | stully, students have re                        | eached the following                        | ng learning results  |                  |                   |
| Professional Competence<br>Knowledge                                 | design and layout of ana  | erobic and aerobic wa                           | aste treatment pla                          | biological waste treatment plan<br>nts in detail, describe different t<br>t methods for waste analytics.   |                  |                   |
| Skills   | The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group. |   |   |  |                  |                   |
| Personal Competence<br>Social Competence                             |   |   |   |  |                  |                   |
| Autonomy   | are capable, in consultat   | tion with supervisors a<br>hermore, they can de | s well as in the int<br>fine targets for ne | iness or test reports and transfo<br>terim presentation, to assess the<br>ew application-or research-orien | eir learning lev | el and define fur |
| Workload in Hours  | Independent Study Time  | 110 Study Time in L                             | acture 70                                   |  |                  |                   |
| Credit points  |   | . 110, Study Time in E                          | cetare 70                                   |  |                  |                   |
| Course achievement   | Compulsory Bonus F<br>Yes None S  | orm<br>Subject theoretical<br>Practical work    | <b>Description</b> and                      |  |                  |                   |
| Examination  | Presentation  |   |   |  |                  |                   |
| Examination duration and   | Elaboration and Presenta  | ation (15-25 minutes i                          | n groups)                                   |  |                  |                   |
| scale  |   |   |   |  |                  |                   |
| Assignment for the   |   | -   |   |  |                  |                   |
| Following Curricula  | Civil Engineering: Specia   | lisation Geotechnical                           | Engineering: Electi                         | ive Compulsory   |                  |                   |
|  | Civil Engineering: Specia   | lisation Coastal Engin                          | eering: Elective Co                         | ompulsory  |                  |                   |
|  | Civil Engineering: Specia   | lisation Water and Tra                          | affic: Elective Com                         | pulsory  |                  |                   |
|  | Energy and Environment  | tal Engineering: Specia                         | alisation Environm                          | ental Engineering: Elective Com  | oulsory          |                   |
|  | Environmental Engineer  | ing: Core Qualification                         | : Compulsory                                |  |                  |                   |
|  | International Manageme  | nt and Engineering: S                           | pecialisation II. End                       | ergy and Environmental Enginee   | ring: Elective   | Compulsory        |
|  |   | 3 3 ,   | '   | ainability: Specialisation Energy:   | 9                | . ,               |
|  | Water and Environmenta  |   |   |  |                  |                   |
|  | Water and Environmenta  |   |   |  |                  |                   |
|  |   | 5 5 - 1, 7-1-1                                  |   |  |                  |                   |

| Course L0328: Waste and Environmental Chemistry |   |  |
|---|---|--|
| Тур   | Practical Course  |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours                               | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer  | Prof. Kerstin Kuchta  |  |
| Language  | DE/EN   |  |
| Cycle   | WiSe  |  |
| Content   | The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as |  |
|   | basis for discussing the results and to evaluate the performance of the group and the individual student.                     |  |
|   | In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results   |  |
|   | evaluation.   |  |
|   | Experiments ar e.g.   |  |
|   | Screening and particle size determination   |  |
|   | Fos/Tac   |  |
|   | AAS   |  |
|   | Chalorific value  |  |
| Literature                                      | Scripte   |  |

| Course L0318: Biological Waste Treatment |   |
|--|---|
| Тур                                      | Project-/problem-based Learning   |
| Hrs/wk                                   | 3   |
| СР                                       | 4   |
| Workload in Hours                        | Independent Study Time 78, Study Time in Lecture 42   |
| Lecturer                                 | Prof. Kerstin Kuchta  |
| Language                                 | EN  |
| Cycle                                    | WiSe  |
| Content                                  | <ol> <li>Introduction</li> <li>biological basics</li> <li>determination process specific material characterization</li> <li>aerobic degradation ( Composting, stabilization)</li> <li>anaerobic degradation (Biogas production, fermentation)</li> <li>Technical layout and process design</li> <li>Flue gas treatment</li> <li>Plant design practical phase</li> </ol> |
| Literature                               |   |

| Module M1505: Adap                | tation to Climate Change in Hyo   | draulic Engineering (AKWAS)                          |                   |                  |  |
|-----------------------------------|---|--|-------------------|------------------|--|
| Courses                           |   |  |                   |                  |  |
| litle                             |   | Тур  | Hrs/wk            | СР               |  |
| daptation to climate change in hy | draulic engineering (L2291)   | Project-/problem-based Learning                      | 4                 | 6                |  |
| Module Responsible                | Prof. Peter Fröhle  |  |                   |                  |  |
| Admission Requirements            |   |  |                   |                  |  |
| Recommended Previous              |   |  |                   |                  |  |
| Knowledge                         | Hydrology, Hydraulic Engineering  |  |                   |                  |  |
|                                   | <ul><li>Hydromechanic, Hydraulics</li><li>Fundamentals of Coastal Engineering, 0</li></ul>                | Coastal, and Flood Protection                        |                   |                  |  |
|                                   | Hydrological Systems  | coustai- and riood riotection                        |                   |                  |  |
|                                   |   |  |                   |                  |  |
| Educational Objectives            | After taking part successfully, students have r   | reached the following learning results               |                   |                  |  |
| Professional Competence           |   |  |                   |                  |  |
| Knowledge                         | Climate protection and climate adaptat  | tion   |                   |                  |  |
|                                   | <ul> <li>Insights into climate change and its reg</li> </ul>  | gional characteristics - fundamentals, climate model | lling / climate n | nodels           |  |
|                                   | Impacts of climate change on the components of the regional hydrological cycle                            |  |                   |                  |  |
|                                   | Fundamentals of analysis of climate da  |  |                   |                  |  |
|                                   | Consequences of the impact of the clim  | nate change  |                   |                  |  |
|                                   | Measures for climate adaptation     Assessment prioritization and communications                          | signation of adaptation managers                     |                   |                  |  |
|                                   | <ul> <li>Assessment, prioritization and commur</li> <li>Fundamentals of the analysis of hydror</li> </ul> |  |                   |                  |  |
|                                   | - Tundamentals of the analysis of flydror   | neteorological and hydrological data                 |                   |                  |  |
| Skills                            |   | and relations, assessment of needs for action        |                   |                  |  |
|                                   |   | otation strategies and adaptation measures           |                   |                  |  |
|                                   |   | tions, application of calculation approaches, meth   | nods, numerica    | ıl models, plann |  |
|                                   | methods   |  |                   |                  |  |
|                                   | Consideration of complex tasks  |  |                   |                  |  |
| Personal Competence               |   |  |                   |                  |  |
| Social Competence                 |   |  |                   |                  |  |
|                                   | Working in heterogenous groups  | and a set of the set of the set                      |                   |                  |  |
|                                   | <ul><li>Working with different scientific / non-s</li><li>Self reflection</li></ul>                       | scientific disciplines                               |                   |                  |  |
|                                   | • Self reflection   |  |                   |                  |  |
| Autonomy                          | Application oriented use of knowledge   | and skills   |                   |                  |  |
|                                   | Autonomous work on complex tasks  | und skills   |                   |                  |  |
| Workload in Hours                 | Independent Study Time 124. Study Time in L   | ecture 56  |                   |                  |  |
| Credit points                     | ,, . ,,   |  |                   |                  |  |
| Course achievement                |   |  |                   |                  |  |
| Examination                       | Written elaboration   |  |                   |                  |  |
| Examination duration and          | Preparation of a written report and a presenta  | ation of a complex task.                             |                   |                  |  |
| scale                             |   |  |                   |                  |  |
| Assignment for the                | Civil Engineering: Specialisation Coastal Engir   | neering: Elective Compulsory                         |                   |                  |  |
| Following Curricula               |   |  |                   |                  |  |
|                                   | Civil Engineering: Specialisation Structural En   |  |                   |                  |  |
|                                   | Civil Engineering: Specialisation Water and Tr  |  |                   |                  |  |
|                                   | Water and Environmental Engineering: Specia   |  |                   |                  |  |
|                                   | Water and Environmental Engineering: Special Water and Environmental Engineering: Special                 |  |                   |                  |  |
|                                   | water and Environmental Engineering: Specia   | ansacion water. Elective Compuisory                  |                   |                  |  |

| Course L2291: Adaptation to | climate change in hydraulic engineering  |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 4  |
| СР                          | 6  |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                    | Prof. Peter Fröhle   |
| Language                    | DE   |
| Cycle                       | WiSe   |
| Content                     | <ul> <li>Climate protection and climate adaptation</li> <li>Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>Fundamentals of the analysis of climate data</li> <li>Concequences of the impacts of climate change (ingenieering science view)</li> <li>Measures for climate change adaptation</li> <li>Assessment, prioritization and communication of measures</li> <li>Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul> |
| Literature                  | Bereitgestellte eLearning Plattform  |

| Engineering                       |  |   |        |    |
|-----------------------------------|--|---|--------|----|
| Module M1717: Adva                | nced Vadose Zone Hydrology   |   |        |    |
| Courses                           |  |   |        |    |
| Title                             |  | Тур   | Hrs/wk | СР |
| Modeling Processes in Vadose Zone | e (L2734)  | Lecture                                     | 1      | 1  |
| Modeling Processes in Vadose Zone | e (L2735)  | Recitation Section (small)                  | 1      | 1  |
| Vadose Zone Hydrology (L2732)     |  | Lecture                                     | 2      | 2  |
| Vadose Zone Hydrology (L2733)     |  | Recitation Section (large)                  | 2      | 2  |
| Module Responsible                | Prof. Nima Shokri  |   |        |    |
| Admission Requirements            | None   |   |        |    |
| <b>Recommended Previous</b>       |  |   |        |    |
| Knowledge                         |  |   |        |    |
| <b>Educational Objectives</b>     | After taking part successfully, students have                                  | e reached the following learning results    |        |    |
| Professional Competence           |  |   |        |    |
| Knowledge                         |  |   |        |    |
| Skills                            |  |   |        |    |
| Personal Competence               |  |   |        |    |
| Social Competence                 |  |   |        |    |
| Autonomy                          |  |   |        |    |
| Workload in Hours                 | Independent Study Time 96, Study Time in L                                     | ecture 84                                   |        |    |
| Credit points                     | 6  |   |        |    |
| Course achievement                | None   |   |        |    |
| Examination                       | Written exam   |   |        |    |
| Examination duration and          | 90 min   |   |        |    |
| scale                             |  |   |        |    |
| Assignment for the                | Civil Engineering: Specialisation Water and 1                                  | Fraffic: Elective Compulsory                |        |    |
| Following Curricula               | Civil Engineering: Specialisation Water and 1                                  | Fraffic: Elective Compulsory                |        |    |
|                                   | Environmental Engineering: Specialisation W                                    | later: Elective Compulsory                  |        |    |
|                                   | Environmental Engineering: Specialisation W                                    | later: Elective Compulsory                  |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water: Elective Compulsory |   |        |    |
|                                   | Water and Environmental Engineering: Spec                                      | ialisation Environment: Elective Compulsory |        |    |
|                                   | Water and Environmental Engineering: Spec                                      | ialisation Cities: Elective Compulsory      |        |    |
|                                   | Water and Environmental Engineering: Spec                                      | ialisation Cities: Elective Compulsory      |        |    |
|                                   | Water and Environmental Engineering: Spec                                      | ialisation Environment: Elective Compulsory |        |    |
|                                   | Water and Environmental Engineering: Spec                                      | ialisation Water: Elective Compulsory       |        |    |

| Course L2734: Modeling Prod | Typ Lecture wk 1 CP 1                               |  |
|-----------------------------|---|--|
| Тур                         | Lecture   |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Hannes Nevermann, Prof. Nima Shokri                 |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Course L2735: Modeling Prod | urse L2735: Modeling Processes in Vadose Zone       |  |
|-----------------------------|---|--|
| Тур                         | Recitation Section (small)                          |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Hannes Nevermann                                    |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     | See interlocking course                             |  |
| Literature                  | See interlocking course                             |  |

| Course L2732: Vadose Zone Hydrology |   |  |
|-------------------------------------|---|--|
| Тур                                 | Lecture   |  |
| Hrs/wk                              | 2   |  |
| СР                                  | 2   |  |
| Workload in Hours                   | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                            | Prof. Nima Shokri                                   |  |
| Language                            | EN  |  |
| Cycle                               | SoSe  |  |
| Content                             |   |  |
| Literature                          |   |  |

| Course L2733: Vadose Zone | Hydrology   |
|---------------------------|---|
| Тур                       | Recitation Section (large)                          |
| Hrs/wk                    | 2   |
| СР                        | 2   |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer                  | Prof. Nima Shokri                                   |
| Language                  | EN  |
| Cycle                     | SoSe  |
| Content                   | See interlocking course                             |
| Literature                | See interlocking course                             |

| Module M1718: Multip   | phase Flow in Porous Media                             |                                      |        |    |
|--|--|--------------------------------------|--------|----|
| C  |  |                                      |        |    |
| Courses  |  |                                      |        |    |
| Title  |  | Тур                                  | Hrs/wk | СР |
| - '  | Multiphase Flow in Porous Media (L2738)                | Recitation Section (small)           | 2      | 2  |
| Fundamentals of Multiphase Flow in<br>Fundamentals of Multiphase Flow in |  | Lecture  Recitation Section (large)  | 2      | 2  |
| Module Responsible   |  | Recitation Section (large)           | 2      | 2  |
| Admission Requirements   |  |                                      |        |    |
| Recommended Previous   | None   |                                      |        |    |
| Kecommended Previous<br>Knowledge  |  |                                      |        |    |
|  | After helice and consent the students have             | d blood following a longuing grounds |        |    |
|  | After taking part successfully, students have reached  | the following learning results       |        |    |
| Professional Competence  |  |                                      |        |    |
| Knowledge  |  |                                      |        |    |
| Skills   |  |                                      |        |    |
| Personal Competence  |  |                                      |        |    |
| Social Competence  |  |                                      |        |    |
| Autonomy   |  |                                      |        |    |
| Workload in Hours  | Independent Study Time 96, Study Time in Lecture 8     | 34                                   |        |    |
| Credit points  | 6  |                                      |        |    |
| Course achievement   | None   |                                      |        |    |
| Examination  | Written exam   |                                      |        |    |
| Examination duration and   | 90 min   |                                      |        |    |
| scale  |  |                                      |        |    |
| Assignment for the   | Civil Engineering: Specialisation Water and Traffic: E | lective Compulsory                   |        |    |
| Following Curricula  | Civil Engineering: Specialisation Geotechnical Engine  | eering: Elective Compulsory          |        |    |
|  | Civil Engineering: Specialisation Geotechnical Engine  | eering: Elective Compulsory          |        |    |
|  | Civil Engineering: Specialisation Water and Traffic: E | lective Compulsory                   |        |    |
|  | Environmental Engineering: Specialisation Water: Ele   | ective Compulsory                    |        |    |
|  | Environmental Engineering: Specialisation Water: Ele   | ective Compulsory                    |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Cities: Elective Compulsory        |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Cities: Elective Compulsory        |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Environment: Elective Compulsory   |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Environment: Elective Compulsory   |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Water: Elective Compulsory         |        |    |
|  | Water and Environmental Engineering: Specialisation    | n Water: Elective Compulsory         |        |    |

| Course L2738: Advanced Mod | ourse L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (small)  |  |
| Hrs/wk                     | 2   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28                           |  |
| Lecturer                   | Prof. Nima Shokri   |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    |   |  |
| Literature                 |   |  |

| Course L2736: Fundamentals of Multiphase Flow in Porous Media |   |  |
|---|---|--|
| Тур   | Lecture   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer  | Prof. Nima Shokri                                   |  |
| Language  | EN  |  |
| Cycle   | SoSe  |  |
| Content   |   |  |
| Literature  |   |  |

| Course L2737: Fundamentals | s of Multiphase Flow in Porous Media                |
|----------------------------|---|
| Тур                        | Recitation Section (large)                          |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer                   | Hannes Nevermann                                    |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | See interlocking course                             |
| Literature                 | See interlocking course                             |

| Module M1721: Wate                | r and Environment: Theory and Application                           |                                 |        |    |
|-----------------------------------|---|---------------------------------|--------|----|
| Courses                           |   |                                 |        |    |
| Title                             |   | Тур                             | Hrs/wk | СР |
| Water and Environment: Applicatio |   | Project-/problem-based Learning | 3      | 4  |
| Water and Environment: Theory (L  | (753)   | Lecture                         | 1      | 2  |
| Module Responsible                | Prof. Nima Shokri   |                                 |        |    |
| Admission Requirements            | None  |                                 |        |    |
| Recommended Previous              |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| Educational Objectives            | After taking part successfully, students have reached the following | g learning results              |        |    |
| Professional Competence           |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| Skills                            |   |                                 |        |    |
| Personal Competence               |   |                                 |        |    |
| Social Competence                 |   |                                 |        |    |
| Autonomy                          |   |                                 |        |    |
| Workload in Hours                 | Independent Study Time 124, Study Time in Lecture 56                |                                 |        |    |
| Credit points                     | 6   |                                 |        |    |
| Course achievement                | None  |                                 |        |    |
| Examination                       | Written elaboration   |                                 |        |    |
| Examination duration and          | Report (about 5-10 pages) and Presentation (about 15 min)           |                                 |        |    |
| scale                             |   |                                 |        |    |
| Assignment for the                | Civil Engineering: Specialisation Coastal Engineering: Elective Con | npulsory                        |        |    |
| Following Curricula               | Civil Engineering: Specialisation Water and Traffic: Elective Compu | ulsory                          |        |    |
|                                   | Civil Engineering: Specialisation Coastal Engineering: Elective Con | npulsory                        |        |    |
|                                   | Civil Engineering: Specialisation Water and Traffic: Elective Compu | ulsory                          |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective Compu     | Isory                           |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective Compu     | Isory                           |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities: Electi  | ive Compulsory                  |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities: Electi  |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Environmen      |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Environmen      |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water: Elect    |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water: Elect    | ive Compulsory                  |        |    |

| Course L2754: Water and Environment: Application and Field Work |  |
|---|--|
| Тур   | Project-/problem-based Learning                          |
| Hrs/wk  | 3  |
| СР  | 4  |
| Workload in Hours   | Independent Study Time 78, Study Time in Lecture 42      |
| Lecturer  | Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni |
| Language  | EN   |
| Cycle   | SoSe   |
| Content   |  |
| Literature  |  |

| Course L2753: Water and Environment: Theory |   |
|---|---|
| Тур   | Lecture   |
| Hrs/wk                                      | 1   |
| СР  | 2   |
| Workload in Hours                           | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                    | Prof. Nima Shokri                                   |
| Language                                    | EN  |
| Cycle                                       | SoSe  |
| Content                                     |   |
| Literature                                  |   |

| Engineering                    |  |                                      |                 |                      |
|--------------------------------|--|--------------------------------------|-----------------|----------------------|
| Module M1702: Proce            | ess Imaging  |                                      |                 |                      |
|                                |  |                                      |                 |                      |
| Courses                        |  |                                      |                 |                      |
| Title                          |  | Тур                                  | Hrs/wk          | СР                   |
| Process Imaging (L2723)        |  | Lecture                              | 2               | 3                    |
| Process Imaging (L2724)        |  | Project-/problem-based Learning      | 2               | 3                    |
| Module Responsible             | Prof. Alexander Penn   |                                      |                 |                      |
| Admission Requirements         | None   |                                      |                 |                      |
| Recommended Previous           |  |                                      |                 |                      |
| Knowledge                      |  |                                      |                 |                      |
| <b>Educational Objectives</b>  | After taking part successfully, students have reached the follow         | ing learning results                 |                 |                      |
| <b>Professional Competence</b> |  |                                      |                 |                      |
| Knowledge                      |  |                                      |                 |                      |
| Skills                         |  |                                      |                 |                      |
| Personal Competence            |  |                                      |                 |                      |
| Social Competence              |  |                                      |                 |                      |
| Autonomy                       |  |                                      |                 |                      |
| Workload in Hours              | Independent Study Time 124, Study Time in Lecture 56                     |                                      |                 |                      |
| Credit points                  | ,                                  |                                      |                 |                      |
| Course achievement             | None   |                                      | _               |                      |
| Examination                    | Written exam   |                                      |                 |                      |
| Examination duration and       | 120 min  |                                      |                 |                      |
|                                | 120 (((()))  |                                      |                 |                      |
| scale                          | Disasses Facility Considiration A. Consul Bisasses F                     | ania ania an Elantina Camandana      |                 |                      |
| Assignment for the             | Bioprocess Engineering: Specialisation A - General Bioprocess E          |                                      |                 |                      |
| Following Curricula            |  |                                      |                 |                      |
|                                | Bioprocess Engineering: Specialisation B - Industrial Bioprocess         |                                      |                 |                      |
|                                | Bioprocess Engineering: Specialisation B - Industrial Bioprocess         |                                      |                 | ochnology" Elective  |
|                                | Bioprocess Engineering: Specialisation C - Bioeconomic Proces            | s Eligilieerilig, Focus Eliergy and  | 1 Bioprocess in | echhology. Elective  |
|                                | Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Proces | es Engineering Focus Energy and      | d Bioprocess T  | achnology: Elective  |
|                                | Compulsory   | ss Eligilieerilig, Focus Eliergy and | i bioprocess in | eciliology. Liective |
|                                | Chemical and Bioprocess Engineering: Specialisation General Pr           | ocess Engineering: Flective Comr     | nulsory         |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation General Pr           |                                      |                 |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation Bioprocess           |                                      | •               |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation Bioprocess           |                                      |                 |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation Chemical I           |                                      |                 |                      |
|                                | Chemical and Bioprocess Engineering: Specialisation Chemical I           | • •                                  |                 |                      |
|                                | Computer Science: Specialisation II: Intelligence Engineering: El        |                                      | , ,             |                      |
|                                | Information and Communication Systems: Specialisation Comm               |                                      | rocessing: Ele  | ctive Compulsory     |
|                                | International Management and Engineering: Specialisation II. Pr          |                                      |                 |                      |
|                                | Theoretical Mechanical Engineering: Specialisation Robotics and          |                                      |                 |                      |
|                                | Theoretical Mechanical Engineering: Specialisation Robotics and          |                                      |                 |                      |
|                                | Process Engineering: Specialisation Process Engineering: Electiv         | ve Compulsory                        |                 |                      |
|                                | Process Engineering: Specialisation Process Engineering: Electiv         | ve Compulsory                        |                 |                      |
|                                | Process Engineering: Specialisation Chemical Process Engineeri           | ng: Elective Compulsory              |                 |                      |
|                                | Process Engineering: Specialisation Chemical Process Engineeri           | ng: Elective Compulsory              |                 |                      |
|                                | Process Engineering: Specialisation Environmental Process Engi           | neering: Elective Compulsory         |                 |                      |
|                                | Process Engineering: Specialisation Environmental Process Engi           | neering: Elective Compulsory         |                 |                      |
|                                | Water and Environmental Engineering: Specialisation Environmental        | ent: Elective Compulsory             |                 |                      |
|                                | Water and Environmental Engineering: Specialisation Environmental        | ent: Elective Compulsory             |                 |                      |
|                                | Water and Environmental Engineering: Specialisation Water: Ele           | ective Compulsory                    |                 |                      |
|                                | Water and Environmental Engineering: Specialisation Water: Ele           | ective Compulsory                    |                 |                      |

