PhD School - Politecnico di Milano

Regulations of the PhD Programme in:

Environmental and Infrastructure Engineering

Cycle XL

1. General Information

PhD School - Politecnico di Milano

PhD Programme: **Environmental and Infrastructure Engineering**

Course start: 12 September 2024

Location of the PhD Programme: Milano Leonardo

Promoter Department: Department of Civil and Environmental Engineering (DICA)

Scientific Disciplinary Sectors

- ICAR/01 Hydraulics
- ICAR/02 Hydraulic and maritime constructions and Hydrology
- ICAR/03 Sanitary Environmental Engineering
- ICAR/04 Highways, railways and airports
- ICAR/06 Topography and Cartography
- GEO/05 Applied Geology

PhD School Website: **http://www.dottorato.polimi.it/en/**

PhD Programme Website:

https://www.dottorato.polimi.it/en/phd-programmes/engineering/environmental-and-infrastructure-engineering

Areas:
01 Water Science and Engineering - SSD ICAR/02 (Hydraulic and maritime constructions and Hydrology)
02 Transport Infrastructures and Geosciences - SSD ICAR/04 (Roads, railroads and airports) - SSD GEO/05 (Applied Geology)
03 Environmental and Hydraulic Engineering and Geomatics - SSD ICAR/03 (Sanitary Environmental Engineering) - SSD ICAR/01 (Hydraulics) - SSD ICAR/06 (Topography and Cartography)

2. General presentation

The PhD in Environmental and Infrastructure Engineering is designed to train young scientist and future professionals to address the scientific and technological challenges associated with environment and infrastructures. The program is characterized by a strong inter- and multi-sectorial structure and is organized according to the following three key thematic profiles: (i) Water Science and Engineering; (ii) Transport Infrastructures and Geosciences; (iii) Environmental and Hydraulic Engineering and Geomatics. Educational and research activities are designed to integrate (i) qualitative process identification, (ii) rigorous theoretical treatment and modelling according to increasing levels of complexity, (iii) design of ensuing applications and (iv) implications to engineering problems and scenarios. Training and research activities place PhD candidates within international networks (see also Section 8).

Area 01 - "Water Science and Engineering"
The main research activities of "Area 01" are centred on the field of water resources spanning from hydrology to coastal engineering. A short description of the main research branches is given in the following.

1. *Hydrology and water resources* addresses in-depth understanding of the physical processes of the hydrological cycle, which determine flood as well as drought phenomena and pollution migration. Measurement and modelling of variables active in water and energy budgets (radiation, evapotranspiration, snow mantle dynamics, hydrological losses) are carried out. In situ data as well as satellite data of the earth's surface are used to understand the processes and their representative scales. Continuous distributed water balance models are developed for simulating and monitoring flood as well as drought processes.
2. *Hydrogeological hazard and mitigation strategies* focuses on the analysis of hydrological extremes, frequency of floods, droughts and precipitation. Probabilistic and physically based models are used together with field observation to study and reproduce rainfall fields, floods and droughts. Early warning operative systems are developed for shallow land sliding, snow avalanching and flood risk.
3. *Hydraulic networks engineering* addresses the evaluation of design variables for urban sewage and aqueducts. In particular, aqueduct efficiency, water quality and quantity in drainage networks and effects of local and diffused structures for flood and pollution controls are investigated.
4. *Coastal engineering* addresses the hydrodynamics of wave motion, marine currents, littoral dynamics and wave-structure interactions..

Area 02 - "Transport Infrastructures and Geosciences"

The main research topics considered as fundamental for the development of research activities concerning transport infrastructures could be summed up in four main topics, reciprocally connected to the topics related to other PhD research profiles.

1. *Transport networks*. Complex transport network modelling (both homogeneous and non-homogeneous modal networks), also considering the functional interactions with regional, national and international territory.
2. *Sustainable development*. Analysis of the complex phenomenology characterizing the dynamics of development and its relations with the infrastructure system. Interaction between tunnels and underground hydraulic systems.
3. *Technological innovation*. Analysis of methods, criteria and indicators for the performance characterization of infrastructure construction and maintenance techniques.
4. *Risk management*. Analysis and development of improvement measures concerning both the construction and management of road infrastructures, aimed at reducing risk for both workers and users. Geological risk deriving from the construction of transportation infrastructures.
5. *Applied geology*. a) analysis of the hydrogeological risk linked to the underground excavation in rocks (e.g., water inflow, piezometric drawdown); b) landslide hazard (assessment of the influence of key hydrogeological parameters, such as permeability and heterogeneity coefficient, on slope instability); c) water resources identification and management, pollution problems, also in coastal aquifers.
6. *Methods. M*odelling and decision process analysis, at a strategic, tactical and operative level, characterizing road infrastructure design, construction and management (including Project Management, Pavement Management Systems, Bridge Management Systems).

Area 03 – "Environmental and Hydraulic Engineering and Geomatics"

Research in **Environmental Engineering** covers the following topics:

1. Water supply technology and treatment, wastewater treatment and reuse, liquid waste treatment, recovery of energy and products from wastewater, liquid waste and sludges,

advanced biological and physical-chemical water and wastewater treatment; sludge management and disposal; anaerobic biotechnologies.

2. Management and planning of environmental resources: source apportionment of pollutant loads and assessment of their effects on the receiving water bodies/environmental components; water quality modelling, scenario analysis and knowledge-based decision support systems of management alternatives.
3. Solid wastes and sludge minimization and management (composting the organic fraction of solid wastes, waste-to-energy plants, sanitary landfill, leachate treatment, hazardous waste solidification). Bioenergy from agricultural wastes and by-products.
4. Air quality assessment and control (statistical models of air quality data, source apportionment techniques, sampling and monitoring of fine and ultrafine atmospheric particles, emissions modelling for impact assessment), gaseous emissions treatment technologies (measurement/analysis of conventional and trace pollutant emissions at lab and field scale plants, evaluation of process techniques for pollutants removal).
5. Contaminated soil, sediment and groundwater: characterization, risk assessment, in-situ and on-site remediation technologies.