| Course L2723: Process Imagi | Course L2723: Process Imaging                       |  |
|-----------------------------|---|--|
| Тур                         | Lecture   |  |
| Hrs/wk                      | 2   |  |
| СР                          | 3   |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28 |  |
| Lecturer                    | Prof. Alexander Penn                                |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Course L2724: Process Imagi | Course L2724: Process Imaging                       |  |
|-----------------------------|---|--|
| Тур                         | Project-/problem-based Learning                     |  |
| Hrs/wk                      | 2   |  |
| СР                          | 3   |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28 |  |
| Lecturer                    | Prof. Alexander Penn, Dr. Stefan Benders            |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Module M1724: Smar       |   |                     |
|--------------------------|---|---------------------|
| Courses                  |   |                     |
| Title                    | Typ Hrs/wk  | СР                  |
| Smart Monitoring (L2762) | Integrated Lecture 2  | 2                   |
| Smart Monitoring (L2763) | Recitation Section (small) 2  | 4                   |
| Module Responsible       | Prof. Kay Smarsly   |                     |
| Admission Requirements   | s None  |                     |
| Recommended Previous     | <b>s</b> Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpfu   | ul. Interest in mod |
| Knowledge                | research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepe                            |                     |
|                          | skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.  |                     |
| Educational Objectives   | s After taking part successfully, students have reached the following learning results  | -                   |
| Professional Competence  |   |                     |
| •                        | e The students will become familiar with the principles and practices of smart monitoring. The students w   | vill he able to des |
| Knowicage                | decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built  |                     |
|                          | environment. In addition, the students will learn to design and to implement intelligent sensor systems using   |                     |
|                          | analysis techniques, modern software design concepts, and embedded computing methodologies. Besides led   |                     |
|                          | also part of this module. In small groups, the students will design smart monitoring systems that int   |                     |
|                          | "intelligent" sensors to be implemented by the students. Specific focus will be put on the application  |                     |
|                          | techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as  | bridges or slopes   |
|                          | on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper  | er. All students of |
|                          | module will "automatically" participate with their smart monitoring system in the annual "Smart Monitori  | ing" competition.   |
|                          | written papers and oral examinations form the final grades. The module will be taught in English. Limited enro  | ollment.            |
| Clálla                   |   |                     |
| Skills                   |   |                     |
| Personal Competence      |   |                     |
| Social Competence        |   |                     |
| Autonomy                 | ·   | _                   |
| Workload in Hours        |   |                     |
| Credit points            |   |                     |
| Course achievement       |   |                     |
|                          | m Written elaboration   |                     |
|                          | d 10 pages of work with 15-minute oral presentation   |                     |
| scale                    |   |                     |
| Assignment for the       |   |                     |
| Following Curricula      |   |                     |
|                          | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory  |                     |
|                          | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory |                     |
|                          | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory  |                     |
|                          | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory   |                     |
|                          | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory  |                     |
|                          | Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory   |                     |
|                          | Environmental Engineering: Specialisation Biotechnology: Elective Compulsory  |                     |
|                          | Environmental Engineering: Specialisation Water: Elective Compulsory  |                     |
|                          | Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory   |                     |
|                          | Environmental Engineering: Specialisation Biotechnology: Elective Compulsory  |                     |
|                          | Environmental Engineering: Specialisation Water: Elective Compulsory  |                     |
|                          | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory   |                     |
|                          | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory   |                     |
|                          | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory  |                     |
|                          | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory  |                     |
|                          | Water and Environmental Engineering: Specialisation Water: Elective Compulsory  |                     |
|                          | Water and Environmental Engineering: Specialisation Water: Elective Compulsory  |                     |

| Course L2762: Smart Monito | ring   |
|----------------------------|--|
| Тур                        | Integrated Lecture   |
| Hrs/wk                     | 2  |
| СР                         | 2  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                   | Prof. Kay Smarsly  |
| Language                   | EN   |
| Cycle                      | WiSe/SoSe  |
| Content                    | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| Literature                 |  |

| Course L2763: Smart Monito | ring   |
|----------------------------|--|
| Тур                        | Recitation Section (small)   |
| Hrs/wk                     | 2  |
| СР                         | 4  |
| Workload in Hours          | Independent Study Time 92, Study Time in Lecture 28  |
| Lecturer                   | Prof. Kay Smarsly  |
| Language                   | EN   |
| Cycle                      | WiSe/SoSe  |
| Content                    | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the "Smart Monitoring" competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature. |
| Literature                 |  |

### **Specialization Water**

| Module M0705: Groun               | ndwater  |                                      |                   |                       |
|-----------------------------------|--|--------------------------------------|-------------------|-----------------------|
| Courses                           |  |                                      |                   |                       |
| Title                             |  | Тур                                  | Hrs/wk            | СР                    |
| Geohydraulic and Solute Transport | (L0539)  | Lecture                              | 2                 | 2                     |
| Geohydraulic and Solute Transport | (L0540)  | Recitation Section (small)           | 1                 | 1                     |
| Simulation in Groundwater Hydrolo | gy (L0541)   | Lecture                              | 1                 | 1                     |
| Simulation in Groundwater Hydrolo | gy (L0542)   | Recitation Section (small)           | 2                 | 2                     |
| Module Responsible                | NN   |                                      |                   |                       |
| Admission Requirements            | None   |                                      |                   |                       |
| Recommended Previous              | - Craund water budgelegy   |                                      |                   |                       |
| Knowledge                         | Ground water hydrology     Undramashanias  |                                      |                   |                       |
|                                   | Hydromechanics   |                                      |                   |                       |
|                                   |  |                                      |                   |                       |
| Educational Objectives            | After taking part successfully, students have reached the fi   | Nowing learning results              |                   |                       |
|                                   | Arter taking part successivily, students have reached the h  | bilowing learning results            |                   |                       |
| Professional Competence           |  |                                      |                   |                       |
| Knowieage                         | The students are able to describe the fate of solutes in the   | - ·                                  | en soil and wate  | r body quantitatively |
|                                   | and qualitatively. They are able to do this with simulation r  |                                      |                   |                       |
| Skills                            | The students are able to describe conceptually movement and storage of water in the unsaturated zone. They are able to analyse |                                      |                   |                       |
|                                   | pF- functions and Ku functions. They can model transport of solutes in the unsaturated and saturated zoned. They are able to   |                                      |                   |                       |
|                                   | determine dispersiities, sorption coefficients, decay rates a  | nd dissolution rates for organic and | d inorganic subst | ances.                |
| Personal Competence               |  |                                      |                   |                       |
|                                   | The students can help to each other.   |                                      |                   |                       |
| Autonomy                          | none   |                                      |                   |                       |
| Workload in Hours                 | Independent Study Time 96, Study Time in Lecture 84  |                                      |                   |                       |
| Credit points                     | 6  |                                      |                   |                       |
| Course achievement                | None   |                                      |                   |                       |
| Examination                       | Written exam   |                                      |                   |                       |
| Examination duration and          | 60 min written exam and written papers   |                                      |                   |                       |
| scale                             |  |                                      |                   |                       |
| Assignment for the                | Civil Engineering: Specialisation Structural Engineering: Ele  | ctive Compulsory                     |                   |                       |
| Following Curricula               | Civil Engineering: Specialisation Geotechnical Engineering:  | Elective Compulsory                  |                   |                       |
|                                   | Civil Engineering: Specialisation Coastal Engineering: Elect   | ve Compulsory                        |                   |                       |
|                                   | Civil Engineering: Specialisation Water and Traffic: Elective  | Compulsory                           |                   |                       |
|                                   | Process Engineering: Specialisation Environmental Process  | Engineering: Elective Compulsory     |                   |                       |
|                                   | Process Engineering: Specialisation Process Engineering: E   | ective Compulsory                    |                   |                       |
|                                   | Water and Environmental Engineering: Specialisation Water  | r: Compulsory                        |                   |                       |
|                                   | Water and Environmental Engineering: Specialisation Envir  | onment: Elective Compulsory          |                   |                       |
|                                   | Water and Environmental Engineering: Specialisation Cities   | : Elective Compulsory                |                   |                       |
|                                   |  |                                      |                   |                       |

| Course L0539: Geohydraulic | and Solute Transport   |
|----------------------------|--|
| Тур                        | Lecture  |
| Hrs/wk                     | 2  |
| СР                         | 2  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                   | Sonja Götz   |
| Language                   | DE   |
| Cycle                      | WiSe   |
| Content                    | Pump test analysis, water content-water suction functions, unsaturated hydraulic conductivity function, Brooks-Corey relation, van |
|                            | Genuchten relation, solute transport in unsaturated zone, solute transport and reactions in groundwater                            |
| Literature                 | Todd; K. (2005): Groundwater Hydrology   |
|                            | Fetter, C.W. (2001): Applied Hydrogeology  |
|                            | Hölting & Coldewey (2005): Hydrogeologie   |
|                            | Charbeneau, R.J. (2000): Groundwater Hydraulics and pollutant Transport  |

| Course L0540: Geohydraulic and Solute Transport |   |
|---|---|
| Тур   | Recitation Section (small)                          |
| Hrs/wk  | 1   |
| СР  | 1   |
| Workload in Hours                               | Independent Study Time 16, Study Time in Lecture 14 |
| Lecturer  | Sonja Götz  |
| Language  | DE  |
| Cycle   | WiSe  |
| Content   | See interlocking course                             |
| Literature                                      | See interlocking course                             |

| Course L0541: Simulation in | Groundwater Hydrology   |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 1   |
| СР                          | 1   |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14   |
| Lecturer                    | Sonja Götz  |
| Language                    | DE  |
| Cycle                       | WiSe  |
| Content                     | Basics and theoretical background of simulation models frequently used in science and practise for pumping test analysis, water |
|                             | movement in vadose zone, solute transport in vadose zone, groundwater recharge, solute transport in groundwater                 |
| Literature                  | Handbücher der verwendeten Slumationsmodelle werden bereitgestellt.   |

| Course L0542: Simulation in | Course L0542: Simulation in Groundwater Hydrology   |  |
|-----------------------------|---|--|
| Тур                         | Recitation Section (small)                          |  |
| Hrs/wk                      | 2   |  |
| СР                          | 2   |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                    | Sonja Götz  |  |
| Language                    | DE  |  |
| Cycle                       | WiSe  |  |
| Content                     | See interlocking course                             |  |
| Literature                  | See interlocking course                             |  |

| Module M0801: Water Resources and -Supply       |   |   |                  |                |
|---|---|---|------------------|----------------|
| Courses   |   |   |                  |                |
|   |   |   |                  |                |
| <b>Title</b> Chemistry of Drinking Water Treatr | nont (L0211)  | <b>Typ</b><br>Lecture                   | Hrs/wk<br>2      | <b>CP</b><br>1 |
| Chemistry of Drinking Water Treatr              |   | Recitation Section (large)              | 1                | 2              |
| Water Resource Management (L04)                 |   | Lecture                                 | 2                | 2              |
| Water Resource Management (L04)                 |   | Recitation Section (small)              | 1                | 1              |
| Module Responsible                              | Prof. Mathias Ernst   |   |                  |                |
| Admission Requirements                          | None  |   |                  |                |
| Recommended Previous                            | Knowledge of water management and the key proce   | esses involved in water treatment.      |                  |                |
| Knowledge                                       |   |   |                  |                |
| Educational Objectives                          | After taking part successfully, students have reache  | d the following learning results        |                  |                |
| Professional Competence                         |   |   |                  |                |
| Knowledge                                       | Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.  |   |                  |                |
| Skills  | Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.   |   |                  |                |
| Personal Competence                             |   |   |                  |                |
| Social Competence  Autonomy                     | Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.  Students will be in a position to work on a subject independently and present on this subject. |   |                  |                |
| Waydaad in Harre                                | Independent Study Time 06 Study Time in Lecture   | 24                                      |                  |                |
| Credit points                                   | Independent Study Time 96, Study Time in Lecture 6  | 04                                      |                  |                |
| Course achievement                              |   |   |                  |                |
| Examination                                     | Written exam  |   |                  |                |
| Examination duration and                        |   |   |                  |                |
| scale   | oo miii (chemistry) i presentation  |   |                  |                |
| Assignment for the                              | Civil Engineering: Specialisation Structural Engineer   | ing: Elective Compulsory                |                  |                |
| Following Curricula                             | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |   |                  |                |
|   | Civil Engineering: Specialisation Water and Traffic: 0  |   |                  |                |
|   | Civil Engineering: Specialisation Coastal Engineering   |   |                  |                |
|   | Energy and Environmental Engineering: Specialisati  |   | : Elective Compu | ilsory         |
|   | International Management and Engineering: Special   | •                                       |                  | •              |
|   | Water and Environmental Engineering: Specialisatio  | • |                  |                |
|   | Water and Environmental Engineering: Specialisatio  | • •                                     |                  |                |
|   | Water and Environmental Engineering: Specialisatio  |   |                  |                |
|   | z z z zg zg zpecialisatio   |   |                  |                |

| Course L0311: Chemistry of | Drinking Water Treatment  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 1   |
| Workload in Hours          | Independent Study Time 2, Study Time in Lecture 28  |
| Lecturer                   | Dr. Klaus Johannsen   |
| Language                   | DE  |
| Cycle                      | WiSe  |
| Content                    | The topic of this course is water chemistry with respect to drinking water treatment and water distribution   |
|                            | Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).  Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.  Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester. |
| Literature                 | MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.  DVGW (Hrsg.): Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.  Jensen, J. N.: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.   |

| Course L0312: Chemistry of | ourse L0312: Chemistry of Drinking Water Treatment  |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (large)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                   | Dr. Klaus Johannsen                                 |  |
| Language                   | DE  |  |
| Cycle                      | WiSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| Course L0402: Water Resour |   |
|----------------------------|---|
|                            | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Prof. Mathias Ernst   |
| Language                   | DE  |
| Cycle                      | WiSe  |
| Content                    | The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview:  • Current situation of global water resources  - User and Stakeholder conflicts  - Wasserressourcenmanagement in urbane Gebieten  - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.  - Ökobilanzierung, Benchmarking in der Wasserversorgung |
| Literature                 | <ul> <li>Aktuelle UN World Water Development Reports</li> <li>Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>Ppt der Vorlesung</li> </ul>  |

| Course L0403: Water Resour | Course L0403: Water Resource Management             |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (small)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 1   |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                   | Prof. Mathias Ernst                                 |  |
| Language                   | DE  |  |
| Cycle                      | WiSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| Module M1403: Const                | truction and Simulation of Sewerag   | e Systems                           |        |    |
|------------------------------------|--|-------------------------------------|--------|----|
| Courses                            |  |                                     |        |    |
| Title                              |  | Тур                                 | Hrs/wk | СР |
| Construction and renovation of urb | -  | Seminar                             | 3      | 3  |
| Simulation of sewerage systems (L  | 2006)  | Seminar                             | 3      | 3  |
| Module Responsible                 | Prof. Ralf Otterpohl   |                                     |        |    |
| Admission Requirements             | None   |                                     |        |    |
| Recommended Previous<br>Knowledge  | Hydraulics in pipes and gravity-sewers  Mechanics Soil mechanics and foundation engineering Knowledge about urban sewerage systems a   | nd water management                 |        |    |
| Educational Objectives             | After taking part successfully, students have reache   | ed the following learning results   |        |    |
| Professional Competence            |  |                                     |        |    |
| Knowledge                          | Students can describe urban wastewater systems by means of software-based modeling. In case studies they can perform system and weak point analyzes. In addition, they can analyze the hydraulic effects quantitatively. Furthermore, they have the knowledge to comprehend flow events in gravity-sewers based on the St. Venant equations.  Students have knowledge of static and structural requirements of the sewer system. Cases of damage are investigated and the knowledge regarding different renovation technologies for sewer systems is acquired. |                                     |        |    |
| Skills                             | The students can simulate different run-off events in sewer systems and are able to dimension the sewer systems accordingly. Moreover, they can determine suitable construction materials and static requirements for different cases of application.  |                                     |        |    |
| Personal Competence                |  |                                     |        |    |
| •                                  | Students are able to apply the acquired skills in a to   | eam and can impart this knowledge.  |        |    |
| Autonomy                           | Students can solve problems in the field of wastewater systems independently, concerning in particular dimensioning and simulation of sewer systems. Furthermore, they are able to present and justify their solutions.  |                                     |        |    |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture   | 84                                  |        |    |
| Credit points                      | 6  |                                     |        |    |
| Course achievement                 | CompulsoryBonusFormNo20 %Presentation  | Description                         |        |    |
| Examination                        | Written elaboration  |                                     |        |    |
| Examination duration and           | nach Absprache   |                                     |        |    |
| scale                              |  |                                     |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic:   | Compulsory                          |        |    |
| Following Curricula                | Water and Environmental Engineering: Specialisation  | ' '                                 |        |    |
|                                    | Water and Environmental Engineering: Specialisation  | on Environment: Elective Compulsory |        |    |

| Course L1998: Construction | and renovation of urban sewer systems   |  |  |
|----------------------------|---|--|--|
| Тур                        | Seminar   |  |  |
| Hrs/wk                     | 3   |  |  |
| СР                         | 3   |  |  |
| Workload in Hours          |   |  |  |
|                            | Prof. Ingo Weidlich   |  |  |
|                            | 3   |  |  |
| Language                   |   |  |  |
| Cycle                      | WiSe  |  |  |
| Content                    | The lecture focusses on construction and renovation of urban se   | ewer pipelines.  |  |
|                            | Construction:   |  |  |
|                            | Pipe materials, types and joint technology  |  |  |
|                            | Open trenches   |  |  |
|                            | Trenchless technologies   |  |  |
|                            | Pipe Statics:   |  |  |
|                            |   |  |  |
|                            | Design of sewers according to ATV A 127      Tarth prossure on pipes pipe deformation sutting forces.   |  |  |
|                            | <ul> <li>Earth pressure on pipes, pipe deformation, cutting forces</li> <li>Comparison with other international calculation approach</li> </ul> |  |  |
|                            | Companson with other international calculation approach   | 165  |  |
|                            | Renovation:   |  |  |
|                            | Failure case study  |  |  |
|                            | Overview on the different renovation technologies   |  |  |
|                            | Liner design according to DWA-A 143   |  |  |
|                            |   |  |  |
| Literature                 |   | Titel  |  |
|                            | 1   | ATV A 127, Abwassertechnische Vereinigung e.V., Arbeitsblatt A   |  |
|                            |   | 127, Regelwerk Abwasser-Abfall, Vertrieb: GFA, DK 628.22 (083),A 127, 2000                                       |  |
|                            | 2   | DIN EN 1610, Verlegung und Prüfung von Abwasserleitungen und   |  |
|                            |   | -kanälen, Beuth Verlag, Berlin, 1997   |  |
|                            | 3   | Arbeitsblatt DWA-A 143-1, Sanierung von  |  |
|                            |   | Entwässerungssystemen außerhalb von Gebäuden, Teil 1:  |  |
|                            |   | Planung und Überwachung von Sanierungsmaßnahmen Februar  |  |
|                            |   | 2015   |  |
|                            | 4   | Arbeitsblatt DWA-A 143-2, Sanierung von  |  |
|                            |   | Entwässerungssystemen außerhalb von Gebäuden Teil 2:   |  |
|                            |   | Statische Berechnung zur Sanierung von Abwasserleitungen und   |  |
|                            | 5   | -kanälen mit Lining und Montageverfahren, Juli 2015<br>DIN EN 752:2008, 2008: Entwässerungssysteme außerhalb von |  |
|                            |   | Gebäuden - Kanalmanagement.  |  |
|                            | 6   | Zeitschrift 3R, Fachzeitschrift für sichere und effiziente   |  |
|                            |   | Rohrleitungssysteme  |  |
|                            | 7   | Handbuch für den Rohrleitungsbau Band 1 und 2, 4. Auflage,   |  |
|                            |   | Günter Wossog, 2015  |  |
|                            | 8   | Rohrleitungstechnik, Walter Wagner, Vogel Buchverlag, 2006   |  |
|                            | 9   | Stein D., Stein R., "Instandhaltung von Kanalisationen", 1008 S.,  |  |
|                            |   | ISBN 978-3-9810648-4-1   Verlag Prof. DrIng. Stein & Partner   |  |
|                            | 10  | GmbH, 2014 Stein, D., "Grabenloser Leitungsbau", 1. Auflage, Gebundene   |  |
|                            |   | Ausgabe - 1166 Seiten, Ernst & Sohn Verlag, 2003, ISBN:  |  |
|                            |   | 3433017786   |  |
|                            | 11  | Willoughby D:A: "Horizontal Directional Drilling: Utility and  |  |
|                            |   | Pipeline Applications" Digital Engineering Library @ McGraw-Hill -   |  |
|                            |   | The McGraw-Hill Companies, Inc., 2005  |  |
|                            | 12  | Weidlich I., "Erddruck auf Rohre", 1. Auflage, ISBN 3-89999-027-   |  |
|                            |   | 7, 227 Seiten, 2012  |  |

| Course L2006: Simulation of | sewerage systems   |  |
|-----------------------------|--|--|
| Тур                         | eminar   |  |
| Hrs/wk                      | 3  |  |
| СР                          | 3  |  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42  |  |
| Lecturer                    | Prof. Ralf Otterpohl   |  |
| Language                    | EN   |  |
| Cycle                       | WiSe   |  |
| Content                     | Modeling of sewer systems:   |  |
|                             | <ul> <li>Modeling approaches in wastewater management, especially approaches to integrated modeling</li> <li>Planning processes, calculations and design approaches for elements of gravity-sewers</li> <li>Model setup</li> <li>St. Venant equation and simplifications of models (kinematic wave etc.)</li> <li>Calculation &amp; modeling of solids transport (advection, diffusion, dispersion and sales processes)</li> <li>Examples for modeling with SWMM (EPA, USA)</li> </ul> |  |
| Literature                  |  |  |

| Module M0513: Syste   | em Aspects of Renewable Energies  |                                    |                  |                   |
|---|---|------------------------------------|------------------|-------------------|
| Courses   |   |                                    |                  |                   |
| Title Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021) |   | Typ Lecture                        | Hrs/wk           | <b>CP</b> 2       |
| Energy Trading (L0019) Energy Trading (L0020)   |   | Lecture Recitation Section (small) | 1                | 1                 |
| Deep Geothermal Energy (L0025)  |   | Lecture                            | 2                | 2                 |
| Module Responsible  | Prof. Martin Kaltschmitt  |                                    |                  |                   |
| Admission Requirements  | None  |                                    |                  |                   |
| Recommended Previous  | Module: Technical Thermodynamics I  |                                    |                  |                   |
| Knowledge   | Module: Technical Thermodynamics II   |                                    |                  |                   |
| Educational Objectives  | After taking part successfully, students have reached the follo   | wing learning results              |                  |                   |
| Professional Competence   |   |                                    |                  |                   |
| Knowledge   | Students are able to describe the processes in energy trading relation to current subject specific problems. Furthermore electrochemical energy conversion in fuel cells and can esta   | re, they are able to explain       | the basics of    | thermodynamics of |
|   | electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.  |                                    |                  |                   |
| Skills  | Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode. |                                    |                  |                   |
|   | Furthermore, the students are able to explain the procedures other modules on renewable energy projects. In this context markets and energy trades.   |                                    |                  |                   |
| Personal Competence   |   |                                    |                  |                   |
| Social Competence   | Students are able to discuss issues in the thematic fields in th  | e renewable energy sector addre    | ssed within the  | module.           |
| Autonomy  | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.   |                                    |                  |                   |
| Workload in Hours   | Independent Study Time 96, Study Time in Lecture 84   |                                    |                  |                   |
| Credit points   | 6   |                                    |                  |                   |
| Course achievement  | None  |                                    |                  |                   |
| Examination   | Written exam  |                                    |                  |                   |
| Examination duration and  | 3 hours written exam  |                                    |                  |                   |
| scale   |   |                                    |                  |                   |
| Assignment for the  | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory  |                                    |                  |                   |
| Following Curricula   | Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory  |                                    |                  |                   |
|   | International Management and Engineering: Specialisation II.  |                                    |                  | C                 |
|   | International Management and Engineering: Specialisation II.  | •                                  | -                |                   |
|   | International Management and Engineering: Specialisation II. Renewable Energies: Core Qualification: Compulsory   | rrocess Engineering and Biotechi   | iology: Elective | Compuisory        |
|   | Process Engineering: Specialisation Environmental Process En  | aineering: Flective Compulsory     |                  |                   |
|   | Process Engineering: Specialisation Process Engineering: Elec   |                                    |                  |                   |
|   | Water and Environmental Engineering: Specialisation Water: I  |                                    |                  |                   |
|   | Water and Environmental Engineering: Specialisation Environ   | ment: Elective Compulsory          |                  |                   |

| Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage |  |  |
|---|--|--|
| Тур   | Lecture  |  |
| Hrs/wk  | 2  |  |
| СР  | 2  |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer  | Prof. Michael Fröba  |  |
| Language  | DE   |  |
| Cycle   | SoSe   |  |
| Content   | 1. Introduction to electrochemical energy conversion 2. Function and structure of electrolyte 3. Low-temperature fuel cell |  |
| Literature  | Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003   |  |

| Course L0019: Energy Tradin | ıg   |
|-----------------------------|--|
| Тур                         | Lecture  |
| Hrs/wk                      | 1  |
| СР                          | 1  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14  |
| Lecturer                    | Michael Sagorje, Dr. Sven Orlowski   |
| Language                    | DE   |
| Cycle                       | SoSe   |
| Content                     | <ul> <li>Basic concepts and tradable products in energy markets</li> <li>Primary energy markets</li> <li>Electricity Markets</li> <li>European Emissions Trading Scheme</li> <li>Influence of renewable energy</li> <li>Real options</li> <li>Risk management</li> </ul> Within the exercise the various tasks are actively discussed and applied to various cases of application. |
| Literature                  |  |

| Course L0020: Energy Tradin | urse L0020: Energy Trading                          |  |
|-----------------------------|---|--|
| Тур                         | Recitation Section (small)                          |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Michael Sagorje, Dr. Sven Orlowski                  |  |
| Language                    | DE  |  |
| Cycle                       | SoSe  |  |
| Content                     | See interlocking course                             |  |
| Literature                  | See interlocking course                             |  |

| Course L0025: Deep Geother | rmal Energy   |  |
|----------------------------|---|--|
| Тур                        | Lecture   |  |
| Hrs/wk                     | 2   |  |
| СР                         |   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer                   | Dr. Ben Norden  |  |
| Language                   | DE  |  |
| Cycle                      | SoSe  |  |
| Content                    | <ol> <li>Introduction to the deep geothermal use</li> <li>Geological Basics I</li> <li>Geology and thermal aspects</li> <li>Rock Physical Aspects</li> <li>Geochemical aspects</li> <li>Exploration of deep geothermal reservoirs</li> <li>Drilling technologies, piping and expansion</li> <li>Borehole Geophysics</li> <li>Underground system characterization and reservoir engineering</li> <li>Microbiology and Upper-day system components</li> <li>Adapted investment concepts, cost and environmental aspect</li> </ol>   |  |
| Literature                 | <ul> <li>Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)</li> <li>www.geo-energy.org</li> <li>Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.</li> <li>Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.</li> <li>Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)</li> <li>Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH &amp; Co. KGaA; Auflage: 1. Auflage (19. April 2010)</li> </ul> |  |

| Module M0703: Soil a              | nd Groundwater Contaminatio   | n   |                  |           |
|-----------------------------------|---|---|------------------|-----------|
|                                   |   |   |                  |           |
| Courses                           |   |   |                  |           |
| Γitle                             |   | Тур   | Hrs/wk           | СР        |
| Contamination and Remediation (L  |   | Project Seminar                                 | 3                | 3         |
| NAPL in Soil and Groundwater (L05 |   | Lecture   | 1                | 1         |
| NAPL in Soil and Groundwater (L05 | 46)   | Recitation Section (small)                      | 2                | 2         |
| Module Responsible                |   |   |                  |           |
| Admission Requirements            | None  |   |                  |           |
| Recommended Previous<br>Knowledge | Ground water hydrology     Geohydraulic and solute transport     Hydromechanics   |   |                  |           |
| <b>Educational Objectives</b>     | After taking part successfully, students have   | reached the following learning results          |                  |           |
| Professional Competence           |   |   |                  |           |
| Knowledge                         | The students are able to analyse contamination in soils and groundwater. They are able to create remediation concepts for LNAP contamnations. They are faminliar with Monitored Natural Attenuation  .  |   |                  |           |
| Skills                            | The students are able to analyse contaminations in soils and groundwater using special engineering methods. They can do transport modelling in the unsaturated zone, estimations of groundwater pollution and analyse the impacts of remediation measures. They can forecast die distribution, mobility and remediation of non aquaous phase liquids in soil and groundwater. |   |                  |           |
| Personal Competence               |   |   |                  |           |
| Social Competence                 | The students are able to prepare complex co   | entamination issues in teamwork and are able to | find remediation | measures. |
| Autonomy                          | None  |   |                  |           |
| Workload in Hours                 | Independent Study Time 96, Study Time in L  | ecture 84                                       |                  |           |
| Credit points                     | 6   |   |                  |           |
| Course achievement                | None  |   |                  |           |
| Examination                       | Written exam  |   |                  |           |
| Examination duration and          | Klausur 60 min; Referat 15 min;   |   |                  |           |
| scale                             |   |   |                  |           |
| Assignment for the                | Civil Engineering: Specialisation Water and T   | raffic: Elective Compulsory                     |                  |           |
| -                                 | Water and Environmental Engineering: Speci  |   |                  |           |
| -                                 | Water and Environmental Engineering: Speci  | alisation Environment: Elective Compulsory      |                  |           |
|                                   | Water and Environmental Engineering: Speci  | alisation Cities: Elective Compulsory           |                  |           |

| Course L0547: Contamination | ourse L0547: Contamination and Remediation   |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project Seminar  |  |  |
| Hrs/wk                      | 3  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42  |  |  |
| Lecturer                    | Prof. Nima Shokri, Hannes Nevermann  |  |  |
| Language                    | EN   |  |  |
| Cycle                       | SoSe   |  |  |
| Content                     | Processing of a complex soil and groundwater contamination site. Students perform analyses of data to detect the contamination |  |  |
|                             | and to analyse the groundwater hazard and to develop a concept for remediation of the damage.                                  |  |  |
| Literature                  | entfällt   |  |  |

| Course L0545: NAPL in Soil and Groundwater |  |  |
|--|--|--|
| Тур  | Lecture  |  |
| Hrs/wk                                     | 1  |  |
| СР   | 1  |  |
| Workload in Hours                          | Independent Study Time 16, Study Time in Lecture 14  |  |
| Lecturer                                   | Prof. Nima Shokri  |  |
| Language                                   | EN   |  |
| Cycle                                      | SoSe   |  |
| Content                                    | concept of capillarity, multi phase distribution in poraus media, residual saturation, rellative permeability, infiltration of NAPL into |  |
|  | the subsurface, vertical distribution of LNAPL, specific volume  |  |
| Literature                                 | Charbeneau, R.J. (2000): Groundwater Hydraulics and pollutant Transport  |  |

| Course L0546: NAPL in Soil a | Course L0546: NAPL in Soil and Groundwater          |  |
|------------------------------|---|--|
| Тур                          | Recitation Section (small)                          |  |
| Hrs/wk                       | 2   |  |
| СР                           | 2   |  |
| Workload in Hours            | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                     | Prof. Nima Shokri                                   |  |
| Language                     | EN  |  |
| Cycle                        | SoSe  |  |
| Content                      | See interlocking course                             |  |
| Literature                   | See interlocking course                             |  |

| Engineering                                |   |  |               |                       |
|--|---|--|---------------|-----------------------|
| Module M0827: Modeling in Water Management |   |  |               |                       |
| Courses                                    |   |  |               |                       |
| Title                                      |   | Тур  | Hrs/wk        | СР                    |
| Groundwater Modeling using Modflow (L0543) |   | Lecture                                    | 1             | 1                     |
| Groundwater Modeling using Modfle          |   | Recitation Section (small)                 | 2             | 2                     |
| Modeling of Water Supply and Sewe          | er Network (L0875)  | Project-/problem-based Learning            | 2             | 3                     |
| Module Responsible                         | Dr. Klaus Johannsen   |  |               |                       |
| Admission Requirements                     | None  |  |               |                       |
| Recommended Previous                       | Groundwater   |  |               |                       |
| Knowledge                                  | groundwater hydraulics and transport of substar   | nces                                       |               |                       |
|  | Pipe Systems  |  |               |                       |
|  | <ul> <li>Knowledge on urban water infrastructures, in</li> </ul>  | particular drinking water systemsand u     | rban drainag  | e systems including   |
|  | special structures  |  |               |                       |
|  | Hydraulics of drinking water supply systems and   | sewer systems                              |               |                       |
|  | Basic knowledge on water management   |  |               |                       |
| Educational Objectives                     | After taking part successfully, students have reached t   | he following learning results              |               |                       |
| Professional Competence                    | 3 p   | 3  |               |                       |
| Knowledge                                  | The students are able to describe the modelling of grou   | undwater flow and transport as well as urb | an water infr | astructures. They can |
| 3  |   |  |               | -                     |
|  | carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water. |  |               |                       |
|  |   |  |               |                       |
|  |   |  |               |                       |
| Skills                                     | The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios  |  |               |                       |
|  | and can compare or assess different solutions for existing problems by application of selected software products. The students are  |  |               |                       |
|  | able to use different software solutions (e.g. EPANET, EPA-SWMM).   |  |               |                       |
|  |   |  |               |                       |
|  |   |  |               |                       |
|  |   |  |               |                       |
| Barranal Compatons                         |   |  |               |                       |
| Personal Competence                        | Wird nicht vermittelt.  |  |               |                       |
| Social Competence                          | wird nicht vermitteit.  |  |               |                       |
| Autonomy                                   | Wird nicht vermittelt.  |  |               |                       |
| Workload in Hours                          | Independent Study Time 110, Study Time in Lecture 70  | )  |               |                       |
| Credit points                              | 6   |  |               |                       |
| Course achievement                         | None  |  |               |                       |
| Examination                                | Oral exam   |  |               |                       |
| Examination duration and                   | 20 min  |  |               |                       |
| scale                                      |   |  |               |                       |
| -  |   | • •  |               |                       |
| Following Curricula                        | Civil Engineering: Specialisation Geotechnical Engineer   | , ,  |               |                       |
|  | Civil Engineering: Specialisation Coastal Engineering: E  | • •  |               |                       |
|  | Civil Engineering: Specialisation Water and Traffic: Elec   |  |               |                       |
|  | Water and Environmental Engineering: Specialisation V   |  |               |                       |
|  | Water and Environmental Engineering: Specialisation E   | • • •                                      |               |                       |
|  | Water and Environmental Engineering: Specialisation C   | Cities: Elective Compulsory                |               |                       |

| Course L0543: Groundwater | ourse L0543: Groundwater Modeling using Modflow  |  |  |
|---------------------------|--|--|--|
| Тур                       | Lecture  |  |  |
| Hrs/wk                    | 1  |  |  |
| СР                        | 1  |  |  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14  |  |  |
| Lecturer                  | Sonja Götz   |  |  |
| Language                  | DE/EN  |  |  |
| Cycle                     | SoSe   |  |  |
| Content                   | Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work |  |  |
|                           | with the model PMWIN for practical case studies.   |  |  |
| Literature                | MODFLOW-Handbuch   |  |  |
|                           | Chiang, Wen Hsien: PMWIN   |  |  |
|                           |  |  |  |

| Course L0544: Groundwater | Course L0544: Groundwater Modeling using Modflow    |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (small)                          |  |
| Hrs/wk                    | 2   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                  | Sonja Götz  |  |
| Language                  | DE/EN   |  |
| Cycle                     | SoSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Course L0875: Modeling of V | urse L0875: Modeling of Water Supply and Sewer Network   |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project-/problem-based Learning  |  |  |
| Hrs/wk                      | 2  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |  |  |
| Lecturer                    | Dr. Klaus Johannsen, Weitere Mitarbeiter   |  |  |
| Language                    | DE   |  |  |
| Cycle                       | SoSe   |  |  |
| Content                     |  |  |  |
| Literature                  | Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014. |  |  |

| 3 3                                   |  |   |                    |                       |
|---------------------------------------|--|---|--------------------|-----------------------|
| Module M0857: Geochemical Engineering |  |   |                    |                       |
| Courses                               |  |   |                    |                       |
| Title                                 |  | Тур   | Hrs/wk             | СР                    |
| Contaminated Sites and Landfilling    | (L0906)  | Lecture                                     | 2                  | 2                     |
| Contaminated Sites and Landfilling    | (L0907)  | Recitation Section (large)                  | 1                  | 2                     |
| Geochemical Engineering (L0904)       |  | Lecture                                     | 2                  | 2                     |
| Module Responsible                    | Dr. Marco Ritzkowski   |   |                    |                       |
| Admission Requirements                | None   |   |                    |                       |
| Recommended Previous                  | Module: General and Inorganic Chemistry,   |   |                    |                       |
| Knowledge                             | Module:Organic Chemistry,  |   |                    |                       |
|                                       | Biology (Basic Knowledge)  |   |                    |                       |
|                                       | 3,1  |   |                    |                       |
|                                       |  |   |                    |                       |
| Educational Objectives                | After taking part successfully, students have reache   | ed the following learning results           |                    |                       |
| Professional Competence               |  |   |                    |                       |
| Knowledge                             | With the completion of this module students acqu   | ire profound knowledge of biogeochemica     | I processes, the   | fate of pollutants in |
|                                       | soil and groundwater, and techniques to deposit co   | ntaminated waste material. They are able    | to describe in pri | inciple the behaviour |
|                                       | of chemicals in the environment. Students can expl   | ain and report the approach to remediate    | contaminated sit   | es.                   |
| Skills                                | With the completion of this module students can  | apply the acquired theoretical knowledge    | to model cases     | of site pollution and |
| Skiiis                                | Skills With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollu critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation st |   | ·                  |                       |
|                                       | and techniques. Model projects can be devised and  |   | on amerene re      | mediation strategies  |
|                                       | and teeningles. Model projects can be devised and  | treated.                                    |                    |                       |
| Personal Competence                   |  |   |                    |                       |
| Social Competence                     | Students can discuss technical and scientific tasks  | within a seminar subject specific and inter | disciplinary .     |                       |
| Autonomy                              | Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.   |   |                    |                       |
| Workload in Hours                     | Independent Study Time 110, Study Time in Lecture  | e 70  |                    |                       |
| Credit points                         | 6  |   |                    |                       |
| Course achievement                    | None   |   |                    |                       |
| Examination                           | Written exam   |   |                    |                       |
| Examination duration and              | 2 hours  |   |                    |                       |
| scale                                 |  |   |                    |                       |
| Assignment for the                    | Civil Engineering: Specialisation Water and Traffic:   | Elective Compulsory                         |                    |                       |
| Following Curricula                   | Environmental Engineering: Core Qualification: Elec  | ctive Compulsory                            |                    |                       |
|                                       | Water and Environmental Engineering: Specialisation  | on Water: Elective Compulsory               |                    |                       |
|                                       | Water and Environmental Engineering: Specialisation  | on Environment: Elective Compulsory         |                    |                       |
|                                       | Water and Environmental Engineering: Specialisation  | on Cities: Elective Compulsory              |                    |                       |

| Course L0906: Contaminated |   |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 2   |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                   | Dr. Marco Ritzkowski, Dr. Joachim Gerth   |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects.  The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare. |
| Literature                 | 1) Waste Management. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105, Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) Solid Waste Technology and Management. Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3, Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) Natural attenuation of fuels and chlorinated solvents in the subsurface. Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844   |

| Course L0907: Contaminated | ourse L0907: Contaminated Sites and Landfilling     |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (large)                          |  |
| Hrs/wk                     | 1   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                   | Dr. Marco Ritzkowski, Dr. Joachim Gerth             |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    | See interlocking course                             |  |
| Literature                 | See interlocking course                             |  |

| S                         |  |
|---------------------------|--|
| Course L0904: Geochemical |  |
| Тур                       | Lecture  |
| Hrs/wk                    | 2  |
| СР                        | 2  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                  | Dr. Joachim Gerth  |
| Language                  | EN   |
| Cycle                     | SoSe   |
|                           | As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment. |
| Literature                | Geochemistry, groundwater and pollution. C. A. J. Appelo; D. Postma  Leiden [u.a.] Balkema 2005  Lehrbuchsammlung der TUB, Signatur GWC-515  |

| Module M0870: Management of Surface Water |   |                                     |                    |                     |
|---|---|-------------------------------------|--------------------|---------------------|
| Courses                                   |   |                                     |                    |                     |
| Title                                     |   | Тур                                 | Hrs/wk             | СР                  |
| Modelling of Flow in Rivers and Estu      | uaries (L0810)  | Lecture                             | 3                  | 4                   |
| Nature-Oriented Hydraulic Enginee         | ring / Integrated Flood Protection (L0961)                          | Project-/problem-based Learning     | 2                  | 2                   |
| Module Responsible                        | Prof. Peter Fröhle  |                                     |                    |                     |
| Admission Requirements                    | None  |                                     |                    |                     |
| Recommended Previous                      | Fundamentals of Hydromechanics, Hydraulics, Hydrology and           | Hydraulic Engineering; Hydrau       | ulic Engineering   | I and Hydraulic     |
| Knowledge                                 | Engineering II  |                                     |                    |                     |
| <b>Educational Objectives</b>             | After taking part successfully, students have reached the following | ng learning results                 |                    |                     |
| Professional Competence                   |   |                                     |                    |                     |
| Knowledge                                 | Students are able to define in detail the basic processes that      | are related to the modelling of     | of flows in hydr   | aulic engineering.  |
|   | Besides, they can describe the basic aspects of numerical mode      | elling and actual numerical mode    | els for the simul  | lation of flows and |
|   | waves. They can also depict the concepts of nature oriented hyd     | raulic engineering.                 |                    |                     |
|   |   |                                     |                    |                     |
| Skills                                    | Students are able to apply hydrodynamic-numerical models to pr      |                                     |                    |                     |
|   | able to set up flood-risk management concepts and are able to a     | pply basic concepts of renaturati   | ion to practical p | problems.           |
| Personal Competence                       |   |                                     |                    |                     |
| Social Competence                         | The students are able to deploy their gained knowledge in appl      | ied problems of the practical na    | ture-based hydr    | raulic engineering. |
|   | Additionaly, they will be able to work in team with engineers of o  | ther disciplines.                   |                    |                     |
| Autonomy                                  | The students will be able to independently extend their knowledg    | ge and apply it to new problems.    |                    |                     |
| Workload in Hours                         | Independent Study Time 110, Study Time in Lecture 70                |                                     |                    |                     |
| Credit points                             |   |                                     |                    |                     |
| Course achievement                        |   |                                     |                    |                     |
| Examination                               | Written exam  |                                     |                    |                     |
| Examination duration and                  | The duration of the examination is 150 min. The examination         | includes tasks with respect to t    | the general und    | derstanding of the  |
| scale                                     | lecture contents and calculations tasks.                            |                                     |                    |                     |
| Assignment for the                        | Civil Engineering: Specialisation Water and Traffic: Compulsory     |                                     |                    |                     |
| Following Curricula                       | Environmental Engineering: Core Qualification: Elective Compuls     | ory                                 |                    |                     |
|   | Joint European Master in Environmental Studies - Cities and Susta   | ainability: Core Qualification: Cor | mpulsory           |                     |
|   | Water and Environmental Engineering: Specialisation Water: Con      | npulsory                            |                    |                     |
|   | Water and Environmental Engineering: Specialisation Environmen      | nt: Compulsory                      |                    |                     |
|   | Water and Environmental Engineering: Specialisation Cities: Elec    | tive Compulsory                     |                    |                     |
|   |   |                                     |                    |                     |