Research topics of **Hydraulic Engineering** include: fluid mechanics; fluid-structure interactions; hydraulic measurements; river hydraulics; hydraulic risk quantification and management; flow and transport processes in porous systems; hydraulic networks. Experimental, modeling and methodological aspects are considered. Key research areas include:

1. *Fluid mechanics*. Emphasis is devoted to the analysis of physical processes observed at various scales and their depiction in the context of appropriate interpretive models. Research and educational activities comprise analysis of advanced methodologies of computational and experimental fluid dynamics (e.g., image analysis techniques for hydraulic processes on multiple observational scales) and modeling of processes of fluid-structure interactions for environmental, civil and industrial engineering applications.
2. *River hydraulics and sediment mechanics*. The key research topics are associated with optimization of approaches and technologies for land protection. Research and educational activities include modeling of free surface flows, local and general scour processes, hyper-concentrated flows, flooding and hydraulic risk quantification and management.
3. *Flow and transport processes in porous systems*. Key research topics include: characterization of hydraulic properties from pore-scale to aquifer systems; well testing; inverse modeling / history matching / data assimilation; flow and multicomponent reactive transport process in heterogeneous media under uncertainty; multiphase flows, including oil and gas reservoir engineering; scaling of hydrogeological quantities; mixing processes in coastal aquifers; geothermal fluxes at the reservoir and basin scales. A major focus is the study of theoretical and operational bases for the assessment of hydro-geo-chemical processes governing the distribution and residence time of solutes and fluids in the subsurface. Critical applications include quantification of environmental risk associated with polluted aquifer systems and the improvement of enhanced oil recovery approaches.

Geomatics includes all disciplines dealing with positioning, global and local reference system establishment, surface surveying and reconstruction from a global scale down to the scale of the individual architectural manufact, representing data by graphical or virtual tools, archiving and cross-referencing spatial information in terms of geographic information systems. Summarizing, we can identify the following education and research topics:

1. *Physical geodesy and satellite geodesy*, including estimation and representation of the

gravity field at all scales and its geophysical interpretation.
2. *Positioning, deformation estimation and navigation*, with the use of both classical and satellite techniques, such as GPS.
3. *Surface surveying with optical or other sensors*, such as SAR, LIDAR, etc., at different scales from regional down to the manufact scale.
4. *Digital photogrammetry and image analysis*, including the development of photogrammetric software for the geometrical reconstruction of surfaces and feature extraction.
5. *Remote sensing*, namely the problem of identifying, by suitable spectral analysis, specific geographic information.
6. *Geographic information systems*, with application of the most modern technology for internet GIS and mobile GIS.
7. *Cultural heritage reconstruction and archiving*, with the solution of complex problems of combination of different data into a unique data base, providing three-dimensional virtual models that preserve full geometrical and metrical information.

The PhD Programme is run by a Coordinator (see Attachment A1) and a Faculty Board (see Attachment A2). The Coordinator chairs the Faculty Board, coordinates the preparation of the annual Educational Programme and organises the general educational activities of the PhD course. The Faculty Board is responsible for the Educational programme and for teaching and administrative activities related to the PhD course.

3. Objectives

The PhD Programme is structured according to the three areas illustrated in Section 2. The PhD degree is awarded upon completion of at least three years of advanced study and research. Within these years, a minimum of 25 credits must be acquired through *PhD level courses* (see Section 6). These courses provide the knowledge required as a basis for the general framework illustrated in the PhD Programme and provide the common knowledge background to PhD candidates. Research training is provided through mentoring by the Faculty members. PhD courses will leverage on the long-standing experience and know-how in laboratory activities of the academic board members (see Section 7) as well as of PoliMI-DICA international networks. Contacts with bodies other than Universities have been established through participation to specialized seminars and refresher courses provided by experts from industry, together with short training internships for PhD candidates at highly qualified companies.

Main elements of the programme include: (*a*) an improved preparation of candidates at the fundamental level, as required by the PhD School, with the introduction of new opportunities for candidate evaluation through written exercises and/or oral examinations, and (*b*) development of close ties with stakeholders to foster the emergence of outstanding professional skills attractive to industry.

The key activity of the entire PhD Programme is the development of the thesis/dissertation. This phase should reflect the leading and unconditioned role of research and is fully in line with the requirements and needs of authorities, public bodies and private companies. A research experience at International Research Centres and/or Universities is considered to be highly relevant for PhD candidates to complete their education and to exchange research experience and expertise.

4. Professional opportunities and job market

PhD students will be skilled in an interdisciplinary and multi-sectoral environment and will gain excellent communication, management and research skills. They will acquire a set of skills and a knowledge base that are transferable to a range of real-world ecosystem services-related problems. A PhD in Environmental and Infrastructure Engineering provides highly qualified personnel to cover key positions and roles in research centres, top level management in Public Bodies and Authorities involved in environmental policies, as well as senior consultants for engineering companies within European and international markets.

5. Enrolment

5.1 Admission requirements

Italian and International citizens can apply. They are requested to have graduated in accordance with the pre-existing laws D.M. 3.11.1999 n. 509, or to have a Master of Science degree in accordance with D.M. 3.11.1999 n. 509, or a Master of Science in accordance with D.M. 22.10.2004 n. 270, or similar academic title obtained abroad, equivalent for duration and content to the Italian title, with an overall duration of university studies of at least five years. The certified knowledge of the English language is a requirement for admission. Please refer to the PhD School website for details.