| Тур               | Lecture   |
|-------------------|---|
| Hrs/wk            | 3   |
| СР                | 4   |
| Workload in Hours | Independent Study Time 78, Study Time in Lecture 42 |
| Lecturer          | Dr. Edgar Nehlsen, Prof. Peter Fröhle               |
| Language          | DE/EN   |
| Cycle             | SoSe  |
| Content           | Basics of numerial models / application of models   |
|                   | classification of models                            |
|                   | model concept                                       |
|                   | modelling   |
|                   | ddg   |
|                   | 1D Working Equation                                 |
|                   | Mathematical description of physical processes      |
|                   | Equation of motions                                 |
|                   | conservation of mass                                |
|                   | conservation of momentum                            |
|                   | Initial conditions and boundary conditions          |
|                   | Numerical Methods                                   |
|                   | Time step procedure                                 |
|                   | Finite differences                                  |
|                   | Finite volumes                                      |
|                   |   |
|                   |   |
|                   |   |
|                   |   |

| Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection |   |  |
|---|---|--|
| Тур   | Project-/problem-based Learning   |  |
| Hrs/wk  | 2   |  |
| СР  | 2   |  |
| Workload in Hours   | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer  | Dr. Natasa Manojlovic, Prof. Peter Fröhle   |  |
| Language  | DE/EN   |  |
| Cycle   | SoSe  |  |
| Content   | <ul> <li>Regime-Theory and application for the development of environmental guiding priciples of rivers</li> <li>Engineering - biological measures for the stabilization of rivers</li> <li>Risk management in flood protection</li> <li>Design techniques in technical flood protection</li> <li>Methods for the assessment of flood caused damages</li> </ul> |  |
| Literature  | Vorlesungsumdruck   |  |

| 3 3                                |  |  |                |                        |
|------------------------------------|--|--|----------------|------------------------|
| Module M0871: Hydro                | ological Systems                                 |  |                |                        |
|                                    |  |  |                |                        |
| Courses                            |  |  |                |                        |
| Title                              |  | Тур  | Hrs/wk         | СР                     |
| Applied Surface Hydrology (L0289)  |  | Lecture  | 2              | 2                      |
| Applied Surface Hydrology (L1412)  |  | Project-/problem-based Learning  | 1              | 2                      |
| Interaction Water - Environment in | Fluvial Areas (L0295)                            | Project-/problem-based Learning  | 1              | 2                      |
| Module Responsible                 | Prof. Peter Fröhle                               |  |                |                        |
| Admission Requirements             | None   |  |                |                        |
| Recommended Previous               | Fundamentals of Hydromechanics and Hydrau        | lic Engineering: Hydraulic Engineering I and Hydra                       | ulic Engineeri | ng II                  |
| Knowledge                          |  |  |                |                        |
| <b>Educational Objectives</b>      | After taking part successfully, students have re | eached the following learning results                                    |                |                        |
| Professional Competence            |  |  |                |                        |
| Knowledge                          | The students are able to define the basic con    | cepts of hydrology and water management. They                            | are able to d  | lescribe and quantify  |
|                                    | the relevant processes of the hydrological wat   | er cycle. Besides, the students know the main asp                        | ects of rainfa | ll-run-off-models and  |
|                                    | are able to theoretically derive established res | ervoir / storage models and a unit-hydrograph.                           |                |                        |
|                                    |  |  |                |                        |
| Skills                             | · ·  | ological concepts and approaches and are able t                          |                | •                      |
|                                    |  | oh as the basis for rainfall-run-off-models. The stu                     |                |                        |
|                                    |  | d hydrodynamic values in nature and are able to                          | •              |                        |
|                                    | assess these measurements. Furthermore, the      | ey are able to apply a hydrological model to basic h                     | ydrological p  | roblems.               |
| Personal Competence                |  |  |                |                        |
| Social Competence                  | The students are able to deploy their gained k   | nowledge in applied problems of the hydrology an                         | d water mana   | gement. Additionaly,   |
| •                                  | they will be able to work in team with enginee   |  |                | ,                      |
| Autonomy                           | ,  | end their knowledge and apply it to new problems                         |                |                        |
|                                    | , ,  |  |                |                        |
| Workload in Hours                  | Independent Study Time 124, Study Time in Le     | ecture 56  |                |                        |
| Credit points                      | 6  |  |                |                        |
| Course achievement                 | None   |  |                |                        |
| Examination                        | Written exam                                     |  |                |                        |
| <b>Examination duration and</b>    | The duration of the examination is 90 min. The   | e examination includes tasks with respect to the ge                      | eneral unders  | tanding of the lecture |
| scale                              | contents and calculations tasks.                 |  |                |                        |
| Assignment for the                 | Civil Engineering: Specialisation Water and Tra  | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory |                |                        |
| Following Curricula                | Environmental Engineering: Core Qualification    | : Elective Compulsory  |                |                        |
|                                    | Joint European Master in Environmental Studie    | s - Cities and Sustainability: Core Qualification: Co                    | mpulsory       |                        |
|                                    | Water and Environmental Engineering: Special     | lisation Water: Elective Compulsory                                      |                |                        |
|                                    | Water and Environmental Engineering: Special     | lisation Environment: Elective Compulsory                                |                |                        |
|                                    | Water and Environmental Engineering: Special     | lisation Cities: Elective Compulsory                                     |                |                        |

| Course L0289: Applied Surfa | ce Hydrology  |
|-----------------------------|---|
| Тур                         | Lecture   |
| Hrs/wk                      | 2   |
| СР                          | 2   |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28   |
| Lecturer                    | Prof. Peter Fröhle  |
| Language                    | DE/EN   |
| Cycle                       | SoSe  |
| Content                     | Basics of hydrology:  |
|                             | <ul> <li>Hydrological cycle</li> <li>Data acquisition</li> <li>Data analyses and statistical assessment</li> <li>Statistics of extremes</li> <li>Regionalization methods for hydrological values</li> <li>Rainfall-run-off modelling on the basis of a unit hydrograph conceps</li> <li>Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul> |
| Literature                  | http://de.wikipedia.org/wiki/Kalypso_(Software)   |
|                             | http://kalypso.bjoernsen.de/  |
|                             | http://sourceforge.net/projects/kalypso/  |
|                             |   |

| Course L1412: Applied Surface Hydrology |   |
|---|---|
| Тур                                     | Project-/problem-based Learning                     |
| Hrs/wk                                  | 1   |
| СР                                      | 2   |
| Workload in Hours                       | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                | Prof. Peter Fröhle                                  |
| Language                                | DE/EN   |
| Cycle                                   | SoSe  |
| Content                                 | See interlocking course                             |
| Literature                              | See interlocking course                             |

| Course L0295: Interaction W | ourse L0295: Interaction Water - Environment in Fluvial Areas  |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project-/problem-based Learning  |  |  |
| Hrs/wk                      | 1  |  |  |
| СР                          | 2  |  |  |
| Workload in Hours           | Independent Study Time 46, Study Time in Lecture 14  |  |  |
| Lecturer                    | Prof. Peter Fröhle   |  |  |
| Language                    | DE/EN  |  |  |
| Cycle                       | SoSe   |  |  |
| Content                     | A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester. |  |  |
| Literature                  | -  |  |  |

| Module M0874: Waster                  | water Systems  |   |                   |                        |
|---------------------------------------|--|---|-------------------|------------------------|
| Courses                               |  |   |                   |                        |
| Title                                 |  | Тур                                     | Hrs/wk            | СР                     |
| Wastewater Systems - Collection, Tre  | eatment and Reuse (L0934)  | Lecture                                 | 2                 | 2                      |
| Wastewater Systems - Collection, Tre  | eatment and Reuse (L0943)  | Recitation Section (large)              | 1                 | 1                      |
| Advanced Wastewater Treatment (L0     |  | Lecture                                 | 2                 | 2                      |
| Advanced Wastewater Treatment (L0     | 358)   | Recitation Section (large)              | 1                 | 1                      |
| Module Responsible P                  | rof. Ralf Otterpohl  |   |                   |                        |
| Admission Requirements N              | lone   |   |                   |                        |
| Recommended Previous K                | (nowledge of wastewater management and the key p   | processes involved in wastewater treatm | nent.             |                        |
| Knowledge                             |  |   |                   |                        |
| Educational Objectives A              | After taking part successfully, students have reached  | the following learning results          |                   |                        |
| Professional Competence               |  |   |                   |                        |
| <i>Knowledge</i> S                    | students are able to outline key areas of the full rang  | ge of treatment systems in waste water  | management, as    | well as their mutual   |
| d                                     | dependence for sustainable water protection. They ca   | an describe relevant economic, environr | nental and social | factors.               |
| Skille S                              | Students are able to pre-design and explain the ava  | silable wastewater treatment processes  | and the scope of  | f their application in |
|                                       | nunicipal and for some industrial treatment plants.  | mable wastewater treatment processes    | and the scope of  | п спен аррисасіон п    |
|                                       | municipal and for some moustrial deadment plants.  |   |                   |                        |
| Personal Competence                   |  |   |                   |                        |
| Social Competence S                   | social skills are not targeted in this module.   |   |                   |                        |
| Autonomy S                            | Students are in a position to work on a subject an   | d to organize their work flow independ  | lontly Thoy can   | also procent on this   |
| · · · · · · · · · · · · · · · · · · · | subject.   | a to organize their work now independ   | lentry. They can  | aiso present on this   |
|                                       |  |   |                   |                        |
| Workload in Hours                     | ndependent Study Time 96, Study Time in Lecture 8  | 4                                       |                   |                        |
| Credit points 6                       | 5  |   |                   |                        |
| Course achievement N                  | lone   |   |                   |                        |
| <b>Examination</b> V                  | Vritten exam   |   |                   |                        |
| Examination duration and $1$          | .20 min  |   |                   |                        |
| scale                                 |  |   |                   |                        |
| Assignment for the                    | Civil Engineering: Specialisation Structural Engineerin  | ng: Elective Compulsory                 |                   |                        |
| Following Curricula C                 | Civil Engineering: Specialisation Geotechnical Engine  | ering: Elective Compulsory              |                   |                        |
|                                       | Civil Engineering: Specialisation Coastal Engineering:   | , ,                                     |                   |                        |
| C                                     | Civil Engineering: Specialisation Water and Traffic: Co  | ompulsory                               |                   |                        |
|                                       | Bioprocess Engineering: Specialisation A - General Bi  |   | -                 |                        |
|                                       | Energy and Environmental Engineering: Specialisation   |   | ompulsory         |                        |
|                                       | Environmental Engineering: Specialisation Water: Ele   |   |                   |                        |
|                                       | nternational Management and Engineering: Specialis   | • | -                 |                        |
|                                       | nternational Management and Engineering: Specialis   | • •                                     | nnoiogy: Elective | Compulsory             |
|                                       | Process Engineering: Specialisation Environmental Process Engineering: Specialisation Process Engineer     |   |                   |                        |
|                                       | rocess Engineering: Specialisation Process Engineer<br>Vater and Environmental Engineering: Specialisation |   |                   |                        |
|                                       | Vater and Environmental Engineering: Specialisation  |   |                   |                        |
|                                       | Vater and Environmental Engineering: Specialisation  |   |                   |                        |

| Course L0934: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|--|--|--|
| Тур  | Lecture  |  |
| Hrs/wk   | 2  |  |
| СР   | 2  |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28  |  |
| Lecturer   | Prof. Ralf Otterpohl   |  |
| Language   | EN   |  |
| Cycle  | SoSe   |  |
| Content  | •Understanding the global situation with water and wastewater  |  |
|  | •Regional planning and decentralised systems   |  |
|  | Overview on innovative approaches  |  |
|  | •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse |  |
|  | Mathematical Modelling of Nitrogen Removal   |  |
|  | *Exercises with calculations and design  |  |
| Literature   | Henze, Mogens:   |  |
|  | Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages                                |  |
|  | George Tchobanoglous, Franklin L. Burton, H. David Stensel:  |  |
|  | Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy  |  |
|  | McGraw-Hill, 2004 - 1819 pages   |  |

| Course L0943: Wastewater S | ourse L0943: Wastewater Systems - Collection, Treatment and Reuse |  |  |
|----------------------------|---|--|--|
| Тур                        | Recitation Section (large)  |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 1   |  |  |
| Workload in Hours          | Independent Study Time 16, Study Time in Lecture 14               |  |  |
| Lecturer                   | Prof. Ralf Otterpohl  |  |  |
| Language                   | EN  |  |  |
| Cycle                      | SoSe  |  |  |
| Content                    | See interlocking course   |  |  |
| Literature                 | See interlocking course   |  |  |

| Course L0357: Advanced Wa | stewater Treatment  |  |  |  |  |
|---------------------------|---|--|--|--|--|
| Тур                       | Lecture   |  |  |  |  |
| Hrs/wk                    | 2   |  |  |  |  |
| СР                        | 2   |  |  |  |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28   |  |  |  |  |
| Lecturer                  | Dr. Joachim Behrendt  |  |  |  |  |
| Language                  | EN  |  |  |  |  |
| Cycle                     | SoSe  |  |  |  |  |
| Content                   | Survey on advanced wastewater treatment   |  |  |  |  |
|                           | reuse of reclaimed municipal wastewater   |  |  |  |  |
|                           | Precipitation   |  |  |  |  |
|                           | Flocculation  |  |  |  |  |
|                           | Depth filtration  |  |  |  |  |
|                           | Membrane Processes  |  |  |  |  |
|                           | Activated carbon adsorption   |  |  |  |  |
|                           | Ozonation   |  |  |  |  |
|                           | "Advanced Oxidation Processes"  |  |  |  |  |
|                           | Disinfection  |  |  |  |  |
| Literature                | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003   |  |  |  |  |
|                           | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987  |  |  |  |  |
|                           | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007  |  |  |  |  |
|                           | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung,<br>Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |  |  |  |  |
|                           | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003  |  |  |  |  |

| Course L0358: Advanced Wastewater Treatment |   |  |  |  |  |
|---|---|--|--|--|--|
| Тур   | Recitation Section (large)  |  |  |  |  |
| Hrs/wk                                      | 1   |  |  |  |  |
| СР  | 1   |  |  |  |  |
| Workload in Hours                           | Independent Study Time 16, Study Time in Lecture 14   |  |  |  |  |
| Lecturer                                    | Dr. Joachim Behrendt  |  |  |  |  |
| Language                                    | EN  |  |  |  |  |
| Cycle                                       | SoSe  |  |  |  |  |
| Content                                     | Aggregate organic compounds (sum parameters)  |  |  |  |  |
|   | Industrial wastewater   |  |  |  |  |
|   | Processes for industrial wastewater treatment   |  |  |  |  |
|   | Precipitation   |  |  |  |  |
|   | Flocculation  |  |  |  |  |
|   | Activated carbon adsorption   |  |  |  |  |
|   | Recalcitrant organic compounds  |  |  |  |  |
|   |   |  |  |  |  |
| Literature                                  | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003   |  |  |  |  |
|   | Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987  |  |  |  |  |
|   | Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007  |  |  |  |  |
|   | Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung,<br>Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 |  |  |  |  |
|   | Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003  |  |  |  |  |

| Module M0875: Nexus Engineering - Water, Soil, Food and Energy      |   |                                   |                          |    |  |  |
|---|---|-----------------------------------|--------------------------|----|--|--|
| Courses   |   |                                   |                          |    |  |  |
| Title   |   | Тур                               | Hrs/wk                   | СР |  |  |
| Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229) |   | Seminar                           | 2                        | 2  |  |  |
| Water & Wastewater Systems in a                                     | Global Context (L0939)  | Lecture                           | 2                        | 4  |  |  |
| Module Responsible  | Prof. Ralf Otterpohl  |                                   |                          |    |  |  |
| Admission Requirements  | None  |                                   |                          |    |  |  |
| Recommended Previous  | Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and                   |                                   |                          |    |  |  |
| Knowledge   | sanitation  |                                   |                          |    |  |  |
| Educational Objectives  | After taking part successfully, students have reached   | I the following learning results  |                          |    |  |  |
| Professional Competence   |   |                                   |                          |    |  |  |
| Knowledge   | Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation o                 |                                   |                          |    |  |  |
|   | synergistic systems in Water, Soil, Food and Energy supply.   |                                   |                          |    |  |  |
| Ckilla  |   |                                   |                          |    |  |  |
| SKIIIS  | Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world. |                                   |                          |    |  |  |
|   | around the world.   |                                   |                          |    |  |  |
| Personal Competence   |   |                                   |                          |    |  |  |
| Social Competence   | The students are able to develop a specific topic in a  | team and to work out milestones   | according to a given pla | n. |  |  |
| Autonomy  | Students are in a position to work on a subject and to organize their work flow independently. They can also present on subject.                  |                                   |                          |    |  |  |
| Autonomy  |   |                                   |                          |    |  |  |
|   | subject.  |                                   |                          |    |  |  |
| Workload in Hours   | Independent Study Time 124, Study Time in Lecture   | 56                                |                          |    |  |  |
| Credit points   | 6   |                                   |                          |    |  |  |
| Course achievement  | None  |                                   |                          |    |  |  |
| Examination   | Subject theoretical and practical work  |                                   |                          |    |  |  |
| Examination duration and  | During the course of the semester, the students work towards mile stones. The work includes presentations and papers. De                          |                                   |                          |    |  |  |
| scale   | information can be found at the beginning of the sme  | ester in the StudIP course module | handbook.                |    |  |  |
| Assignment for the  | Civil Engineering: Specialisation Water and Traffic: El   | ective Compulsory                 |                          |    |  |  |
| Following Curricula   | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory  |                                   |                          |    |  |  |
|   | Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory  |                                   |                          |    |  |  |
|   | Environmental Engineering: Core Qualification: Elective Compulsory  |                                   |                          |    |  |  |
|   | Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory  |                                   |                          |    |  |  |
|   | Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory  |                                   |                          |    |  |  |
|   | Process Engineering: Specialisation Process Engineering: Elective Compulsory  |                                   |                          |    |  |  |
|   | Water and Environmental Engineering: Specialisation Water: Elective Compulsory  |                                   |                          |    |  |  |
|   | Water and Environmental Engineering: Specialisation   |                                   | ry                       |    |  |  |
|   | Water and Environmental Engineering: Specialisation   | Cities: Elective Compulsory       |                          |    |  |  |

| Course L1229: Ecological Tox | wn Design - Water, Energy, Soil and Food Nexus   |
|------------------------------|--|
| Тур                          | Seminar  |
| Hrs/wk                       | 2  |
| СР                           | 2  |
| Workload in Hours            | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                     | Prof. Ralf Otterpohl   |
| Language                     | EN   |
| Cycle                        | SoSe   |
| Content                      | <ul> <li>Participants Workshop: Design of the most attractive productive Town</li> <li>Keynote lecture and video</li> <li>The limits of Urbanization / Green Cities</li> <li>The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>Global Ecovillage Network: Upsides and Downsides around the World</li> <li>Visit of an Ecovillage</li> <li>Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion</li> <li>TUHH Rural Development Toolbox</li> <li>Integrated New Town Development</li> <li>Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>Outreach: Participants campaign</li> <li>City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul> |
| Literature                   | <ul> <li>Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in "Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU</li> </ul>  |

| Course L0939: Water & Wast | tewater Systems in a Global Context   |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 4   |
| Workload in Hours          | Independent Study Time 92, Study Time in Lecture 28   |
| Lecturer                   | Prof. Ralf Otterpohl  |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    |   |
| Literature                 | <ul> <li>Keynote lecture and video</li> <li>Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>Water and it's utilization, Integrated Urban Water Management</li> <li>Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>Rehearsal session, Q&amp;A</li> </ul> |
| Literature                 | <ul> <li>Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>  |