The admission to the programs will be established according to the evaluation of the candidates' curricula, motivation letters, and an illustrative report about the development of a possible PhD research, which candidates will send contextually with their application to the admission announcement.

5.2 Admission deadlines and number of vacancies

The number of positions is indicated in the Call for admission to the 40th PhD cycle Programmes available at
https://www.dottorato.polimi.it/en/prospective-phd-candidates/calls-and-regulations
Scholarships are available on both general and specific topics, as described in the call.

6. Contents

6.1 Requirements for the PhD title achievement

The achievement of the PhD title in Environmental and Infrastructure Engineering requires a study and research activity of at least three years equivalent of full-time study, research and development of PhD thesis.

PhD candidates in Environmental and Infrastructure Engineering must earn a minimum of 25 credits from courses (see paragraph 6.3), and continuously conduct studies and research. The Faculty Board may assign extra course credits to be achieved in case it is necessary to complete preparation in specific topics relevant to research projects.

At the beginning of the PhD activities, the Faculty Board assigns a tutor and a Supervisor to each

PhD candidate to supervise and assist him/her in the overall training programme. The tutor shall be a professor belonging to the Faculty Board. The tutors assist the candidates in the choice of courses to be included in the study plan, which is submitted for approval to the Coordinator of the PhD Programme (see also section 6.4). The doctoral activity is carried out under the guidance of a Supervisor, responsible for candidate's research activity, study plan and thesis development. The Supervisor can belong to an institution other than Politecnico di Milano and can be supported by one or more co-supervisors.

6.2 Research development

The main aim of all Politecnico di Milano PhD programmes is the development in the candidates of a research-oriented mind-set, with expertise and skills in a specific research topic. To this end, candidates develop a problem-solving capability in complex contexts, including the capacity of performing deep problem analysis, identifying original solutions, and evaluating their applicability in practical contexts. These skills provide the PhD candidates with major opportunities of development in their research both in the academic field, and in public and private organisations.
PhD candidates are requested to develop an original research contribution. The PhD thesis must thus contribute to increase the knowledge in the candidate's research field. Besides, it has to be coherent with the research topics developed in the Department where the PhD Programme is carried out.

The original research results are collected in the PhD thesis, where the candidate's contribution is put in perspective with respect to the research state of the art in the specific research field. The PhD research is developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities related to the thesis development. The supervisor is not necessarily a member of the Faculty Board and may also belong to an institution different from Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

Further activities intended to develop the candidate's personal skills and research expertise are encouraged during the PhD path. Candidates must acquire the capability to present and discuss their work in their research community. Consequently, both the participation to international conferences and the publication of the research results in peer-reviewed journals are encouraged.

The PhD programme favours the candidates' research interactions with other groups in their research field, preferably abroad. Research visits of at least three months are strongly encouraged, as through them the candidates may acquire further skills to develop their research work and thesis. The duration of the programme is normally three years.

6.3 Objectives and general framework of the teaching activities

The PhD Programmes and the PhD School activate teaching forms of different kind and credit value, including courses, seminars, project workshops, laboratories. Teaching activities both cover the basic research issues (problems, theories, methods), which represent the founding element of the PhD Programme and clearly identify its cultural position and deepen in a specialist way some research issues connected with the problems developed in the theses. Lessons are usually held in English, except when indicated otherwise. The PhD programme includes at least one complete path delivered in English.

The PhD School of Politecnico di Milano proposes a set of courses aiming to train the PhD candidates in soft and transferable skills. The skills and abilities provided by these courses are expected to help candidates across different areas of their careers in order to respond to the rapidly evolving needs of the global economy and society at large. The PhD School courses activated for the 2024-2025

Academic Year are summarized in table B. At least 10 (of the 25) credits from courses that each candidate is required to earn shall be obtained through soft and transferable skills courses organized by the PhD School.

The didactic structure is reported in the tables below, which summarize the candidate's path (as regards coursework activities). At the same time, the programme foresees that the candidates are devoted to research activity in a continuous way, following the lead of their supervisors, and of the Faculty Board. Evaluation procedures for each course are described in the "Manifesto".

First and Second year

Courses	**ETCS (min-max)**
PhD School Courses (see Table B)	10 - 15
Courses characterising the PhD Programme (see Table A)	10 - 20
Other PhD courses and international Summer/WinterSchools (see Table C)	0 - 10

Third year

In the third year the candidate should be devoted entirely to the research and to the development of the PhD thesis.

PhD Course List

A) The PhD Programme in Environmental and Infrastructure Engineering organises the **Characterising Courses** listed in table A. For the admission to the final exam the acquisition of **at least 10 credits** in this list is **mandatory**.

B) The PhD School organises every year general and Inter-doctoral courses. The acquisition of **at least 10 credits** is **mandatory** among the courses of B type. The list of PhD courses organized by the PhD School is also available at the website:

https://www11.ceda.polimi.it/manifestidott/manifestidott/controller/MainPublic.do?check_params=1&k_corso_la=1300&lang=EN&polij_device_category=DESKTOP&__pj0=0&__pj1=890417f7eed83670a89b5545559aa65a

C) Other PhD courses. A maximum of 10 mandatory credits can be obtained by choosing among courses provided by other PhD programmes at Politecnico di Milano and/or external Institutions (in this case the previous approval of the tutor and the PhD Coordinator is mandatory).