| Module M0922: City Planning              |  |  |  |
|--|--|--|--|
| Courses                                  |  |  |  |
| Title                                    | Typ Hrs/wk CP  |  |  |
| City Planning (L1066)                    | Project-/problem-based Learning 4 6  |  |  |
| Module Responsible                       |  |  |  |
| Admission Requirements                   |  |  |  |
| Recommended Previous<br>Knowledge        | for "Principles of Urban Planning": none   |  |  |
|  | for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class "Trans Planning and Traffic Engineering"   |  |  |
| <b>Educational Objectives</b>            | After taking part successfully, students have reached the following learning results   |  |  |
| <b>Professional Competence</b>           |  |  |  |
| Knowledge                                | Students are able to:  |  |  |
|  | use technical terms of urban planning.   |  |  |
|  | describe the main determinants of urban development.   |  |  |
|  | explain and compare different possibilities of how urban development can be influenced.  |  |  |
|  | discuss requirements for public streetscapes.  |  |  |
|  | explain the importance of street design.   |  |  |
| Skills                                   | Students are able to:  |  |  |
|  | read and analyze urban development concepts and designs for streetscapes   |  |  |
|  | appraise such concepts in the context of competing requirements.   |  |  |
|  | design, justify and reflect their own solutions for concrete examples.   |  |  |
| Personal Competence<br>Social Competence | Students are able to:  • discuss intermediate results with each other.  • constructively accept feedback on their own work.  • provide constructive feedback to others.  |  |  |
| Autonomy                                 | Students are able to:  • independently complete a written report including drawings following a broadly pre-defined process.  • assess the consequences of their proposed solutions.  • independently acquire knowledge and apply this to new issues or problem areas. |  |  |
| Workload in Hours                        | Independent Study Time 124, Study Time in Lecture 56   |  |  |
| Credit points                            | 6  |  |  |
| Course achievement                       | None   |  |  |
| Examination                              |  |  |  |
| Examination duration and                 | written assignment, designwork during the semester   |  |  |
| scale                                    |  |  |  |
| Assignment for the                       | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |  |  |
| Following Curricula                      | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |  |  |
|  | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |  |  |
|  | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |  |  |
|  | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory  |  |  |
|  | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   |  |  |
|  | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |  |  |
|  | Water and Environmental Engineering: Specialisation Cities: Compulsory   |  |  |

| g                                  |  |  |        |    |
|------------------------------------|--|--|--------|----|
| Module M0663: Marine Geotechnics   |  |  |        |    |
| Courses                            |  |  |        |    |
| Title                              |  | Тур  | Hrs/wk | СР |
| Marine Geotechnics (L0548)         |  | Lecture  | 1      | 2  |
| Marine Geotechnics (L0549)         |  | Recitation Section (large)                       | 2      | 2  |
| Steel Structures in Foundation and | Hydraulic Engineering (L1146)                        | Lecture  | 2      | 2  |
| Module Responsible                 | Prof. Jürgen Grabe                                   |  |        |    |
| Admission Requirements             | None   |  |        |    |
| Recommended Previous               | complete modules: Geotechnics I-III, Mathe           | ematics I-III                                    |        |    |
| Knowledge                          | courses: Soil laboratory course                      |  |        |    |
| Educational Objectives             | After taking part successfully, students have        | ve reached the following learning results        |        |    |
| Professional Competence            |  |  |        |    |
| Knowledge                          |  |  |        |    |
| Skills                             |  |  |        |    |
| Personal Competence                |  |  |        |    |
| Social Competence                  |  |  |        |    |
| Autonomy                           |  |  |        |    |
| Workload in Hours                  | Independent Study Time 110, Study Time in Lecture 70 |  |        |    |
| Credit points                      | 6  |  |        |    |
| Course achievement                 |  |  |        |    |
| Examination                        | Written exam   |  |        |    |
| Examination duration and           | 90 min   |  |        |    |
| scale                              |  |  |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Geotechni          | ical Engineering: Compulsory                     |        |    |
| Following Curricula                | Civil Engineering: Specialisation Structural         | Engineering: Elective Compulsory                 |        |    |
|                                    | Civil Engineering: Specialisation Coastal Er         | ngineering: Compulsory                           |        |    |
|                                    | Theoretical Mechanical Engineering: Specia           | alisation Maritime Technology: Elective Compulso | ory    |    |
|                                    | Theoretical Mechanical Engineering: Techn            | nical Complementary Course: Elective Compulsor   | у      |    |
|                                    | Water and Environmental Engineering: Spe             |  | -      |    |
|                                    |  | ecialisation Environment: Elective Compulsory    |        |    |
|                                    | Water and Environmental Engineering: Spe             |  |        |    |
|                                    |  |  |        |    |

| Course L0548: Marine Geotechnics |  |  |
|----------------------------------|--|--|
| Тур                              | Lecture  |  |
| Hrs/wk                           | 1  |  |
| СР                               | 2  |  |
| Workload in Hours                | Independent Study Time 46, Study Time in Lecture 14  |  |
| Lecturer                         | Prof. Jürgen Grabe   |  |
| Language                         | DE   |  |
| Cycle                            | SoSe   |  |
| Content                          | <ul> <li>Geotechnical investigation an description of the seabed</li> <li>Foundations of Offshore-Constructions</li> <li>cCliff erosion</li> <li>Sea dikes</li> <li>Port structures</li> <li>Flood protection structures</li> </ul>  |  |
| Literature                       | <ul> <li>EAK (2002): Empfehlungen für Küstenschutzbauwerke</li> <li>EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke</li> <li>Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst &amp; Sohn, Berlin</li> </ul> |  |

| ourse L0549: Marine Geotechnics |   |  |
|---------------------------------|---|--|
| Тур                             | Recitation Section (large)                          |  |
| Hrs/wk                          | 2   |  |
| СР                              | 2   |  |
| Workload in Hours               | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                        | Prof. Jürgen Grabe                                  |  |
| Language                        | DE  |  |
| Cycle                           | SoSe  |  |
| Content                         | See interlocking course                             |  |
| Literature                      | See interlocking course                             |  |

| Course L1146: Steel Structures in Foundation and Hydraulic Engineering |   |  |
|--|---|--|
| Тур  | Lecture   |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28   |  |
| Lecturer   | Frank Feindt  |  |
| Language   | DE  |  |
| Cycle  | SoSe  |  |
| Content  | Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue |  |
| Literature   | EAU 2012, EA-Pfähle, EAB  |  |

| Module M1123: Selec                | ted Topics in Environmental Engineering  |                            |        |    |
|------------------------------------|--|----------------------------|--------|----|
| Courses                            |  |                            |        |    |
| Γitle                              |  | Тур                        | Hrs/wk | СР |
| Environmental Aquatic Chemistry (  | L1444)   | Lecture                    | 2      | 3  |
| xcellence in International Project | Delivery (L2387)   | Integrated Lecture         | 2      | 2  |
| ludge Treatment (L0520)            |  | Lecture                    | 2      | 3  |
| hermal Biomass Utilization (L1767  | ")   | Lecture                    | 2      | 2  |
| Thermal Biomass Utilization (L1768 | 3)   | Recitation Section (small) | 1      | 1  |
| Module Responsible                 | Prof. Mathias Ernst  |                            |        |    |
| Admission Requirements             | None   |                            |        |    |
| Recommended Previous               |  |                            |        |    |
| Knowledge                          |  |                            |        |    |
| Educational Objectives             | After taking part successfully, students have reached the following learning results |                            |        |    |
| Professional Competence            |  |                            |        |    |
| Knowledge                          |  |                            |        |    |
| Skills                             |  |                            |        |    |
| Personal Competence                |  |                            |        |    |
| Social Competence                  |  |                            |        |    |
| Autonomy                           |  |                            |        |    |
| Workload in Hours                  | Depends on choice of courses   |                            |        |    |
| Credit points                      | 6  |                            |        |    |
| Assignment for the                 | Environmental Engineering: Core Qualification: Elective Compuls                      | sory                       |        |    |
| Following Curricula                | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory      |                            |        |    |
|                                    | Water and Environmental Engineering: Specialisation Environme                        | ent: Elective Compulsory   |        |    |
|                                    | Water and Environmental Engineering: Specialisation Water: Ele                       | ective Compulsory          |        |    |

| Course L1444: Environmenta | ll Aquatic Chemistry  |
|----------------------------|---|
| Тур                        | Lecture   |
| Hrs/wk                     | 2   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28   |
| Examination Form           | Klausur   |
| Examination duration and   | 60 min  |
| scale                      |   |
| Lecturer                   | Dr. Klaus Johannsen   |
| Language                   | EN  |
| Cycle                      | SoSe  |
| Content                    | <ul> <li>Concentration and activity</li> <li>Gas-water partitioning</li> <li>Acid/base equilibria</li> <li>Alkalinity and acidity</li> <li>Precipitation/dissolution equilibria</li> <li>Redox equilibria</li> <li>Complex formation</li> <li>Sorption</li> </ul> |
| Literature                 | Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015   |

| Course L2387: Excellence in International Project Delivery |   |  |
|--|---|--|
| Тур  | Integrated Lecture                                  |  |
| Hrs/wk   | 2   |  |
| СР   | 2   |  |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28 |  |
| Examination Form   | laut FSPO   |  |
| Examination duration and                                   | wird zu Beginn der Lehrveranstaltung festgelegt     |  |
| scale  |   |  |
| Lecturer   | Dr. Jens Huckfeldt                                  |  |
| Language   | EN  |  |
| Cycle  | SoSe  |  |
| Content  |   |  |
| Literature   |   |  |

| Course L0520: Sludge Treatment |   |  |
|--------------------------------|---|--|
| Тур                            | Lecture   |  |
| Hrs/wk                         | 2   |  |
| СР                             | 3   |  |
| Workload in Hours              | Independent Study Time 62, Study Time in Lecture 28                 |  |
| Examination Form               | Klausur   |  |
| Examination duration and       | 60 min  |  |
| scale                          |   |  |
| Lecturer                       | Dr. Joachim Behrendt  |  |
| Language                       | EN  |  |
| Cycle                          | SoSe  |  |
| Content                        | Sedimentation characteristic and thickening,                        |  |
|                                | Centrifugation,   |  |
|                                | Flotation,  |  |
|                                | Filtration,   |  |
|                                | Aerobic sludge stabilisation,                                       |  |
|                                | Sludge Digestion,   |  |
|                                | Sludge Disintegration,  |  |
|                                | Sludge Dewatering,  |  |
|                                | Natural Processes for Sludge Treatment,                             |  |
|                                | Nutrient Recovery from Sludge,                                      |  |
|                                | Thermal Processes and Incineration.                                 |  |
| Literature                     | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)                     |  |
|                                | Wastewater engineering: treatment and reuse                         |  |
|                                | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))         |  |
|                                | Boston [u.a.] : McGraw-Hill, 2003                                   |  |
|                                | TUB_HH_Katalog  |  |
|                                | Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes |  |
|                                | Sludge Treatment and Disposal                                       |  |
|                                | ISBN 9781843391661  |  |
|                                | IWA Publishing, 2007  |  |
|                                |   |  |

| Linginicering              |  |
|----------------------------|--|
| Course L1767: Thermal Biom |  |
| Тур                        | Lecture  |
| Hrs/wk                     | 2  |
| СР                         | 2  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28  |
| Examination Form           | Klausur  |
| Examination duration and   | 60 min   |
| scale                      |  |
| Lecturer                   | Prof. Martin Kaltschmitt   |
| Language                   | DE   |
| Cycle                      | WiSe   |
| Content                    | Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.  |
|                            | <ul> <li>The course is structured as follows:</li> <li>Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course</li> <li>Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>Thermo-chemical conversion of solid biofuels</li> </ul>  |
|                            | <ul> <li>Basics of thermo-chemical conversion</li> <li>Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use</li> <li>Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material</li> </ul> |
|                            | <ul> <li>Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)</li> <li>Bio-chemical conversion of biomass         <ul> <li>Basics of bio-chemical conversion</li> <li>Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste</li> </ul> </li> </ul>   |
| Literature                 | fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry  • Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage  Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage  |

| Course L1768: Thermal Biomass Utilization |   |
|---|---|
| Тур                                       | Recitation Section (small)                          |
| Hrs/wk                                    | 1   |
| СР  | 1   |
| Workload in Hours                         | Independent Study Time 16, Study Time in Lecture 14 |
| Examination Form                          | Klausur   |
| Examination duration and                  | 60 min  |
| scale                                     |   |
| Lecturer                                  | Prof. Martin Kaltschmitt                            |
| Language                                  | DE  |
| Cycle                                     | WiSe  |
| Content                                   | See interlocking course                             |
| Literature                                | See interlocking course                             |

| Engineering                        |  |                                     |        |                                       |
|------------------------------------|--|-------------------------------------|--------|---------------------------------------|
| Module M1720: Emer                 | ging Trends in Environmental Engir                   | neering                             |        |                                       |
| Courses                            |  |                                     |        |                                       |
| Title                              |  | Тур                                 | Hrs/wk | СР                                    |
| Microplastics in Environment (L275 | 0)   | Integrated Lecture                  | 2      | 2                                     |
| Research Methods for Energy-Wate   | er-Soil-Climate Nexus (L2751)                        | Lecture                             | 1      | 2                                     |
| Research Trends in Energy-Water-S  | Soil-Climate Nexus (L2752)                           | Seminar                             | 2      | 2                                     |
| Module Responsible                 | Prof. Nima Shokri                                    |                                     |        |                                       |
| Admission Requirements             | None   |                                     |        |                                       |
| Recommended Previous               |  |                                     |        |                                       |
| Knowledge                          |  |                                     |        |                                       |
| Educational Objectives             | After taking part successfully, students have reache | ed the following learning results   |        |                                       |
| Professional Competence            |  |                                     |        |                                       |
| Knowledge                          |  |                                     |        |                                       |
| Skills                             |  |                                     |        |                                       |
| Personal Competence                |  |                                     |        |                                       |
| Social Competence                  |  |                                     |        |                                       |
| Autonomy                           |  |                                     |        |                                       |
| Workload in Hours                  | Independent Study Time 110, Study Time in Lecture    | e 70                                |        |                                       |
| Credit points                      | 6  |                                     |        |                                       |
| Course achievement                 | None   |                                     |        |                                       |
| Examination                        | Written elaboration                                  |                                     |        |                                       |
| Examination duration and           | Report (about 5-10 pages) and Presentation (about    | 15 min)                             |        |                                       |
| scale                              |  |                                     |        |                                       |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic: | Elective Compulsory                 |        |                                       |
| Following Curricula                | Environmental Engineering: Specialisation Water: E   | lective Compulsory                  |        |                                       |
|                                    | Environmental Engineering: Specialisation Waste ar   | nd Energy: Elective Compulsory      |        |                                       |
|                                    | Environmental Engineering: Specialisation Biotechn   | ology: Elective Compulsory          |        |                                       |
|                                    | Water and Environmental Engineering: Specialisation  | on Cities: Elective Compulsory      |        |                                       |
|                                    | Water and Environmental Engineering: Specialisation  | on Environment: Elective Compulsory |        |                                       |
|                                    | Water and Environmental Engineering: Specialisation  | on Water: Elective Compulsory       |        |                                       |
|                                    |  |                                     | ·      | · · · · · · · · · · · · · · · · · · · |

| Course L2750: Microplastics in Environment |   |
|--|---|
| Тур  | Integrated Lecture                                  |
| Hrs/wk                                     | 2   |
| СР   | 2   |
| Workload in Hours                          | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer                                   | Prof. Nima Shokri                                   |
| Language                                   | EN  |
| Cycle                                      | WiSe  |
| Content                                    |   |
| Literature                                 |   |

| Course L2751: Research Met | ourse L2751: Research Methods for Energy-Water-Soil-Climate Nexus |  |  |
|----------------------------|---|--|--|
| Тур                        | Lecture   |  |  |
| Hrs/wk                     | 1   |  |  |
| СР                         | 2   |  |  |
| Workload in Hours          | Independent Study Time 46, Study Time in Lecture 14               |  |  |
| Lecturer                   | Prof. Nima Shokri   |  |  |
| Language                   | EN  |  |  |
| Cycle                      | WiSe  |  |  |
| Content                    |   |  |  |
| Literature                 |   |  |  |

| Course L2752: Research Tren | ourse L2752: Research Trends in Energy-Water-Soil-Climate Nexus |  |  |
|-----------------------------|---|--|--|
| Тур                         | Seminar   |  |  |
| Hrs/wk                      | 2   |  |  |
| СР                          | 2   |  |  |
| Workload in Hours           | Independent Study Time 32, Study Time in Lecture 28             |  |  |
| Lecturer                    | Dr. Salome Shokri-Kuehni  |  |  |
| Language                    | EN  |  |  |
| Cycle                       | WiSe  |  |  |
| Content                     |   |  |  |
| Literature                  |   |  |  |

| Module M0620: Speci               | al Aspects of W  | aste Resource Ma             | nagement           |                                    |                 |                      |
|-----------------------------------|--|------------------------------|--------------------|------------------------------------|-----------------|----------------------|
| Courses                           |  |                              |                    |                                    |                 |                      |
| Title                             |  |                              |                    | Тур                                | Hrs/wk          | СР                   |
| Advanced Topics in Waste Resource | -  |                              |                    | Project-/problem-based Learning    | 3               | 3                    |
| International Waste Management (  |  |                              |                    | Project-/problem-based Learning    | 2               | 3                    |
| Module Responsible                | Prof. Kerstin Kuchta   |                              |                    |                                    |                 |                      |
| Admission Requirements            | None   |                              |                    |                                    |                 |                      |
| Recommended Previous              | basics in waste treatr   | nent technologies            |                    |                                    |                 |                      |
| Knowledge                         |  |                              |                    |                                    |                 |                      |
| Educational Objectives            | After taking part succ   | essfully, students have rea  | ched the followir  | ng learning results                |                 |                      |
| Professional Competence           |  |                              |                    |                                    |                 |                      |
| Knowledge                         |  |                              |                    | as advanced technologies for re    | , ,             | ,                    |
|                                   | from waste in detail.  | This covers collection, tran | sport, treatment   | and disposal in national and into  | ernational conf | texts.               |
| Skills                            | Students are able to   | select suitable processes fo | or the treatment v | with respect to the national or co | ultural and dev | velopmental context. |
|                                   |  |                              |                    | of different technologies and ma   |                 | -                    |
|                                   |  |                              |                    | -                                  |                 |                      |
| Personal Competence               |  |                              |                    |                                    |                 |                      |
| Social Competence                 | Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop  |                              |                    |                                    |                 |                      |
|                                   | cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues.  Furthermore, they can give and accept professional constructive criticisms. |                              |                    |                                    |                 |                      |
|                                   | Furthermore, they ca   | n give and accept profession | onal constructive  | Criticisms.                        |                 |                      |
| Autonomy                          | Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and  |                              |                    |                                    |                 |                      |
|                                   | projects.  |                              |                    |                                    |                 |                      |
| Workload in Hours                 | Indopondent Study Ti   | me 110, Study Time in Lec    | turo 70            |                                    |                 |                      |
|                                   |  | ine 110, Study Time in Lee   | ture 70            |                                    |                 |                      |
| Course achievement                | Compulsory Bonus   | Form                         | Description        |                                    |                 |                      |
| course demevement                 | Yes 20 %   | Written elaboration          |                    |                                    |                 |                      |
| Examination                       | Presentation   |                              |                    |                                    |                 |                      |
| Examination duration and          | PowerPoint presentat   | ion (10-15 minutes)          |                    |                                    |                 |                      |
| scale                             |  |                              |                    |                                    |                 |                      |
| Assignment for the                | Civil Engineering: Spe   | cialisation Water and Traf   | ic: Elective Comp  | oulsory                            |                 |                      |
| Following Curricula               | Environmental Engine   | eering: Specialisation Wast  | e and Energy: Ele  | ective Compulsory                  |                 |                      |
|                                   | Joint European Maste   | r in Environmental Studies   | - Cities and Susta | ainability: Specialisation Energy: | Elective Com    | pulsory              |
|                                   | Water and Environme  | ntal Engineering: Specialis  | ation Water: Elec  | tive Compulsory                    |                 |                      |
|                                   |  | ntal Engineering: Specialis  |                    |                                    |                 |                      |
|                                   | Water and Environme  | ntal Engineering: Specialis  | ation Cities: Elec | tive Compulsory                    |                 |                      |

| Course L1055: Advanced Top | pics in Waste Resource Management   |
|----------------------------|---|
| Тур                        | Project-/problem-based Learning   |
| Hrs/wk                     | 3   |
| СР                         | 3   |
| Workload in Hours          | Independent Study Time 48, Study Time in Lecture 42   |
| Lecturer                   | Prof. Rüdiger Siechau   |
| Language                   | EN  |
| Cycle                      | WiSe  |
| Content                    | Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste collection systems).  The course is split into two parts:  1. part: "Conventional" lecture (development of waste management, legislation, collection, transportation and organisation of waste management, costs, fees and revenues).  2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work out the project were given before during the conventional lecture. Course documents are published in StudIP and communication during project work takes place via StudIP.  The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the |
| Literature                 | presentation.  Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010  PowerPoint slides in Stud IP   |

| Course L0317: International | Waste Management   |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 2  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                    | Prof. Kerstin Kuchta   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics ( Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented.  Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves  Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries.  Single national projects and studies will be prepared and presented by students |
| Literature                  | Basel convention   |

| Module M0822: Proce                     | ss Modeling in Water Technology  |   |                |   |
|---|--|---|----------------|---|
| Courses                                 |  |   |                |   |
| Title                                   |  | Тур   | Hrs/wk         | СР                                      |
| Process Modelling of Wastewater T       | reatment (L0522)   | Project-/problem-based Learning               | 2              | 3                                       |
| Process Modeling in Drinking Water      | Treatment (L0314)  | Project-/problem-based Learning               | 2              | 3                                       |
| Module Responsible                      | Dr. Klaus Johannsen  |   |                |   |
| Admission Requirements                  | None   |   |                |   |
| Recommended Previous                    | Knowledge of the most important processes in drinking                                  | g water and waste water treatment.            |                |   |
| Knowledge                               |  |   |                |   |
| <b>Educational Objectives</b>           | After taking part successfully, students have reached                                  | the following learning results                |                |   |
| Professional Competence                 |  |   |                |   |
| Knowledge                               | Students are able to explain selected processes of di                                  | rinking water and waste water treatment i     | n detail. The  | y are able to explain                   |
|   | basics as well as possibilities and limitations of dynam                               | ic modeling.                                  |                |   |
| Skills                                  | Students are able to use the most important features                                   | Modelica offers. They are able to transpo     | se selected    | processes in drinking                   |
| Skiiis                                  | water and waste water treatment into a mathematica                                     |   |                | _                                       |
|   | They are able to set up and apply models and assess t                                  | ·   | ,              |   |
|   | · · · · · · · · · · · · · · · · · · ·  |   |                |   |
|   |  |   |                |   |
| Personal Competence                     |  |   |                |   |
| · ·                                     | Students are able to solve problems and document so                                    | lutions in a group with members of differe    | nt technical k | ackground. They are                     |
| ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | able to give appropriate feedback and can work consti                                  |   |                | .,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |
|   |  |   |                |   |
|   |  |   |                |   |
| Autonomy                                | Students are able to define a problem, gain the required knowledge and set up a model. |   |                |   |
| ,                                       | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,  |   |                |   |
|   |  |   |                |   |
| Workload in Hours                       | Independent Study Time 124, Study Time in Lecture 5                                    | 6   |                |   |
| Credit points                           | 6  |   |                |   |
| Course achievement                      | None   |   |                |   |
| Examination                             | Written exam   |   |                |   |
| Examination duration and                | 1,5 hours  |   |                |   |
| scale                                   |  |   |                |   |
| Assignment for the                      | Civil Engineering: Specialisation Water and Traffic: Ele                               | ctive Compulsory                              |                |   |
| Following Curricula                     | Environmental Engineering: Specialisation Water: Elec                                  | tive Compulsory                               |                |   |
|   | Joint European Master in Environmental Studies - Citie                                 | s and Sustainability: Specialisation Water: I | Elective Com   | oulsory                                 |
|   | Process Engineering: Specialisation Environmental Pro                                  | cess Engineering: Elective Compulsory         |                |   |
|   | Process Engineering: Specialisation Process Engineering                                | ng: Elective Compulsory                       |                |   |
|   | Water and Environmental Engineering: Specialisation                                    | Water: Elective Compulsory                    |                |   |
|   | Water and Environmental Engineering: Specialisation I                                  |   |                |   |
|   | Water and Environmental Engineering: Specialisation (                                  | Cities: Elective Compulsory                   |                |   |