SPECIALISTIC COURSES, LONG-TRAINING SEMINARS

The attendance of Specialist Courses, Workshops, Schools, Seminars cycles is strongly encouraged and (if these seminars, workshops are certified and evaluated) may permit to acquire credits according to the modalities established by the Faculty Board and previous approval of the study plan submitted by the candidate. These courses and workshops can also be included in the study plan, even if they are not evaluated (and therefore not qualified as credits), as optional "additional teaching". The planned schedule of characterizing courses for the academic year 2024-2025 and 2025-2026 is as follows. All courses are taught in English. Other courses may be activated during the year. In this case the candidates will be promptly informed and will be allowed to insert these new courses in their study plan.

Table A: PHD COURSES CHARACTERISING THE PHD PROGRAMME

SSD	Course name	Professor	A.Y./Semester	ETCS
ICAR/06	Monte Carlo-Markov chains statistical methods	G. VENUTI; M. REGUZZONI	Alternate years	5
ICAR/02	Modelling Extremes and Dependence in Multivariate Problems	C. DE MICHELE; G. SALVADORI; F. DURANTE	Every year	5
ICAR/06	Statistical and numerical methods	R. BARZAGHI; G. VENUTI	Every year	5
ICAR/01	Fluid mechanics	G.V. MESSA	Alternate years	5
ICAR/01	Groundwater- Modeling under uncertainty	A. GUADAGNINI; M. RIVA	Alternate years	5
ICAR/01; ICAR/07	Granular Matter: from packing to flow	D. BERZI; C. DI PRISCO	Alternate years	5
ICAR/01	Particle-laden flows: theory and engineering applications	G.V. MESSA; M. MALAVASI	Alternate years	5
ICAR/02	Probabilistic modeling of sustainable urban drainage systems	A. RAIMONDI	Every year	5
ICAR/02	Sustainable Water and Food Security	M.C. RULLI	Every year	5
ICAR/02	Mountain hydrology and climate change	D. BOCCHIOLA	Every year	5
ICAR/02	Sea Waves and Hydropower	A. BIANCHI; G. PASSONI	Every year	5
ICAR/02	Remote Sensing and its Applications in Cryospheric Sciences	C. DE MICHELE; A.N. ARSLAN	Every year	5
ICAR/03	Advanced techniques for (bio)chemical reactor modelling	A. TUROLLA	Alternate years	5
ICAR/03	Statistics applied to Environmental Engineering	A. AZZELLINO	Every year	5
ICAR/04	Road material performances characterization	E. TORALDO	Alternate years	5
ICAR/06	Satellite Positioning	C. DE GAETANI	Alternate years	5
ICAR/06	Advanced Geographycal Information Systems	D. CARRION	Alternate years	5
ICAR/06	Photogrammetry and Image Analysis	L. PINTO; V. CASELLA	Alternate years	5
ICAR/06	Satellite geodesy	F. MIGLIACCIO	Alternate years	5
ICAR/06	DTM generation	R. BARZAGHI	Alternate years	5

Note: for courses with “Alternate years”, please refer to the “Manifesto” of each Academic Year (**https://www11.ceda.polimi.it/manifestidott/manifestidott/controller/MainPublic.do?check_params=1&k_corso_la=1378&lang=IT&polij_device_category=DESKTOP&__pj0=0&__pj1=bbe419be3f5dbb191dacee2542907a2b**).

Table B SUGGESTED CROSS –SECTORAL COURSES

Professor	Course Name	ECTS
ALIVERTI ANDREA	ETHICS IN RESEARCH	5
ARMONDI SIMONETTA	STRENGTHENING CRITICAL SPATIAL THINKING	5
ARNABOLDI MICHELA	ADVANCED INTERACTION SKILLS FOR ACADEMIC PROFESSIONALS	5
BISCARI PAOLO	INDUSTRIAL SKILLS	5
BISCARI PAOLO	ENGLISH FOR ACADEMIC COMMUNICATION	5
BISCARI PAOLO	SCIENTIFIC COMMUNICATION IN ENGLISH	5
BISCARI PAOLO	RESEARCH SKILLS	5
BOBADILLA RODRIGUEZ HERNAN FELIPE	SCIENTIFIC MODELS: CONCEPTUAL FOUNDATIONS AND PHILOSOPHICAL ISSUES	5
BOERI ELISA	RECORDING WORK 4 BUILDING MEMORY: METHODS, PRACTICES, TOOLS, SKILLS TO MANAGE THE KNOWLEDGE	5
BROVELLI MARIA ANTONIA	THE COPERNICUS GREEN REVOLUTION FOR SUSTAINABLE DEVELOPMENT	5
BRUNETTO DOMENICO SAVIO	INNOVATIVE TEACHING SKILLS	5
CANINA MARIA RITA	CREATIVE DESIGN THINKING	5
CARDILLI LORENZO	EUROPEAN CULTURE	5
COLOMBO GABRIELE	RESEARCH COMMUNICATION. ISSUE MAPPING: EXPLORING PUBLIC DEBATES SURROUNDING ACADEMIC TOPICS	5
CONCI CLAUDIO	COMMUNICATION STRATEGIES THAT SCORE IN WORLDWIDE ACADEMIA	5
DI BLAS NICOLETTA	PROFESSIONAL COMMUNICATION	5
FUGGETTA ALFONSO	PROJECT MANAGEMENT BASICS	5
HESSELBEIN CHRISTOPHER LORENZ	TECHNOLOGY AND SOCIETY	5
IAROSSI MARIA POMPEIANA	POWER OF IMAGES AND VISUAL COMMUNICATION FOR RESEARCH DISSEMINATION	5
LAVAGNA MONICA	SUSTAINABILITY METRICS, LIFE CYCLE ASSESSMENT AND ENVIRONMENTAL FOOTPRINT	5
MANCINI MAURO	PROJECT MANAGEMENT (IN ACTION)	5
MASARATI PIERANGELO	ETHICAL ASPECTS OF RESEARCH ON DUAL USE TECHNOLOGIES	5
OPPIO ALESSANDRA	HOW TO SUPPORT COMPLEX DECISIONS: APPROACHES AND TOOLS	5
OSSI PAOLO MARIA	SULLA RESPONSABILITÀ DELLA TECNICA	5
PAGANONI ANNA MARIA	LA COMUNICAZIONE NELLA SCIENZA	5
PARMEGGIANI FABIO	SCIENCE, TECHNOLOGY, SOCIETY AND WIKIPEDIA	5
PIZZOCARO SILVIA LUISA	PRACTICING RESEARCH COLLABORATION	5
ROCCHI DANIELE	ETHICS OF ARTIFICIAL INTELLIGENCE	5

SANCASSANI SUSANNA	TEACHING METHODOLOGIES, STRATEGIES AND STYLES	5
SHENDRIKOVA DIANA	SCIENCE DIPLOMACY FOR RESEARCHERS. FILLING THE GAP BETWEEN SCIENCE AND POLICY WITHIN THE GLOBAL CHALLENGES	5
VOLONTE PAOLO GAETANO	INTRODUCTION TO ACADEMIC RESEARCH	5
VOLONTE PAOLO GAETANO	TECHNOLOGY AND INEQUALITY	5

Table C OTHER PhD COURSES

Course name
All doctoral courses offered by all the PhD programmes of the Politecnico di Milano and/or by other Institutions can be selected

6.4 PhD Agreement

During the first year of the doctoral program, the PhD candidates must sign a PhD Agreement with their Supervisor and tutor, according to the "Doctoral Agreement Manual" attached to the University PhD Regulations.

6.5 Presentation of the study plan

PhD candidates must submit a study plan, which may be revised periodically (approximately every three months), in order to adequate it to possible changes in the course list, or to needs motivated by the development of their PhD career. The study plans must be approved by the PhD programme Coordinator, according to the modalities established by the Faculty Board of the PhD Programme itself.

6.6 Yearly evaluations

Candidates present their work to the Faculty Board at least once a year. The candidates must pass an annual evaluation in order to be admitted to the following PhD year. The third-year evaluation establishes the candidate's admission to the final PhD defence.
As a result of each annual evaluation, the candidates passing the exam receive an evaluation (A/B/C/D) and may proceed with the enrolment at the following year. Candidates who do not pass the exam are qualified either as “Repeating candidate” (Er) or “not able to carry on with the PhD” (Ei). In the former case (Er), the candidates are allowed to repeat the PhD year at most once. The PhD scholarships – if any – are suspended during the repetition year. In the latter case (Ei) the candidates are excluded from the PhD programme and lose their scholarships – if any.
After the final year, candidates who have achieved sufficient results, but need more time to conclude their research work and write their theses, may obtain the admission to a further year.

6.7 PhD thesis preparation and final exam

The main objective of the PhD career is the development of an original research contribute. The PhD thesis is expected to contribute to the advance of the knowledge in the candidate's research field.
The PhD study and research work are carried out, full time, during the three years of the PhD course. Stages or study periods in National or International companies or external Institutions may complete

the candidate's preparation. The resulting theses need to be coherent with the research issues developed in the Department where the PhD programme is developed. The candidate must present an original thesis, discuss its contribution to the state of the art in the research field.

The PhD research is developed following the lead of a supervisor, who supports the candidate in the setting out and in the everyday activities regarding the thesis development. At the conclusion of the PhD studies, the Faculty Board evaluates the candidates. Candidates who receive a positive evaluation submit their theses to two external reviewers for refereeing. If the evaluation provided by the reviewers is positive (or after the revisions required by the external reviewers), the candidates defend their thesis in a final exam, in front of a Committee composed of three members (at least two of which must be external experts).

Candidates will be asked to demonstrate knowledge of the Italian language, equal to at least A1 level of the Common European Framework of Reference for the knowledge of languages. This requirement will be needed in order to register for the final exam. Italian native speakers and all those who can demonstrate knowledge of the Italian language to the required level will be exempt.

7. Laboratories, PhD Secretariat Services

Laboratory Gaudenzio Fantoli

Established in 1939, it hosts activities related to Hydraulic Engineering and Water Science Engineering. It comprises areas devoted to research and educational activities. Two main floors, each covering an area of about 800 m^2, are currently devoted to laboratory activities. The Lab staff comprises 4 people. Major hydraulic facilities include:

- *Free surface flume*: a 30 m 1.0 m 0.6 m flume with adjustable floor and glass sides, a fixed floor flume with glass sides. It is provided with the tools to convert the structure into a wave flume (piston wavemaker, artificial beach, wave gauges).
- *Hydraulic channel:* a 6 m × 0.5 m × 0.5 m free surface flume designed for studying fluid-structure interaction by means of direct measurement of forces, stress distributions, displacements and velocity distributions. Image analysis techniques are employed for kinematic measurements.
- *Test plant for flow resistances*: a water flow loop, provided with flowmeter and pressure transmitters, dedicated to measure the loss coefficient and other characteristics of regulation devices (including, *e.g.* valves, resistors, connectors). The plant is also equipped with high pressure pumps.
- *Transparent pressurized duct*: specifically built for sediment transport and scour experiments with image processing measurements. The duct length is 5.8 m with a cross section 40 cm wide and 16 cm deep. In the central part of the duct is a recess section with a length of 2 m and depth of 0.5 m. The hydraulic head in the duct is imposed by a Bazin weir located in the downstream tank; the upstream tank is provided with a streamlined inlet to avoid wakes in the flow.
- *Dam-break flume*: used to investigate the dam-break wave (unsteady flow) of a hyperconcentrated mixture of water and cohesionless granular matter. It consists of a 6 m long, square section (0.5 x 0.5 m) flume of adjustable slope. Failure of the dam is simulated by means of a pneumatic rising sluice-gate (opening time t = 0.3 s). One of the side walls of the flume is made of glass in order to record of wave propagation by means of a digital camera.
- *Rotating drum*: this device is used to investigate the behavior of a steady dry granular flow over a loose bed. It consists of a cylinder (inner diameter D = 1 m and axial length W = 250

mm) half-filled with granular material, which is mounted on a pair of friction rollers and rotates around its axis at a constant angular velocity. One of the endplates of the cylinder is made of 10 mm thick glass to allow optical measurement of the flow fields through a progressive CCD scan camera.