| Course L0522: Process Mode | elling of Wastewater Treatment   |
|----------------------------|--|
| Тур                        | Project-/problem-based Learning  |
| Hrs/wk                     | 2  |
| СР                         | 3  |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                   | Dr. Joachim Behrendt   |
| Language                   | DE/EN  |
| Cycle                      | WiSe   |
| Content                    | Mass and energy balances   |
|                            | Tracer modelling   |
|                            | Activated Sludge Model   |
|                            | Wastewater Treatment Plant Modelling (continously and SBR)   |
|                            | Sludge Treatment (ADM, aerobic autothermal)  |
|                            | Biofilm Modelling  |
| Literature                 | Henze, Mogens (Seminar on Activated Sludge Modelling,; Kollekolle Seminar on Activated Sludge Modelling,;) Activated sludge modelling: processes in theory and practice; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146 [London]: IWA Publ., 2002 TUB_HH_Katalog Henze, Mogens Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London: IWA Publ., 2002 TUB_HH_Katalog Henze, Mogens Wastewater treatment: biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.]: Springer, 2002 TUB_HH_Katalog Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim: WILEY-VCH, 2007 TUB_HH_Katalog |

| Course L0314: Process Mode | ling in Drinking Water Treatment   |
|----------------------------|--|
| Тур                        | Project-/problem-based Learning  |
| Hrs/wk                     | 2  |
| СР                         | 3  |
| Workload in Hours          | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                   | Dr. Klaus Johannsen  |
| Language                   | DE/EN  |
| Cycle                      | WiSe   |
| Content                    | In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica.                                     |
|                            | In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam. |
| Literature                 | OpenModelica: https://openmodelica.org/index.php/download/download-windows   |
|                            | OpenModelica - Modelica Tutorial: https://openmodelica.org/index.php/useresresources/userdocumentation   |
|                            | OpenModelica - Users Guide: https://openmodelica.org/index.php/useresresources/userdocumentation   |
|                            | Peter Fritzson: Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.  |
|                            | MHW (rev. by Crittenden, J. et al.): Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.  |
|                            | Stumm, W., Morgan, J.J.: Aquatic chemistry. John Wiley & Sons, New York, 1996.   |
|                            | <b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.  |
|                            |  |

| Courses                         |   |   |                      |                     |
|---------------------------------|---|---|----------------------|---------------------|
| Title                           |   | Тур   | Hrs/wk               | СР                  |
| Membrane Technology (L0399)     |   | Lecture   | 2                    | 3                   |
| Membrane Technology (L0400)     |   | Recitation Section (small)  | 1                    | 2                   |
| Membrane Technology (L0401)     |   | Practical Course  | 1                    | 1                   |
| Module Responsible              | Prof. Mathias Ernst   |   |                      |                     |
| Admission Requirements          | None  |   |                      |                     |
| Recommended Previous            | Basic knowledge of water chemistry. Knowledge of  | the core processes involved in water, gas $% \left( 1\right) =\left( 1\right) \left( 1$ | and steam treatn     | nent                |
| Knowledge                       |   |   |                      |                     |
| Educational Objectives          | After taking part successfully, students have reache  | ed the following learning results   |                      |                     |
| <b>Professional Competence</b>  |   |   |                      |                     |
| Knowledge                       | Students will be able to rank the technical applicati   | ions of industrially important membrane p   | rocesses. They w     | ill be able to expl |
|                                 | the different driving forces behind existing memb   | orane separation processes. Students wil  | l be able to nam     | ne materials used   |
|                                 | membrane filtration and their advantages and dis  | advantages. Students will be able to exp  | lain the key diffe   | rences in the use   |
|                                 | membranes in water, other liquid media, gases and   | l in liquid/gas mixtures.   |                      |                     |
| Skille                          | Students will be able to prepare mathematical equ   | uations for material transport in porous a  | nd solution-diffus   | ion membranes :     |
| Skiiis                          | calculate key parameters in the membrane separa   | ·   |                      |                     |
|                                 | available boundary data and provide recommend   |   |                      |                     |
|                                 | experiments, students will be able to classify th   |   |                      |                     |
|                                 | membrane materials. Students will be able to chara  |   |                      |                     |
|                                 | measures to control this.   | deterise the formation of the founing layer i   | ii diliciciie water. | з ана арргу ссет    |
|                                 | measures to control this.   |   |                      |                     |
| Personal Competence             |   |   |                      |                     |
| Social Competence               | Students will be able to work in diverse teams on t   | tasks in the field of membrane technology   | . They will be ab    | le to make decision |
|                                 | within their group on laboratory experiments to be  | undertaken jointly and present these to ot  | hers.                |                     |
| Autonomy                        | Students will be in a position to salve homework  | on the tenis of membrane technology in  | danandantly Tha      | w will be sanable   |
| Autonomy                        | Students will be in a position to solve homework finding creative solutions to technical questions. | on the topic of membrane technology in  | иерепиения. тне      | y will be capable   |
|                                 | initially creative solutions to technical questions.  |   |                      |                     |
| Workload in Hours               | Independent Study Time 124, Study Time in Lecture   | e 56  |                      |                     |
| Credit points                   | 6   |   |                      |                     |
| Course achievement              | None  |   |                      |                     |
| Examination                     | Written exam  |   |                      |                     |
| <b>Examination duration and</b> | 90 min  |   |                      |                     |
| scale                           |   |   |                      |                     |
| Assignment for the              | Civil Engineering: Specialisation Water and Traffic:  | Elective Compulsory   |                      |                     |
| Following Curricula             | Bioprocess Engineering: Specialisation A - General I  | Bioprocess Engineering: Elective Compulso   | ory                  |                     |
|                                 | Bioprocess Engineering: Specialisation B - Industria  | l Bioprocess Engineering: Elective Compul   | sory                 |                     |
|                                 | Chemical and Bioprocess Engineering: Specialisatio  | on Chemical Process Engineering: Elective   | Compulsory           |                     |
|                                 | Chemical and Bioprocess Engineering: Specialisatio  | on General Process Engineering: Elective C  | ompulsory            |                     |
|                                 | Energy and Environmental Engineering: Specialisati  | ion Energy and Environmental Engineering  | յ։ Elective Compu    | lsory               |
|                                 | Environmental Engineering: Specialisation Water: E  | Elective Compulsory   |                      |                     |
|                                 | Joint European Master in Environmental Studies - Ci   | ities and Sustainability: Specialisation Wat  | er: Elective Comp    | oulsory             |
|                                 | Process Engineering: Specialisation Process Engineer  | ering: Elective Compulsory  |                      |                     |
|                                 | Process Engineering: Specialisation Environmental   | Process Engineering: Elective Compulsory  |                      |                     |
|                                 | Water and Environmental Engineering: Specialisation   | on Water: Elective Compulsory   |                      |                     |
|                                 | Water and Environmental Engineering: Specialisation   | on Environment: Elective Compulsory   |                      |                     |
|                                 | Water and Environmental Engineering: Specialisation   | on Cities: Elective Compulsory  |                      |                     |

| Course L0399: Membrane Technology |  |  |
|-----------------------------------|--|--|
| Тур                               | Lecture  |  |
| Hrs/wk                            | 2  |  |
| СР                                | 3  |  |
| Workload in Hours                 | Independent Study Time 62, Study Time in Lecture 28  |  |
| Lecturer                          | Prof. Mathias Ernst  |  |
| Language                          | EN   |  |
| Cycle                             | WiSe   |  |
| Content                           | The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well.  |  |
|                                   | Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. |  |
|                                   | The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.  |  |
| Literature                        | <ul> <li>T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.</li> <li>Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>   |  |

| Course L0400: Membrane Te | ourse L0400: Membrane Technology                    |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (small)                          |  |
| Hrs/wk                    | 1   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 46, Study Time in Lecture 14 |  |
| Lecturer                  | Prof. Mathias Ernst                                 |  |
| Language                  | EN  |  |
| Cycle                     | WiSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Course L0401: Membrane Te | Course L0401: Membrane Technology                   |  |
|---------------------------|---|--|
| Тур                       | Practical Course                                    |  |
| Hrs/wk                    | 1   |  |
| СР                        | 1   |  |
| Workload in Hours         | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                  | Prof. Mathias Ernst                                 |  |
| Language                  | EN  |  |
| Cycle                     | WiSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Module M0864: Practi               | ical Course in Water and Wast                | tewater Technology                              |                      |                        |
|------------------------------------|--|---|----------------------|------------------------|
| Courses                            |  |   |                      |                        |
| Title                              |  | Тур   | Hrs/wk               | СР                     |
| Practical Course in Water and Wast | ewater Technology I (L0503)                  | Practical Course                                | 2                    | 3                      |
| Practicle Course of Wastewater Tec | hnology II (L0607)                           | Practical Course                                | 3                    | 3                      |
| Module Responsible                 | Dr. Dorothea Rechtenbach                     |   |                      |                        |
| Admission Requirements             | None   |   |                      |                        |
| Recommended Previous               | Basic knowledge in chemistry and physics (   | knowledge acquired at school)                   |                      |                        |
| Knowledge                          |  |   |                      |                        |
| <b>Educational Objectives</b>      | After taking part successfully, students hav | e reached the following learning results        |                      |                        |
| <b>Professional Competence</b>     |  |   |                      |                        |
| Knowledge                          | The students know basic analytical proced    | lures for evaluating the quality of water and   | wastewater. They ha  | ve knowledge about     |
|                                    | fundamental process engineering features     | of important water and wastewater treatment     | technologies.        |                        |
| Skills                             | The students are able to understand and      | to practically apply methodologies for waster   | water analysis as we | ell as descriptions of |
|                                    | experiments and experimental setups in wa    | astewater technology.                           |                      |                        |
| Personal Competence                |  |   |                      |                        |
| Social Competence                  |  |   |                      |                        |
| Autonomy                           | The students are able to conduct experimen   | nts following written procedures without extern | nal assistance.      |                        |
| Workload in Hours                  | Independent Study Time 110, Study Time in    | n Lecture 70                                    |                      |                        |
| Credit points                      | 6  |   |                      |                        |
| Course achievement                 | None   |   |                      |                        |
| Examination                        | Written elaboration                          |   |                      |                        |
| Examination duration and           | ca. 5 Stunden                                |   |                      |                        |
| scale                              |  |   |                      |                        |
| Assignment for the                 | Civil Engineering: Specialisation Water and  | Traffic: Elective Compulsory                    |                      |                        |
| Following Curricula                | Water and Environmental Engineering: Spe-    | cialisation Water: Elective Compulsory          |                      |                        |
|                                    | Water and Environmental Engineering: Spe-    | cialisation Environment: Elective Compulsory    |                      |                        |
|                                    | Water and Environmental Engineering: Spe-    | cialisation Cities: Elective Compulsory         |                      |                        |

| Course L0503: Practical Course in Water and Wastewater Technology I |  |
|---|--|
| Тур   | Practical Course   |
| Hrs/wk  | 2  |
| СР  | 3  |
| Workload in Hours   | Independent Study Time 62, Study Time in Lecture 28                                    |
| Lecturer  | Dr. Dorothea Rechtenbach   |
| Language  | EN   |
| Cycle   | WiSe   |
| Content   | - Impact of pretreatment of wastewater samples on analytical results                   |
|   | - Analysis of nutrients in wastewater samples (different methods for nitrate analysis) |
|   | - Alkalinity   |
|   | - TOC, COD   |
|   | - microscopic analysis of microorganisms relevant in wastewater treatment              |
| Literature  | Skript auf StudIP  |

| Course L0607: Practicle Course of Wastewater Technology II |   |
|--|---|
| Тур  | Practical Course                                    |
| Hrs/wk   | 3   |
| СР   | 3   |
| Workload in Hours  | Independent Study Time 48, Study Time in Lecture 42 |
| Lecturer   | Dr. Joachim Behrendt                                |
| Language   | DE/EN   |
| Cycle  | WiSe  |
| Content  | Experiments:  |
|  | Oxygen transfer                                     |
|  | Oxygen Uptake rate                                  |
|  | Sludge dewatering                                   |
|  | Tracer  |
|  | Flocculation  |
| Literature   | Skript/Script                                       |

| Linginieering                     |  |   |                          |            |
|-----------------------------------|--|---|--------------------------|------------|
| Module M0902: Wast                | ewater Treatment and Air Poll  | ution Abatement                               |                          |            |
| Courses                           |  |   |                          |            |
| litle                             |  | Тур   | Hrs/wk                   | СР         |
| Biological Wastewater Treatment ( | _0517)   | Lecture                                       | 2                        | 3          |
| Air Pollution Abatement (L0203)   |  | Lecture                                       | 2                        | 3          |
| Module Responsible                | Dr. Swantje Pietsch-Braune   |   |                          |            |
| Admission Requirements            | None   |   |                          |            |
| Recommended Previous              | Basic knowledge of biology and chemistry   |   |                          |            |
| Knowledge                         | I  |   |                          |            |
|                                   | Basic knowledge of solids process engineeri  | ing and separation technology                 |                          |            |
|                                   |  |   |                          |            |
| Educational Objections            | A first believe and the second of the second | and the fellowing leaves as well-             |                          |            |
| Educational Objectives            | After taking part successfully, students have  | e reached the following learning results      |                          |            |
| Professional Competence           | After suggestful sempletion of the module s  | tudents are able to                           |                          |            |
| Knowieuge                         | After successful completion of the module s  | ludents are able to                           |                          |            |
|                                   | <ul> <li>name and explain biological processe</li> </ul>   | es for waste water treatment,                 |                          |            |
|                                   | <ul> <li>characterize waste water and sewage</li> </ul>  | e sludge,                                     |                          |            |
|                                   | <ul> <li>discuss legal regulations in the area of</li> </ul>   | of emissions and air quality                  |                          |            |
|                                   | <ul> <li>explain the effects of air pollutants or</li> </ul>   | n the environment,                            |                          |            |
|                                   | <ul> <li>name and explan off gas tretament p</li> </ul>  | processes and to define their area of applica | ation                    |            |
| Skills                            | Students are able to   |   |                          |            |
| 55                                |  |   |                          |            |
|                                   | <ul> <li>choose and design processs steps for</li> </ul>   | the biological waste water treatment          |                          |            |
|                                   | <ul> <li>combine processes for cleaning of off</li> </ul>  | f-gases depending on the pollutants contain   | ned in the gases         |            |
| Personal Competence               |  |   |                          |            |
| Social Competence                 |  |   |                          |            |
| Autonomy                          |  |   |                          |            |
| Workload in Hours                 | Independent Study Time 124, Study Time in  | Lecture 56                                    |                          |            |
| Credit points                     |  |   |                          |            |
| Course achievement                |  |   |                          |            |
| Examination                       | Written exam   |   |                          |            |
| Examination duration and          | 90 min   |   |                          |            |
| scale                             |  |   |                          |            |
| Assignment for the                | Civil Engineering: Specialisation Water and <sup>-</sup>   | Traffic: Elective Compulsory                  |                          |            |
| Following Curricula               | Bioprocess Engineering: Specialisation A - G   |   | mpulsory                 |            |
|                                   | Chemical and Bioprocess Engineering: Spec  | ialisation General Process Engineering: Ele   | ctive Compulsory         |            |
|                                   | Environmental Engineering: Specialisation V  |   | -                        |            |
|                                   | International Management and Engineering:  | : Specialisation II. Energy and Environment   | al Engineering: Elective | Compulsory |
|                                   | Joint European Master in Environmental Stud  |   |                          |            |
|                                   | Renewable Energies: Specialisation Bioener   | gy Systems: Elective Compulsory               |                          |            |
|                                   | Process Engineering: Specialisation Environ  | mental Process Engineering: Elective Comp     | oulsory                  |            |
|                                   | Process Engineering: Specialisation Process  | Engineering: Elective Compulsory              |                          |            |
|                                   | Water and Environmental Engineering: Spec  | cialisation Water: Elective Compulsory        |                          |            |
|                                   | Water and Environmental Engineering: Spec  | cialisation Environment: Compulsory           |                          |            |
|                                   | Water and Environmental Engineering: Spec  | cialisation Cities: Compulsory                |                          |            |

| Тур               | Lecture   |
|-------------------|---|
| Hrs/wk            | 2   |
| СР                | 3   |
| Workload in Hours | Independent Study Time 62, Study Time in Lecture 28 |
| Lecturer          | Dr. Joachim Behrendt                                |
| Language          | DE/EN   |
| Cycle             | WiSe  |
| Content           | Charaterisation of Wastewater                       |
|                   | Metobolism of Microorganisms                        |
|                   | Kinetic of mirobiotic processes                     |
|                   | Calculation of bioreactor for wastewater treatment  |
|                   | Concepts of Wastewater treatment                    |
|                   | Design of WWTP                                      |
|                   | Excursion to a WWTP                                 |
|                   | Biofilms  |
|                   | Biofim Reactors                                     |
|                   | Anaerobic Wastewater and sldge treatment            |
|                   | resources oriented sanitation technology            |
|                   | Future challenges of wastewater treatment           |

| Literature | Gujer, Willi   |
|------------|--|
|            | Siedlungswasserwirtschaft : mit 84 Tabellen  |
|            | ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?    |
|            | id=2842122&prov=M&dok_var=1&dok_ext=htm  |
|            | Berlin [u.a.] : Springer, 2007   |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Wastewater treatment : biological and chemical processes   |
|            | ISBN: 3540422285 (Pp.)   |
|            | Berlin [u.a.] : Springer, 2002   |
|            | TUB_HH_Katalog   |
|            | Imhoff, Karl (Imhoff, Klaus R.;)   |
|            | Taschenbuch der Stadtentwässerung : mit 10 Tafeln  |
|            | ISBN: 3486263331 ((Gb.))   |
|            | München [u.a.]: Oldenbourg, 1999   |
|            | TUB_HH_Katalog   |
|            | Lange, Jörg (Otterpohl, Ralf; Steger-Hartmann, Thomas;)  |
|            | Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft  |
|            | ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334          |
|            | Donaueschingen-Pfohren : Mall-Beton-Verl., 2000  |
|            | TUB_HH_Katalog   |
|            | Mudrack, Klaus (Kunst, Sabine;)  |
|            | Biologie der Abwasserreinigung : 18 Tabellen   |
|            | ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903                  |
|            | Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003  |
|            | TUB_HH_Katalog   |
|            | Tchobanoglous, George (Metcalf & Eddy, Inc., ;)  |
|            | Wastewater engineering : treatment and reuse   |
|            | ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))  |
|            | Boston [u.a.] : McGraw-Hill, 2003  |
|            | TUB_HH_Katalog   |
|            | Henze, Mogens  |
|            | Activated sludge models ASM1, ASM2, ASM2d and ASM3   |
|            | ISBN: 1900222248   |
|            | London: IWA Publ., 2002  |
|            | TUB_HH_Katalog   |
|            | Kunz, Peter  |
|            | Umwelt-Bioverfahrenstechnik  |
|            | Vieweg, 1992   |
|            | Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt (Deutsche Vereinigung für                |
|            | Wasserwirtschaft, Abwasser und Abfall, ;)  |
|            | Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe |
|            | aus der Abwasserbehandlung, Kleinkläranlagen   |
|            | ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL:  |
|            | http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf   |
|            | Weimar : Universitätsverl, 2006  |
|            | TUB_HH_Katalog   |
|            | Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall   |
|            | DWA-Regelwerk  |
|            | Hennef : DWA, 2004   |
|            | TUB_HH_Katalog   |
|            | Wiesmann, Udo (Choi, In Su; Dombrowski, Eva-Maria;)  |
|            | Fundamentals of biological wastewater treatment  |
|            | ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm              |
|            | Weinheim: WILEY-VCH, 2007  |
|            | TUB_HH_Katalog   |
|            |  |
|            |  |

| Course L0203: Air Pollution | Abatement  |
|-----------------------------|--|
| Тур                         | Lecture  |
| Hrs/wk                      | 2  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                    | Dr. Swantje Pietsch-Braune, Christian Eichler  |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators. |
| Literature                  | Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls 2. ed London [u.a.] : Spon, 2002   |