Other site facilities include: a series of calibrated basins with a total capacity of 50 m^3, a computer centre, an electronics workshop for construction and repair of instrumentation; a mechanical workshop for the construction of experimental facilities, laboratory instrumentation for measuring most hydraulic parameters (including an automated system to detect and measure river-bed shapes), and field instrumentation to measure hydrodynamic processes. The Lab has been certified within the SQA (Quality Assurance Protocol of the Politecnico) within the context of hydraulic parameter measurements, determination of characteristic curves of hydraulic machinery and field and laboratory scale flow rate determination. The laboratory is a SIT certified Calibration Centre for measurement of liquid flow rates (range: 3-80 l/s). Finally, a total free area of 600 m^2 is available for set-up of hydraulic models. The area is served by an overhead traveling crane of 1500 kg_p and by a piping system allowing a maximum flow rate of about 600 l/s.

Laboratory of Environmental Engineering (LIA – Laboratorio di Ingegneria Ambientale)
It hosts activities related to Environmental Technologies. It currently covers 580 m^2 and is divided into two sections: the analytical section with different working areas (wet chemistry, sample preparation, analytical instrumentation, and biology) and the pilot-plant section. The Laboratory staff comprises 3 permanent staff (2 graduates) and one temporary position (graduate). The main activities of Laboratory are: (a) sampling and determination of pollutants in different environmental matrices (water, air, soil, sludge, solid waste); (b) evaluation of remedial technologies with laboratory pilot plants; (c) planning and management of demonstrative wastewater treatment pilot plant; (d) tests of biodegradation and treatability of wastewaters by means of titration/respirometric sensors an BMP (biomethane potential); (e) tests for the characterization of sludge and digestates with CST (capillary suction time), filtration apparatus and a zetameter. Analytical instrumentation includes: electrometry, nephelometry, molecular absorption spectrophotometry, atomic absorption spectrometry, liquid chromatography (ionic and HPLC), gas-chromatography, X-ray spectrometry, polarography, voltammetry, TOC analyser, ion-coupled plasma mass Spectrometry (ICP-MS). The Laboratory is also equipped with instrumentation for sampling of liquid, solid and gaseous pollutants.
The pilot plant section is equipped with: aerobic and anaerobic instrumented bioreactors for activated sludge and fixed biomass processes, membrane bioreactors, batch reactors for contaminated soil remediation, reactors for chemical oxidation and water disinfection, biosensors for the study of microbial activity. Experimental activity through pilot-plants is frequently carried out at public institutions and private firms.

Research Laboratory on Transportation Infrastructures (InfraLab)
The Research Laboratory on Transportation Infrastructures (InfraLab) is nowadays a European leading laboratory for both university education and experimental scientific research. Regarding education activities, InfraLab, recently renewed, is equipped by a teaching room, offering to the candidates the possibility of performing several standard tests on construction materials. From the experimental research point of view, the activities of InfraLab are mainly focused on the study of new materials, methods and technologies for construction and maintenance of transportation infrastructures, at different scales, including both laboratory tests, and real scale assessments by on-site test tracks, thanks to an experimental area of 50.000 m^2 located in Carpiano (Mi). Quality

controls of materials and pavements during construction and in-service infrastructures' monitoring are two other key activities of the Laboratory. InfraLab is equipped by a set of machines and apparatus for materials' characterization according to European and US standards, also including specific and performance-related tests. In this view, the Laboratory also designs and develops in-house test equipment, up to the prototype level, both independently and in collaboration with companies. Moreover, InfraLab is able to assist authorities and enterprises during the development, design, construction and maintenance of transportation infrastructures.

Laboratory of Geomatics
The recent development of the subject has fostered activities in new fields of advanced research such as spatial geodesy, navigation, photogrammetry, remote sensing, numerical cartography, Geographic Information Systems (GIS), as well as a return to the field of geophysics. These studies are conducted by the Department with the support of structures such as:
- the International Service for the Geoid, which can be considered as an IT laboratory for the gravity field
- the laboratory of Geomatics, which is partly instrumental and partly IT.

The main instruments, software and activities conducted in the laboratory are illustrated in the following.
Surveying and monitoring: GPS instruments (geodetic and low-cost receivers); Total stations and levelling instruments; UAV; measurements to monitor ground, buildings and structures; photogrammetric surveying of architectural manufacts; thematic mapping; infrastructure land registry.
Data management and interpretation: Gravimetric data interpretation; geoid determination; spatial mission analysis; GPS permanent network analysis; Statistical methods in surveying and monitoring; integration of images and maps; management of GIS data bases; evaluation of uncertainty and reliability.

Additional details are available at:
https://www.dica.polimi.it/research/research-laboratories/?lang=en
https://www.dica.polimi.it/research/interdepartmental-laboratories/?lang=en

PhD Secretariat Services

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8. Internationalisation and intersectoriality

Carrying out study and research activities at external laboratories is strongly recommended. Politecnico di Milano supports joint PhD paths with International Institutions, as well as Joint and Double PhD programmes. Further information is available on the PhD School website and on the PhD programme website. Some agreements and collaborations with international institutions are currently active for the PhD programme in Environmental and Infrastructure Engineering, as summarized below.

- Pontificia Universidad Católica De Chile (Chile) (PhD Double Degree Agreement)

- University of Lausanne (Switzerland) (PhD Double Degree Agreement)
- The University of Arizona (USA) (Research collaboration)
- Imperial College London (UK) (Research collaboration)
- ETH Zurich (Switzerland) (Research collaboration)
- TU Delft (The Netherlands) (Research collaboration)
- Universitat Politecnica de Catalunya – Barcelonatech (Spain) (Research collaboration).

Interaction with and exposure to non-academic sectors provides significant benefits to doctoral candidates as well as to research and innovation intensive employment sectors. Direct exposure to the challenges and opportunities in non-academic sectors of the economy and society at large is fostered by networking, connectivity, inter-sectorial mobility and wide access to knowledge. In particular, the PhD programme in Environmental and Infrastructure Engineering collaborates with the following Research Agencies and/or Industrial partners:

- A2A Life Company (Research collaboration and scholarship funding)
- Acque Bresciane (Research collaboration and scholarship funding)
- Agenzia Spaziale Italiana (Italian Space Agency) (Research collaboration and scholarship funding)
- Appflue s.r.l. (Research collaboration and scholarship funding)
- Arianet s.r.l. (Research collaboration and scholarship funding)
- Autorità di bacino distrettuale del fiume Po (Research collaboration and scholarship funding)
- Banca d'Italia (Research collaboration and scholarship funding)
- Bracco Imaging S.p.A. (Research collaboration and scholarship funding)
- EBWorld (Research collaboration and scholarship funding)
- ENEL Foundation (Research collaboration and scholarship funding)
- ENI (Research collaboration)
- ERSAF – Ente Regionale Servizi all'Agricoltura e alle Foreste (Research collaboration and scholarship funding)
- European Space Agency (Research collaboration and scholarship funding)
- Geolog Technologies srl (Research collaboration and scholarship funding)
- Gruppo CAP (Research collaboration and scholarship funding)
- Lario Reti Holding (Research collaboration and scholarship funding)
- Metropolitana Milanese S.p.A. (Research collaboration)
- Pibiviesse s.r.l. (Research collaboration and scholarship funding)
- Piksel s.r.l. (Research collaboration and scholarship funding)
- Rea Dalmine S.p.A. (Research collaboration and scholarship funding)
- Regione Lombardia (Research collaboration and scholarship funding)
- RSE S.p.A. – Ricerche sul Sistema Energetico (Research collaboration and scholarship funding)
- Tecne SpA (Research collaboration and scholarship funding)
- Water Alliance, Acque di Lombardia (Research collaboration)

Attachment A1 – PhD Programme Coordinator

Prof. Monica Riva - Short CV (2 pages)

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Dipartimento di Ingegneria Civile e Ambientale (DICA)
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Piazza L. Da Vinci, 32 - 20133 Milano (Italy)

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e-mail: monica.riva@polimi.it

Born. December 13th, 1970, Lecco (Italy)

Education. Graduated in Civil Engineering (hydraulics), Polimi (1996). Doctoral Degree in Hydraulic Engineering, Polimi (2000).

ACADEMIC RECORD

2015 –: Professor at the Dept. of Civil and Environmental Engineering (DICA) of Politecnico di Milano (PoliMi)

2013–: Adjunct Professor, Dept. of Hydrology and Water Resources, The University of Arizona, Tucson, Arizona, USA.

2013 – 2015: Associate Professor, Dept. of Civil and Environmental Engineering (DICA), PoliMi.

2011 – 2013: Associate Professor, Dept. of Environmental, Hydraulic, Infrastructures and Surveying Engineering (DIIAR), PoliMi.

2002 – 2010: Assistant Professor, DIIAR, PoliMi.

2013, 2014: Professeur Invité at the University of Strasbourg, France.

2011, 2012: Visiting Professor at the Dept. of Hydrology and Water Resources, The University of Arizona, Tucson, Arizona, USA.

2008: Visiting Scientist at the CNRS/INSU, Poitiers (France). Program: HTHS, Hydrodynamic and Transfers in Hydrogeological Systems, EC2CO/MACH-1: Modeling of Heterogeneous Carbonate Aquifers.

1999, 2006: Visiting Scientist at Dept. of Hydrology and Water Resources, The University of Arizona, Tucson, Arizona, USA.

1999 – 2002: Assistant Researcher, DIIAR, PoliMi.

INSTITUTIONAL ACTIVITIES. Rector Delegate for International Networks (since 2020). Chair of the Advisory Assembly of ENHANCE-European Universities of Technology Alliance (since 2024). Vice-Head of the PhD programme in Environmental and Infrastructure Engineering, DICA, PoliMi (2019-2023). Vice-Chair of the Advisory Assembly of ENHANCE- (2020-2024).Member of the international committee of DICA (2014-2016). Member of the Faculty (Collegio Docenti) and of the Board (Giunta) of the PhD programme in Environmental and Infrastructure Engineering, DICA, PoliMi (since 2012).