| Courses                            |  |
|------------------------------------|--|
| Title                              | Typ Hrs/wk CP  |
| Integrated Transportation Planning |  |
| Module Responsible                 | Prof. Carsten Gertz  |
| Admission Requirements             | None   |
|                                    | some knowledge of transport planning, e.g. through taking the undergraduate class "Transport Planning and Traffic Engineerin                                   |
| Knowledge                          |  |
|                                    | After taking part successfully, students have reached the following learning results   |
| Professional Competence            | Children and abla to   |
| Knowieage                          | Students are able to:  |
|                                    | describe interdependencies between land-use/location choice and transportation/mobility behaviour  |
|                                    | explain and evaluate the social, ecological and economic effects of transport and land-use policy measures.  |
|                                    | <ul> <li>relate current issues in the area of integrated transport planning and formulate an opinion on them.</li> </ul>                                       |
|                                    |  |
| <u></u>                            |  |
| Skills                             | Students are able to:  |
|                                    | quantify important parameters, which influence travel demand or are influenced by it.  |
|                                    | <ul> <li>comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document th</li> </ul>                     |
|                                    | results in accordance with scientific conventions.   |
|                                    |  |
|                                    |  |
| Personal Competence                |  |
| Social Competence                  | Students are able to:  |
|                                    | provide feedback on topical contents and their teaching.   |
|                                    | constructively handle feedback on their own work.  |
|                                    | produce results in group work and document these.  |
|                                    |  |
|                                    |  |
| Autonomy                           | Students are able to:  |
|                                    | assess potential consequences of their future professional activities  |
|                                    | independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for                                       |
|                                    | its execution.   |
|                                    |  |
|                                    |  |
|                                    | Independent Study Time 124, Study Time in Lecture 56   |
| Credit points                      |  |
| Course achievement                 |  |
|                                    | Written elaboration  |
| Examination duration and           | written assignment with presentation during the semester   |
| scale Assignment for the           | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |
| Following Curricula                | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory |
| i onowing curricula                | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory    |
|                                    | Civil Engineering: Specialisation Water and Traffic: Compulsory  |
|                                    | Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory  |
|                                    | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   |
|                                    | Water and Environmental Engineering: Specialisation Environment: Elective Compulsory   |
|                                    | Water and Environmental Engineering: Specialisation Cities: Compulsory   |

| Course L1068: Integrated Tr | ansportation Planning  |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 4  |
| СР                          | 6  |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                    | Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß   |
| Language                    | DE   |
| Cycle                       | WiSe   |
|                             | The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.:  • interactions between transport and the environment and consequent limitations  • characteristics of integrated planning  • complex planning processes  • interdependencies of location choice and mobility behaviour  • transport and land-use policies  • project on current issues in transportation studies |
| Literature                  | Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin.  Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin,  Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)  |

| Module M0948: Study           | / Work Water/ Waste Water   |
|-------------------------------|---|
| Courses                       |   |
| Title                         | Typ Hrs/wk CP   |
| Module Responsible            | Dozenten des SD B   |
| Admission Requirements        | None  |
| Recommended Previous          |   |
| Knowledge                     |   |
| <b>Educational Objectives</b> | After taking part successfully, students have reached the following learning results  |
| Professional Competence       |   |
| Knowledge                     | The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.   |
|                               | The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.   |
|                               | Scientific work techniques that are used can be described and critically reviewed.  |
| Skills                        | The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.  |
| Personal Competence           |   |
| Social Competence             | The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.   |
| Autonomy                      | The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology. |
| Workload in Hours             | Independent Study Time 180, Study Time in Lecture 0   |
| Credit points                 | 6   |
| Course achievement            | None  |
| Examination                   | Study work  |
| Examination duration and      |   |
| scale                         |   |
| Assignment for the            | Water and Environmental Engineering: Specialisation Water: Compulsory   |
| Following Curricula           |   |

| 3 3                      |   |                                 |                            |                       |
|--------------------------|---|---------------------------------|----------------------------|-----------------------|
| Module M0949: Rural      | <b>Development and Resources Oriented</b>                   | Sanitation for diffe            | erent Climate Zon          | ies                   |
| Courses                  |   |                                 |                            |                       |
| Title                    |   | Time                            | Hwa hule                   | СР                    |
|                          | Oriented Sanitation for different Climate Zones (L0942)     | <b>Typ</b><br>Seminar           | Hrs/wk<br>2                | 3                     |
|                          | Oriented Sanitation for different Climate Zones (L0942)     | Lecture                         | 2                          | 3                     |
| Module Responsible       | Prof. Ralf Otterpohl  |                                 |                            |                       |
| Admission Requirements   | None  |                                 |                            |                       |
| Recommended Previous     | Basic knowledge of the global situation with rising pover   | ty, soil degradation, lack of w | ater resources and sanita  | ation                 |
| Knowledge                |   |                                 |                            |                       |
| Educational Objectives   | After taking part successfully, students have reached the   | e following learning results    |                            |                       |
| Professional Competence  |   |                                 |                            |                       |
| Knowledge                | Students can describe resources oriented wastewater s       | systems mainly based on so      | urce control in detail. Th | ey can comment on     |
|                          | techniques designed for reuse of water, nutrients and so    | il conditioners.                |                            |                       |
|                          | Students are able to discuss a wide range of proven app     | reaches in Bural Developmen     | at from and for many rogic | one of the world      |
|                          | students are able to discuss a wide range of proven app     | Toaches in Kurai Developinen    | it from and for many regi  | ons of the world.     |
|                          |   |                                 |                            |                       |
| Skills                   | Students are able to design low-tech/low-cost sanitation    | on, rural water supply, rain    | water harvesting system    | s, measures for the   |
|                          | rehabilitation of top soil quality combined with food and   | water security. Students can    | consult on the basics of   | soil building through |
|                          | "Holisitc Planned Grazing" as developed by Allan Savory     | •                               |                            |                       |
| Personal Competence      |   |                                 |                            |                       |
| •                        | The students are able to develop a specific topic in a tea  | ım and to work out milestone    | s according to a given pla | ın.                   |
|                          |   |                                 |                            |                       |
| Autonomy                 | Students are in a position to work on a subject and to      | o organize their work flow in   | ndependently. They can     | also present on this  |
|                          | subject.  |                                 |                            |                       |
| Workload in Hours        | Independent Study Time 124, Study Time in Lecture 56        |                                 |                            |                       |
| Credit points            | 6   |                                 |                            |                       |
| Course achievement       | None  |                                 |                            |                       |
| Examination              | Subject theoretical and practical work                      |                                 |                            |                       |
| Examination duration and | During the course of the semester, the students work to     | owards mile stones. The worl    | k includes presentations   | and papers. Detailed  |
| scale                    | information will be provided at the beginning of the sme    | ster.                           |                            |                       |
| Assignment for the       | Civil Engineering: Specialisation Water and Traffic: Electi | ive Compulsory                  |                            |                       |
| Following Curricula      | Bioprocess Engineering: Specialisation A - General Biopro   | ocess Engineering: Elective C   | Compulsory                 |                       |
|                          | Chemical and Bioprocess Engineering: Specialisation Ger     | neral Process Engineering: El   | ective Compulsory          |                       |
|                          | Environmental Engineering: Specialisation Water: Electiv    | e Compulsory                    |                            |                       |
|                          | International Management and Engineering: Specialisation    | on II. Energy and Environmen    | tal Engineering: Elective  | Compulsory            |
|                          | Joint European Master in Environmental Studies - Cities a   | and Sustainability: Specialisat | tion Water: Elective Comp  | ulsory                |
|                          | Process Engineering: Specialisation Environmental Proce     | ess Engineering: Elective Com   | ipulsory                   |                       |
|                          | Process Engineering: Specialisation Process Engineering:    | : Elective Compulsory           |                            |                       |
|                          | Water and Environmental Engineering: Specialisation Wa      | ater: Elective Compulsory       |                            |                       |
|                          | Water and Environmental Engineering: Specialisation En      | •                               | ory                        |                       |
|                          | Water and Environmental Engineering: Specialisation Cit     | ies: Elective Compulsory        |                            |                       |

| Course L0942: Rural Develop | oment and Resources Oriented Sanitation for different Climate Zones   |
|-----------------------------|---|
| Тур                         | Seminar   |
| Hrs/wk                      | 2   |
| СР                          | 3   |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28   |
| Lecturer                    | Prof. Ralf Otterpohl  |
| Language                    | EN  |
| Cycle                       | WiSe  |
| Content                     |   |
|                             | <ul> <li>Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists.</li> <li>The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.</li> </ul>   |
| Literature                  | <ul> <li>J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek)</li> <li>Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)</li> <li>Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys</li> </ul> |

| Course L0941: Rural Develop | ment and Resources Oriented Sanitation for different Climate Zones   |
|-----------------------------|--|
| Тур                         | Lecture  |
| Hrs/wk                      | 2  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28  |
| Lecturer                    | Prof. Ralf Otterpohl   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | <ul> <li>Living Soil - THE key element of Rural Development</li> <li>Participatory Approaches</li> <li>Rainwater Harvesting</li> <li>Ecological Sanitation Principles and practical examples</li> <li>Permaculture Principles of Rural Development</li> <li>Performance and Resilience of Organic Small Farms</li> <li>Going Further: The TUHH Toolbox for Rural Development</li> <li>EMAS Technologies, Low cost drinking water supply</li> </ul> |
| Literature                  | <ul> <li>Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk</li> <li>Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> </ul>  |

| Engineering"                                       |  |  |                         |                      |
|--|--|--|-------------------------|----------------------|
| Module M0581: Wate                                 | r Protection   |  |                         |                      |
| Courses  |  |  |                         |                      |
| Title  |  | Тур  | Hrs/wk                  | СР                   |
| Water Protection and Wastewater Management (L0226) |  | Lecture                                    | 3                       | 3                    |
| Water Protection and Wastewater N                  | Management (L2008)   | Project Seminar                            | 3                       | 3                    |
| Module Responsible                                 | Prof. Ralf Otterpohl   |  |                         |                      |
| Admission Requirements                             | None   |  |                         |                      |
| Recommended Previous                               |  |  |                         |                      |
| Knowledge  | Basic knowledge in water management  | ;  |                         |                      |
|  | Good knowledge in urban drainage;  | and the all as in the second               |                         |                      |
|  | Good knowledge of wastewater treatments     Good knowledge of pollutants (o.g. COE | ·  |                         |                      |
|  | <ul> <li>Good knowledge of pollutants (e.g. COD</li> </ul>                         | o, BOD, 15, N, P) and their properties;    |                         |                      |
| <b>Educational Objectives</b>                      | After taking part successfully, students have r                                    | eached the following learning results      |                         |                      |
| Professional Competence                            |  |  |                         |                      |
| Knowledge  | The students can describe the basic principles                                     | of the regulatory framework related to th  | e international and Eu  | ropean water sector  |
|  | They can explain limnological processes, sul                                       | ostance cycles and water morphology in     | detail. They are able   | e to assess complex  |
|  | problems related to water protection, such a                                       | s ecosystem service and wastewater tre     | atment with a special   | focus on innovative  |
|  | solutions, remediation measures as well as co                                      | nceptual approaches.                       |                         |                      |
| Skille   | Students can accurately assess current proble                                      | ame and cituations in a country-specific o | r local context. They c | an suggest concrete  |
| Skiiis   | actions to contribute to the planning of tom                                       |  |                         |                      |
|  | administrative and legislative solutions to solv                                   |  | , they can suggest ap   | spropriate teerimean |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
| Personal Competence                                |  |  |                         |                      |
| Social Competence                                  | The students can work together in internation                                      | al groups.                                 |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
| Autonomy   | Students are able to organize their work flow                                      | to prepare presentations and discussions   | They can acquire an     | propriate knowledge  |
| riateriorny  | by making enquiries independently.   | to propare presentations and discussions   | mey can acquire ap      | propriate informedge |
|  | 3 - 4  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
|  |  |  |                         |                      |
| Workload in Hours                                  | Independent Study Time 96, Study Time in Lea                                       | cture 84                                   |                         |                      |
| Credit points                                      |  |  |                         |                      |
| Course achievement                                 |  |  |                         |                      |
| Examination  | Presentation   |  |                         |                      |
|  | Term paper plus presentation   |  |                         |                      |
| scale  | - Fahar brosenation  |  |                         |                      |
|  |  |  |                         |                      |
| Assignment for the                                 | Civil Engineering: Specialisation Structural Eng                                   | gineering: Elective Compulsory             |                         |                      |
| Following Curricula                                | Civil Engineering: Specialisation Geotechnical                                     | Engineering: Elective Compulsory           |                         |                      |
|  | Civil Engineering: Specialisation Coastal Engin                                    | , ,  |                         |                      |
|  | Civil Engineering: Specialisation Water and Tra                                    | • •  |                         |                      |
|  | Environmental Engineering: Specialisation Wa                                       | , ,  |                         |                      |
|  | International Management and Engineering: S  |  |                         |                      |
|  | Joint European Master in Environmental Studie                                      | • •  | n Water: Elective Comp  | oulsory              |
|  | Water and Environmental Engineering: Specia  |  |                         |                      |
|  | Water and Environmental Engineering: Specia  |  |                         |                      |
|  | Water and Environmental Engineering: Specia  | iisation Environment: Compulsory           |                         |                      |

| Course L0226: Water Protect | tion and Wastewater Management   |
|-----------------------------|--|
| Тур                         | Lecture  |
| Hrs/wk                      | 3  |
| СР                          | 3  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42  |
| Lecturer                    | Prof. Ralf Otterpohl   |
| Language                    | EN   |
| Cycle                       | WiSe   |
| Content                     | The lecture focusses on:  Regulatory Framework (e.g. WFD)  Main instruments for the water management and protection  In depth knowledge of relevant measures of water pollution control  Urban drainage, treatment options in different regions on the world  Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration  Case Studies and Field Trips  |
| Literature                  | <ul> <li>The literature listed below is available in the library of the TUHH.</li> <li>Water and wastewater technology Hammer, M. J. 1., &amp; . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.</li> <li>Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). New York, NY: McGraw-Hill.</li> <li>Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.</li> </ul> |

| Course L2008: Water Protect | urse L2008: Water Protection and Wastewater Management |  |  |
|-----------------------------|--|--|--|
| Тур                         | Project Seminar  |  |  |
| Hrs/wk                      | 3  |  |  |
| СР                          | 3  |  |  |
| Workload in Hours           | Independent Study Time 48, Study Time in Lecture 42    |  |  |
| Lecturer                    | Prof. Ralf Otterpohl                                   |  |  |
| Language                    | EN   |  |  |
| Cycle                       | WiSe   |  |  |
| Content                     |  |  |  |
| Literature                  |  |  |  |

| Module M1505: Adap                | tation to Climate Change in Hyd   | Iraulic Engineering (AKWAS)                          |                     |                  |
|-----------------------------------|---|--|---------------------|------------------|
| Courses                           |   |  |                     |                  |
| litle                             |   | Тур  | Hrs/wk              | СР               |
| daptation to climate change in hy | draulic engineering (L2291)   | Project-/problem-based Learning                      | 4                   | 6                |
| Module Responsible                | Prof. Peter Fröhle  |  |                     |                  |
| Admission Requirements            |   |  |                     |                  |
| Recommended Previous              |   |  |                     |                  |
| Knowledge                         | Hydrology, Hydraulic Engineering  |  |                     |                  |
|                                   | Hydromechanic, Hydraulics     Fundamentals of Constal Engineering (                     | Caratal and Fland Dustration                         |                     |                  |
|                                   | Fundamentals of Coastal Engineering, C     Underlogical Systems                         | Loastal- and Flood Protection                        |                     |                  |
|                                   | Hydrological Systems  |  |                     |                  |
| <b>Educational Objectives</b>     | After taking part successfully, students have r   | reached the following learning results               |                     |                  |
| <b>Professional Competence</b>    |   |  |                     |                  |
| Knowledge                         | Climate protection and climate adaptat  | ion  |                     |                  |
|                                   |   | jional characteristics - fundamentals, climate model | lling / climate r   | nodels           |
|                                   |   | ponents of the regional hydrological cycle           | iiiig / ciiiiidec i | nodels           |
|                                   | Fundamentals of analysis of climate data  |  |                     |                  |
|                                   | Consequences of the impact of the clim  |  |                     |                  |
|                                   | Measures for climate adaptation   |  |                     |                  |
|                                   | Assessment, prioritization and commun   | nication of adaptation measures                      |                     |                  |
|                                   | <ul> <li>Fundamentals of the analysis of hydron</li> </ul>                              | neteorological and hydrological data                 |                     |                  |
| Skills                            |   |  |                     |                  |
| Skiiis                            |   | and relations, assessment of needs for action        |                     |                  |
|                                   | <ul> <li>Creative thinking: development of adap</li> </ul>                              | otation strategies and adaptation measures           |                     |                  |
|                                   |   | tions, application of calculation approaches, meth   | nods, numerica      | ll models, plann |
|                                   | methods   |  |                     |                  |
|                                   | Consideration of complex tasks  |  |                     |                  |
| Personal Competence               |   |  |                     |                  |
| Social Competence                 |   |  |                     |                  |
|                                   | Working in heterogenous groups  | sisskifis dissistings                                |                     |                  |
|                                   | <ul> <li>Working with different scientific / non-se</li> <li>Self reflection</li> </ul> | cientific disciplines                                |                     |                  |
|                                   | • Self reflection   |  |                     |                  |
| Autonomy                          | Application oriented use of knowledge a   | and skills   |                     |                  |
|                                   | Autonomous work on complex tasks  | und skins  |                     |                  |
| Workload in Hours                 | Independent Study Time 124. Study Time in L   | ecture 56  |                     |                  |
| Credit points                     | ,   |  |                     |                  |
| Course achievement                |   |  |                     |                  |
| Examination                       |   |  |                     |                  |
| Examination duration and          | Preparation of a written report and a presenta  | ation of a complex task.                             |                     |                  |
| scale                             |   | ·  |                     |                  |
| Assignment for the                | Civil Engineering: Specialisation Coastal Engin   | neering: Elective Compulsory                         |                     |                  |
| Following Curricula               |   |  |                     |                  |
|                                   | Civil Engineering: Specialisation Structural Eng  | gineering: Elective Compulsory                       |                     |                  |
|                                   | Civil Engineering: Specialisation Water and Tra   | affic: Elective Compulsory                           |                     |                  |
|                                   | Water and Environmental Engineering: Specia   |  |                     |                  |
|                                   | Water and Environmental Engineering: Specia   |  |                     |                  |
|                                   | Water and Environmental Engineering: Specia   | llisation Water: Elective Compulsory                 |                     |                  |

| Course L2291: Adaptation to | climate change in hydraulic engineering  |
|-----------------------------|--|
| Тур                         | Project-/problem-based Learning  |
| Hrs/wk                      | 4  |
| СР                          | 6  |
| Workload in Hours           | Independent Study Time 124, Study Time in Lecture 56   |
| Lecturer                    | Prof. Peter Fröhle   |
| Language                    | DE   |
| Cycle                       | WiSe   |
| Content                     | <ul> <li>Climate protection and climate adaptation</li> <li>Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>Fundamentals of the analysis of climate data</li> <li>Concequences of the impacts of climate change (ingenieering science view)</li> <li>Measures for climate change adaptation</li> <li>Assessment, prioritization and communication of measures</li> <li>Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul> |
| Literature                  | Bereitgestellte eLearning Plattform  |

| Engineering                       |  |  |        |    |
|-----------------------------------|--|--|--------|----|
| Module M1717: Adva                | nced Vadose Zone Hydrology                   |  |        |    |
| Courses                           |  |  |        |    |
| Title                             |  | Тур  | Hrs/wk | СР |
| Modeling Processes in Vadose Zone | e (L2734)                                    | Lecture                                      | 1      | 1  |
| Modeling Processes in Vadose Zone | e (L2735)                                    | Recitation Section (small)                   | 1      | 1  |
| Vadose Zone Hydrology (L2732)     |  | Lecture                                      | 2      | 2  |
| Vadose Zone Hydrology (L2733)     |  | Recitation Section (large)                   | 2      | 2  |
| Module Responsible                | Prof. Nima Shokri                            |  |        |    |
| Admission Requirements            | None   |  |        |    |
| <b>Recommended Previous</b>       |  |  |        |    |
| Knowledge                         |  |  |        |    |
| <b>Educational Objectives</b>     | After taking part successfully, students hav | re reached the following learning results    |        |    |
| <b>Professional Competence</b>    |  |  |        |    |
| Knowledge                         |  |  |        |    |
| Skills                            |  |  |        |    |
| Personal Competence               |  |  |        |    |
| Social Competence                 |  |  |        |    |
| Autonomy                          |  |  |        |    |
| Workload in Hours                 | Independent Study Time 96, Study Time in     | Lecture 84                                   |        |    |
| Credit points                     | 6  |  |        |    |
| Course achievement                | None   |  |        |    |
| Examination                       | Written exam                                 |  |        |    |
| Examination duration and          | 90 min                                       |  |        |    |
| scale                             |  |  |        |    |
| Assignment for the                | Civil Engineering: Specialisation Water and  | Traffic: Elective Compulsory                 |        |    |
| Following Curricula               | Civil Engineering: Specialisation Water and  | Traffic: Elective Compulsory                 |        |    |
|                                   | Environmental Engineering: Specialisation    | Water: Elective Compulsory                   |        |    |
|                                   | Environmental Engineering: Specialisation    | Water: Elective Compulsory                   |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Water: Elective Compulsory       |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Environment: Elective Compulsory |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Cities: Elective Compulsory      |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Cities: Elective Compulsory      |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Environment: Elective Compulsory |        |    |
|                                   | Water and Environmental Engineering: Spe     | cialisation Water: Elective Compulsory       |        |    |

| Course L2734: Modeling Prod | ourse L2734: Modeling Processes in Vadose Zone      |  |
|-----------------------------|---|--|
| Тур                         | Lecture   |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Hannes Nevermann, Prof. Nima Shokri                 |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Course L2735: Modeling Prod | ourse L2735: Modeling Processes in Vadose Zone      |  |
|-----------------------------|---|--|
| Тур                         | Recitation Section (small)                          |  |
| Hrs/wk                      | 1   |  |
| СР                          | 1   |  |
| Workload in Hours           | Independent Study Time 16, Study Time in Lecture 14 |  |
| Lecturer                    | Hannes Nevermann                                    |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     | See interlocking course                             |  |
| Literature                  | See interlocking course                             |  |