RESEARCH ACTIVITY. Research activity has been focused mainly (about 200 publications, of which 112 on peer reviewed international journals and two book Chapters included in the Journal Citation Report) on subsurface flow and transport dynamics, parameter estimation, stochastic groundwater hydrology, probabilistic well capture zones, scaling in hydrology, stochastic inverse modeling, uncertainty quantification, multiphase flows, oil recovery, experimental, analytical and numerical

methods, interpretation and modeling of experimental data, groundwater management. One of her main contributions is the development of methodologies and tools for prediction of groundwater flow and processes governing the spreading of conservative and reactive solutes in hydro-geo-chemically heterogeneous geomaterials by means of conditional moments of the state variable of interest. She developed and applied innovative stochastic and upscaling techniques to quantify multiphase flow features of immiscible and miscible fluids. She has developed a theory (sub-Gaussian models) capable of capturing the non-Gaussian and scaling behavior exhibited by many hydrological-hydrogeological-environmental variables. She has introduced novel metrics to perform global sensitivity analysis across multiple interpretive models with uncertain parameters. Currently, her main research activities include (*i*) management of groundwater resources under multiple stressors and source of uncertainty and (*ii*) impact of the availability of groundwater quantity and quality on ecosystems. She is a leading scientist of the MIPORE research group of Polimi @ DICA (www.mipore.polimi.it). She has been PI of several national and international projects (e.g., IMVUL-Towards Improved Groundwater Vulnerability Assessment, EU, FP7-PEOLE-2007-1-1-ITN, 2008-2012; Hydroelectric energy by osmosis in coastal areas, MUR, 2013-2015; FracRisk – Furthering the knowledge base for reducing the Environmental Footprint of Shale Gas Development, EU Horizon 2020 Research and Innovation programme, 2016-2018). She has coordinated the Water JPI project WE-NEED (2016-2019) "WatEr NEEDs, Availability, Quality and Sustainability", within the ERA-NET Cofund Water Works 2014. She has delivered 14 keynotes/invited talks.

SPECIAL PROFESSIONAL/EDITORIAL ACTIVITIES. Council Member of *Interpore*, International Society for Porous Media (since 2019). Editor of the International Journal *Encyclopedia of Geosciences*, European Geosciences Union, EGU (since 2018). Chair of the Subsurface Hydrology and Groundwater sub-division, Hydrological Sciences division of EGU (2016-2020). Editor of the International Journal Hydrology and Earth System Sciences, EGU (since 2013). Associate Editor of the International Journal *Water Resources Research*, American Geophysical Union, AGU (since 2010). Associate Editor of the International Journal *Reviews of Geophysics*, AGU (204- 2009). **Memberships:** American Geophysical Union; European Geophysical Union; Interpore-International Society for Porous Media; National Groundwater Association; Board of Engineers (Italy).

Selected 5 Publications in international referee journals

1. Siena M., C. Recalcati, A. Guadagnini, M. Riva (2023) A Gaussian-Mixture based stochastic framework for the interpretation of spatial heterogeneity in multimodal fields*, Journal of Hydrology*, 617 Part A, 128849, doi: 10.1016/j.jhydrol.2022.128849.
2. Bianchi Janetti E., M. Riva, A. Guadagnini (2021) Natural springs and probabilistic risk assessment under uncertain conditions, *Science of Total Environment,* 751*,* 141430, doi: 10.1016/j.scitotenv.2020.141430
3. Siena M., M. Riva (2020) Impact of geostatistical reconstruction approaches on model calibration for flow in highly heterogeneous aquifers*, Stochastic Environmental Research and Risk Assessment*, 34(10), 1591-1606, doi 10.1007/s00477-020-01865-2.
4. Dell'Oca A., M. Riva, A. Guadagnini (2017) Moment-based Metrics for Global Sensitivity Analysis of Hydrological Systems, *Hydrol. Earth Syst. Sci*., 21, 6219–6234, doi:10.5194/hess-21-6219-2017.
5. Riva M., S. P. Neuman, A. Guadagnini (2015), New scaling model for variables and increments with heavy-tailed distributions, *Water Resour. Res*., 51, 4623-4634, doi:10.1002/ 2015WR016998.

Additional information is available at **www.mipore.polimi.it**

Attachment A2 – PhD Faculty Board

Name	Affiliation	Scientific Disciplinary Sector
Barzaghi Riccardo	Politecnico di Milano – DICA	ICAR/06 Topography and Cartography
Antonelli Manuela	Politecnico di Milano – DICA	ICAR/03 Sanitary Environmental Engineering
Becciu Gianfranco	Politecnico di Milano – DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Bocchiola Daniele	Politecnico di Milano – DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Canziani Roberto (Deputy Coordinator)	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Corbari Chiara	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Crispino Maurizio	Politecnico di Milano - DICA	ICAR/04 Highways, railways and airports
De Michele Carlo	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
De Gaetani Carlo	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Grosso Mario	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Guadagnini Alberto	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Lonati Giovanni	Politecnico di Milano - DICA	ICAR/03 Sanitary Environmental Engineering
Longoni Laura	Politecnico di Milano - DICA	GEO/05 Applied Geology
Malavasi Stefano	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Mancini Marco	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Migliaccio Federica	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography
Papini Monica	Politecnico di Milano - DICA	GEO/05 Applied Geology
Radice Alessio	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Ravazzani Giovanni	Politecnico di Milano - DICA	ICAR/02 Hydraulic and maritime constructions and Hydrology
Riva Monica (Coordinator)	Politecnico di Milano - DICA	ICAR/01 Hydraulics
Toraldo Emanuele	Politecnico di Milano - DICA	ICAR/04 Highways, railways and airports
Venuti Giovanna	Politecnico di Milano - DICA	ICAR/06 Topography and Cartography

Attachment A3 – PhD Advisory Board

Name	Affiliation
Sanchez-Vila Xavier	Politechnical University of Catalonia, Barcelona (SP)
Ackerer Philippe	CNRS, Strasbourg (F)
Tania Tellini	Utilitalia – Coordinatrice settore Acqua
Sansalone John J.	University of Florida(USA)
Burlando Paolo	ETH Zurigo (CH)
Luca Dei Cas	ARPA Lombardia
Valentina Bisinella	Technical University of Denmark (DK)
Losa Massimo	Università di Pisa
Nico Snew	University of Stuttgart (DE)