| Course L2732: Vadose Zone | ourse L2732: Vadose Zone Hydrology                  |  |
|---------------------------|---|--|
| Тур                       | Lecture   |  |
| Hrs/wk                    | 2   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                  | Prof. Nima Shokri                                   |  |
| Language                  | EN  |  |
| Cycle                     | SoSe  |  |
| Content                   |   |  |
| Literature                |   |  |

| Course L2733: Vadose Zone | ourse L2733: Vadose Zone Hydrology                  |  |
|---------------------------|---|--|
| Тур                       | Recitation Section (large)                          |  |
| Hrs/wk                    | 2   |  |
| СР                        | 2   |  |
| Workload in Hours         | Independent Study Time 32, Study Time in Lecture 28 |  |
| Lecturer                  | Prof. Nima Shokri                                   |  |
| Language                  | EN  |  |
| Cycle                     | SoSe  |  |
| Content                   | See interlocking course                             |  |
| Literature                | See interlocking course                             |  |

| Module M1718: Multip               | phase Flow in Porous Media                          |                                       |        |    |
|------------------------------------|---|---------------------------------------|--------|----|
|                                    |   |                                       |        |    |
| Courses                            |   |                                       |        |    |
| Title                              |   | Тур                                   | Hrs/wk | СР |
| Advanced Modeling Techniques for   | Multiphase Flow in Porous Media (L2738)             | Recitation Section (small)            | 2      | 2  |
| Fundamentals of Multiphase Flow in | n Porous Media (L2736)                              | Lecture                               | 2      | 2  |
| Fundamentals of Multiphase Flow in | n Porous Media (L2737)                              | Recitation Section (large)            | 2      | 2  |
| Module Responsible                 | Prof. Nima Shokri                                   |                                       |        |    |
| Admission Requirements             | None  |                                       |        |    |
| <b>Recommended Previous</b>        |   |                                       |        |    |
| Knowledge                          |   |                                       |        |    |
| <b>Educational Objectives</b>      | After taking part successfully, students have reacl | hed the following learning results    |        |    |
| Professional Competence            |   |                                       |        |    |
| Knowledge                          |   |                                       |        |    |
| Skills                             |   |                                       |        |    |
| Personal Competence                |   |                                       |        |    |
| Social Competence                  |   |                                       |        |    |
| Autonomy                           |   |                                       |        |    |
| Workload in Hours                  | Independent Study Time 96, Study Time in Lecture 84 |                                       |        |    |
| Credit points                      | 6   |                                       |        |    |
| Course achievement                 | None  |                                       |        |    |
| Examination                        | Written exam  |                                       |        |    |
| Examination duration and           | 90 min  |                                       |        |    |
| scale                              |   |                                       |        |    |
| Assignment for the                 | Civil Engineering: Specialisation Water and Traffic | : Elective Compulsory                 |        |    |
| Following Curricula                | Civil Engineering: Specialisation Geotechnical Eng  | ineering: Elective Compulsory         |        |    |
| _                                  | Civil Engineering: Specialisation Geotechnical Eng  | ineering: Elective Compulsory         |        |    |
|                                    | Civil Engineering: Specialisation Water and Traffic | : Elective Compulsory                 |        |    |
|                                    | Environmental Engineering: Specialisation Water:    | Elective Compulsory                   |        |    |
|                                    | Environmental Engineering: Specialisation Water:    | Elective Compulsory                   |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | ion Cities: Elective Compulsory       |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | cion Cities: Elective Compulsory      |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | cion Environment: Elective Compulsory |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | ion Environment: Elective Compulsory  |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | ion Water: Elective Compulsory        |        |    |
|                                    | Water and Environmental Engineering: Specialisat    | ion Water: Elective Compulsory        |        |    |

| Course L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media |   |
|--|---|
| Тур  | Recitation Section (small)                          |
| Hrs/wk   | 2   |
| СР   | 2   |
| Workload in Hours  | Independent Study Time 32, Study Time in Lecture 28 |
| Lecturer   | Prof. Nima Shokri                                   |
| Language   | EN  |
| Cycle  | SoSe  |
| Content  |   |
| Literature   |   |

| Course L2736: Fundamentals | urse L2736: Fundamentals of Multiphase Flow in Porous Media |  |
|----------------------------|---|--|
| Тур                        | Lecture   |  |
| Hrs/wk                     | 2   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28         |  |
| Lecturer                   | Prof. Nima Shokri   |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    |   |  |
| Literature                 |   |  |

| Course L2737: Fundamentals | Course L2737: Fundamentals of Multiphase Flow in Porous Media |  |
|----------------------------|---|--|
| Тур                        | Recitation Section (large)                                    |  |
| Hrs/wk                     | 2   |  |
| СР                         | 2   |  |
| Workload in Hours          | Independent Study Time 32, Study Time in Lecture 28           |  |
| Lecturer                   | Hannes Nevermann  |  |
| Language                   | EN  |  |
| Cycle                      | SoSe  |  |
| Content                    | See interlocking course                                       |  |
| Literature                 | See interlocking course                                       |  |

| Module M1721: Water               | r and Environment: Theory and Applicati                         | on                              |        |    |
|-----------------------------------|---|---------------------------------|--------|----|
| Courses                           |   |                                 |        |    |
| Title                             |   | Тур                             | Hrs/wk | СР |
| Water and Environment: Applicatio | n and Field Work (L2754)  | Project-/problem-based Learning | 3      | 4  |
| Water and Environment: Theory (L2 | 2753)   | Lecture                         | 1      | 2  |
| Module Responsible                | Prof. Nima Shokri   |                                 |        |    |
| Admission Requirements            | None  |                                 |        |    |
| Recommended Previous              |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| <b>Educational Objectives</b>     | After taking part successfully, students have reached the fo    | llowing learning results        |        |    |
| Professional Competence           |   |                                 |        |    |
| Knowledge                         |   |                                 |        |    |
| Skills                            |   |                                 |        |    |
| Personal Competence               |   |                                 |        |    |
| Social Competence                 |   |                                 |        |    |
| Autonomy                          |   |                                 |        |    |
| Workload in Hours                 | Independent Study Time 124, Study Time in Lecture 56            |                                 |        |    |
| Credit points                     | 6   |                                 |        |    |
| Course achievement                | None  |                                 |        |    |
| Examination                       | Written elaboration   |                                 |        |    |
| Examination duration and          | Report (about 5-10 pages) and Presentation (about 15 min)       |                                 |        |    |
| scale                             |   |                                 |        |    |
| Assignment for the                | Civil Engineering: Specialisation Coastal Engineering: Election | ve Compulsory                   |        |    |
| Following Curricula               | Civil Engineering: Specialisation Water and Traffic: Elective   | Compulsory                      |        |    |
|                                   | Civil Engineering: Specialisation Coastal Engineering: Electi   | ve Compulsory                   |        |    |
|                                   | Civil Engineering: Specialisation Water and Traffic: Elective   | Compulsory                      |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective C     | Compulsory                      |        |    |
|                                   | Environmental Engineering: Specialisation Water: Elective C     | Compulsory                      |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities      |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Cities      | ' '                             |        |    |
|                                   | Water and Environmental Engineering: Specialisation Enviro      | , ,                             |        |    |
|                                   | Water and Environmental Engineering: Specialisation Enviro      |                                 |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water       | ' '                             |        |    |
|                                   | Water and Environmental Engineering: Specialisation Water       | r: Elective Compulsory          |        |    |

| Course L2754: Water and Environment: Application and Field Work |  |
|---|--|
| Тур   | Project-/problem-based Learning                          |
| Hrs/wk  | 3  |
| СР  | 4  |
| Workload in Hours   | Independent Study Time 78, Study Time in Lecture 42      |
| Lecturer  | Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni |
| Language  | EN   |
| Cycle   | SoSe   |
| Content   |  |
| Literature  |  |

| Course L2753: Water and Environment: Theory |   |
|---|---|
| Тур   | Lecture   |
| Hrs/wk                                      | 1   |
| СР  | 2   |
| Workload in Hours                           | Independent Study Time 46, Study Time in Lecture 14 |
| Lecturer                                    | Prof. Nima Shokri                                   |
| Language                                    | EN  |
| Cycle                                       | SoSe  |
| Content                                     |   |
| Literature                                  |   |

| Linginieering                                      |  |                                    |                  |                      |
|--|--|------------------------------------|------------------|----------------------|
| Module M1702: Proce                                | ess Imaging  |                                    |                  |                      |
| Courses  |  |                                    |                  |                      |
| Title  |  | Time                               | Hen hade         | CD                   |
|  |  | Typ<br>Lecture                     | Hrs/wk<br>2      | <b>CP</b><br>3       |
| Process Imaging (L2723)<br>Process Imaging (L2724) |  | Project-/problem-based Learning    | 2                | 3                    |
| Module Responsible                                 | Prof. Alexander Penn   | Troject /problem basea Learning    |                  |                      |
| Admission Requirements                             | None   |                                    |                  |                      |
| Recommended Previous                               | None   |                                    |                  |                      |
| Knowledge  |  |                                    |                  |                      |
|  | After taking part successfully students have reached the follow  | wing learning results              |                  |                      |
| Educational Objectives                             | After taking part successfully, students have reached the follow | wing learning results              |                  |                      |
| Professional Competence                            |  |                                    |                  |                      |
| Knowledge  |  |                                    |                  |                      |
| Skills   |  |                                    |                  |                      |
| Personal Competence                                |  |                                    |                  |                      |
| Social Competence                                  |  |                                    |                  |                      |
| Autonomy   |  |                                    |                  |                      |
| Workload in Hours                                  |  |                                    |                  |                      |
| Credit points                                      | 6  |                                    |                  |                      |
| Course achievement                                 | None   |                                    |                  |                      |
| Examination  | Written exam   |                                    |                  |                      |
| <b>Examination duration and</b>                    | 120 min  |                                    |                  |                      |
| scale  |  |                                    |                  |                      |
| Assignment for the                                 | Bioprocess Engineering: Specialisation A - General Bioprocess    | Engineering: Elective Compulsory   |                  |                      |
| Following Curricula                                | Bioprocess Engineering: Specialisation A - General Bioprocess    | Engineering: Elective Compulsory   |                  |                      |
|  | Bioprocess Engineering: Specialisation B - Industrial Bioprocess | s Engineering: Elective Compulsory | /                |                      |
|  | Bioprocess Engineering: Specialisation B - Industrial Bioprocess | s Engineering: Elective Compulsory | /                |                      |
|  | Bioprocess Engineering: Specialisation C - Bioeconomic Proce     | ess Engineering, Focus Energy and  | d Bioprocess 7   | Technology: Elective |
|  | Compulsory   |                                    |                  |                      |
|  | Bioprocess Engineering: Specialisation C - Bioeconomic Proce     | ess Engineering, Focus Energy and  | d Bioprocess T   | Technology: Elective |
|  | Compulsory   |                                    |                  |                      |
|  | Chemical and Bioprocess Engineering: Specialisation General F    | Process Engineering: Elective Comp | oulsory          |                      |
|  | Chemical and Bioprocess Engineering: Specialisation General F    | Process Engineering: Elective Comp | oulsory          |                      |
|  | Chemical and Bioprocess Engineering: Specialisation Bioproces    | ss Engineering: Elective Compulsor | У                |                      |
|  | Chemical and Bioprocess Engineering: Specialisation Bioproces    | ss Engineering: Elective Compulsor | У                |                      |
|  | Chemical and Bioprocess Engineering: Specialisation Chemical     | Process Engineering: Elective Con  | npulsory         |                      |
|  | Chemical and Bioprocess Engineering: Specialisation Chemical     | Process Engineering: Elective Con  | npulsory         |                      |
|  | Computer Science: Specialisation II: Intelligence Engineering: I | Elective Compulsory                |                  |                      |
|  | Information and Communication Systems: Specialisation Comr       | nunication Systems, Focus Signal F | rocessing: Ele   | ctive Compulsory     |
|  | International Management and Engineering: Specialisation II. F   | rocess Engineering and Biotechno   | logy: Elective ( | Compulsory           |
|  | Theoretical Mechanical Engineering: Specialisation Robotics ar   | nd Computer Science: Elective Com  | ıpulsory         |                      |
|  | Theoretical Mechanical Engineering: Specialisation Robotics ar   | nd Computer Science: Elective Com  | ıpulsory         |                      |
|  | Process Engineering: Specialisation Process Engineering: Elect   | ive Compulsory                     |                  |                      |
|  | Process Engineering: Specialisation Process Engineering: Elect   | ive Compulsory                     |                  |                      |
|  | Process Engineering: Specialisation Chemical Process Engineer    | ring: Elective Compulsory          |                  |                      |
|  | Process Engineering: Specialisation Chemical Process Engineer    | ring: Elective Compulsory          |                  |                      |
|  | Process Engineering: Specialisation Environmental Process Eng    | gineering: Elective Compulsory     |                  |                      |
|  | Process Engineering: Specialisation Environmental Process Eng    | gineering: Elective Compulsory     |                  |                      |
|  | Water and Environmental Engineering: Specialisation Environn     | nent: Elective Compulsory          |                  |                      |
|  | Water and Environmental Engineering: Specialisation Environn     | nent: Elective Compulsory          |                  |                      |
|  | Water and Environmental Engineering: Specialisation Water: E     | lective Compulsory                 |                  |                      |
|  | Water and Environmental Engineering: Specialisation Water: E     | lective Compulsory                 |                  |                      |

| Course L2723: Process Imagi | ourse L2723: Process Imaging                        |  |
|-----------------------------|---|--|
| Тур                         | Lecture   |  |
| Hrs/wk                      | 2   |  |
| СР                          | 3   |  |
| Workload in Hours           | Independent Study Time 62, Study Time in Lecture 28 |  |
| Lecturer                    | Prof. Alexander Penn                                |  |
| Language                    | EN  |  |
| Cycle                       | SoSe  |  |
| Content                     |   |  |
| Literature                  |   |  |

| Course L2724: Process Imaging |   |
|-------------------------------|---|
| Тур                           | Project-/problem-based Learning                     |
| Hrs/wk                        | 2   |
| СР                            | 3   |
| Workload in Hours             | Independent Study Time 62, Study Time in Lecture 28 |
| Lecturer                      | Prof. Alexander Penn, Dr. Stefan Benders            |
| Language                      | EN  |
| Cycle                         | SoSe  |
| Content                       |   |
| Literature                    |   |

| Module M1724: Smart Monitoring |  |            |        |    |
|--------------------------------|--|------------|--------|----|
| Courses                        |  |            |        |    |
| Title                          | Тур  |            | Hrs/wk | СР |
| Smart Monitoring (L2762)       | Integrated Lectu   | ire        | 2      | 2  |
| Smart Monitoring (L2763)       | Recitation Section   | on (small) | 2      | 4  |
| Module Responsible             | Prof. Kay Smarsly  |            |        |    |
| Admission Requirements         | None   |            |        |    |
| Recommended Previous           | Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in moder   |            |        |    |
| Knowledge                      | research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deeper skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.   |            |        |    |
| Educational Objectives         | s After taking part successfully, students have reached the following learning resul   | lts        |        |    |
| Professional Competence        |  |            |        |    |
| Knowledge                      | The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module. In small groups, the students will design smart monitoring systems that integrate a number of "intelligent" sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will "automatically" participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment. |            |        |    |
| Skills                         |  |            |        |    |
| Personal Competence            |  |            |        |    |
| Social Competence              |  |            |        |    |
| Autonomy                       |  |            |        |    |
| Workload in Hours              |  |            |        |    |
| Credit points                  |  |            | ·      |    |
| Course achievement             |  |            | ·      |    |
|                                |  |            |        |    |
| Examination                    |  |            |        |    |
| Examination duration and scale |  |            |        |    |
| Assignment for the             |  |            |        |    |
| Following Curricula            |  |            |        |    |
|                                | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |            |        |    |
|                                | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |            |        |    |
|                                | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory   |            |        |    |
|                                | Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory  |            |        |    |
|                                | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory  |            |        |    |
|                                | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory   |            |        |    |
|                                | Environmental Engineering: Specialisation Waste and Energy: Elective Compulso  | ory        |        |    |
|                                | Environmental Engineering: Specialisation Biotechnology: Elective Compulsory   |            |        |    |
|                                | Environmental Engineering: Specialisation Water: Elective Compulsory   |            |        |    |
|                                | Environmental Engineering: Specialisation Waste and Energy: Elective Compulso  | ry         |        |    |
|                                | Environmental Engineering: Specialisation Biotechnology: Elective Compulsory   |            |        |    |
|                                | Environmental Engineering: Specialisation Water: Elective Compulsory   |            |        |    |
|                                | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory  | /          |        |    |
|                                | Water and Environmental Engineering: Specialisation Cities: Elective Compulsory  | /          |        |    |
|                                | Water and Environmental Engineering: Specialisation Environment: Elective Com  | ipulsory   |        |    |
|                                | Water and Environmental Engineering: Specialisation Environment: Elective Com  | pulsory    |        |    |
|                                | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   | У          |        |    |
|                                | Water and Environmental Engineering: Specialisation Water: Elective Compulsory   | У          |        |    |

| Course L2762: Smart Monitoring |  |
|--------------------------------|--|
| Тур                            | Integrated Lecture   |
| Hrs/wk                         | 2  |
| СР                             | 2  |
| Workload in Hours              | Independent Study Time 32, Study Time in Lecture 28  |
| Lecturer                       | Prof. Kay Smarsly  |
| Language                       | EN   |
| Cycle                          | WiSe/SoSe  |
| Content                        | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| Literature                     |  |

| Course L2763: Smart Monitoring |  |  |
|--------------------------------|--|--|
| Тур                            | Recitation Section (small)   |  |
| Hrs/wk                         | 2  |  |
| СР                             | 4  |  |
| Workload in Hours              | Independent Study Time 92, Study Time in Lecture 28  |  |
| Lecturer                       | Prof. Kay Smarsly  |  |
| Language                       | EN   |  |
| Cycle                          | WiSe/SoSe  |  |
| Content                        | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the "Smart Monitoring" competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature. |  |
| Literature                     |  |  |

### Thesis

| urcoc                                      |   |
|--|---|
| urses                                      | T United. CD  |
| ile Madula Basnansible                     | Typ Hrs/wk CP   |
| Module Responsible  Admission Requirements | Professoren der TUHH  |
| Admission Requirements                     | According to General Regulations §21 (1):   |
|  | At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.   |
|  | The least to create points have to be defined an stady programme. The examinations bound decides on exceptions.   |
| Recommended Previous                       |   |
| Knowledge                                  |   |
| Educational Objectives                     | After taking part successfully, students have reached the following learning results  |
| Professional Competence  Knowledge         |   |
| Knowieuge                                  | • The students can use specialized knowledge (facts, theories, and methods) of their subject competently on speci-  |
|  | issues.   |
|  | The students can explain in depth the relevant approaches and terminologies in one or more areas of their su  |
|  | describing current developments and taking up a critical position on them.  • The students can place a research task in their subject area in its context and describe and critically assess the str  |
|  | research.   |
|  |   |
|  |   |
| Skills                                     | The students are able:  |
|  | . To colock apply and if necessary develop further methods that are suitable for solving the specialized problem in ave   |
|  | <ul> <li>To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in que:</li> <li>To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex a</li> </ul> |
|  | incompletely defined problems in a solution-oriented way.   |
|  | To develop new scientific findings in their subject area and subject them to a critical assessment.   |
|  |   |
| Personal Competence                        | Charles and   |
| Social Competence                          | Students can  |
|  | Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structure.   |
|  | way.  |
|  | Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addre   |
|  | while upholding their own assessments and viewpoints convincingly.  |
|  |   |
| Autonomy                                   | Students are able:  |
| ,  |   |
|  | To structure a project of their own in work packages and to work them off accordingly.  To work their own in death into a lower packages and to work them off accordingly.  |
|  | <ul> <li>To work their way in depth into a largely unknown subject and to access the information required for them to do so.</li> <li>To apply the techniques of scientific work comprehensively in research of their own.</li> </ul>                                 |
|  | To apply the techniques of scientific work complehensively in research of their own.  |
| Workload in Hours                          | Independent Study Time 900, Study Time in Lecture 0   |
| Credit points                              | 30  |
| Course achievement                         | None  |
| Examination                                | Thesis  |
| Examination duration and                   | According to General Regulations  |
| scale                                      | C. U.F. alternation Thereto Computers   |
| Assignment for the Following Curricula     | Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory  |
| Tollowing Curricula                        | Chemical and Bioprocess Engineering: Thesis: Compulsory   |
|  | Computer Science: Thesis: Compulsory  |
|  | Electrical Engineering: Thesis: Compulsory  |
|  | Energy and Environmental Engineering: Thesis: Compulsory  |
|  | Energy Systems: Thesis: Compulsory  |
|  | Environmental Engineering: Thesis: Compulsory   |
|  | Aircraft Systems Engineering: Thesis: Compulsory  |
|  | Global Innovation Management: Thesis: Compulsory  |
|  | Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory   |
|  | Interdisciplinary Mathematics: Thesis: Compulsory   |
|  | International Management and Engineering: Thesis: Compulsory  |
|  | Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory  |
|  | Logistics, Infrastructure and Mobility: Thesis: Compulsory  |
|  | i   |
|  | Materials Science: Thesis: Compulsory   |

| Engineering" |   |
|--------------|---|
|              | Mechatronics: Thesis: Compulsory  |
|              | Biomedical Engineering: Thesis: Compulsory                              |
|              | Microelectronics and Microsystems: Thesis: Compulsory                   |
|              | Product Development, Materials and Production: Thesis: Compulsory       |
|              | Renewable Energies: Thesis: Compulsory                                  |
|              | Naval Architecture and Ocean Engineering: Thesis: Compulsory            |
|              | Ship and Offshore Technology: Thesis: Compulsory                        |
|              | Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory               |
|              | Theoretical Mechanical Engineering: Thesis: Compulsory                  |
|              | Process Engineering: Thesis: Compulsory                                 |
|              | Water and Environmental Engineering: Thesis: Compulsory                 |
|              | Certification in Engineering & Advisory in Aviation: Thesis: Compulsory |