Earth Sciences

Faculty of Civil Engineering and Geosciences
Delft University of Technology

Quality Assurance Netherlands Universities (QANU)
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
Telefax: +31 (0) 30 230 3129
E-mail: info@qanu.nl
Internet: www.qanu.nl

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This report was finalized on 28 January 2013.

Report on the bachelor's programme Applied Earth Sciences and the master's programme Applied Earth Sciences of Delft University of Technology

This report takes the NVAO's Assessment framework for limited programme assessments as a starting point.

Administrative data regarding the programmes

Bachelor's programme Applied Earth Sciences

Name of the programme:	Applied Earth Sciences
CROHO number:	56959
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	n.a.
Location:	Delft
Mode(s) of study:	full time
Expiration of accreditation:	31 December 2013

Master's programme Applied Earth Sciences

Name of the programme:	Applied Earth Sciences
CROHO number:	60360
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Petroleum Engineering and Geosciences, Applied Geophysics, Resource Engineering, Geo-Engineering, Geoscience and Remote Sensing.
Location:	Delft
Mode(s) of study:	full time
Expiration of accreditation:	31 December 2013

The visit of the assessment committee Earth Sciences to the Faculty of Civil Engineering and Geosciences of Delft University of Technology took place on 17 September 2012.

Administrative data regarding the institution

Name of the institution:	Delft University of Technology
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

Quantitative data regarding the programmes

The required quantitative data regarding the programmes are included in Appendix 5.

Composition of the assessment committee

The committee that assessed the bachelor's programme Applied Earth Sciences and the master's programme Applied Earth Sciences consisted of:

- Prof. M.A. Herber (chair), professor of Geo-Energy, University of Groningen, the Netherlands;
- Prof. M. Landrø, professor of Applied Geophysics, NTNU Tronheim (Norwegian University of Science and Technology), Norway;
- Prof. J.W. Hopmans, professor of Vadose Zone Hydrology, University of California (Davis), USA;
- Prof. Emeritus D.E. Walling, hydrologist/geomorphologist, University of Exeter, UK;
- Drs. R.L. Prenen, Msc, independent educational advisor;
- M.M. Cazemier MSc (student member), master's graduate of Earth Sciences, Hydrology and Water Quality, Wageningen University.

The committee was supported by dr. Willemijn van Gastel, who acted as secretary.

Appendix 1 contains the curricula vitae of the members of the committee.

Working method of the assessment committee

Preparation
After receiving the critical reflection, the project manager checked the quality and completeness of the information provided. After approval, the critical reflection was forwarded to the committee, in both printed form and digitally. In addition, the chair of the committee selected a total of 15 theses for the bachelor's programme and 16 of the master's programme that was assessed (see Appendix 7). The selected theses were read by the committee.

Before the site visit the project manager created a draft programme for the interviews (see Appendix 6). The draft programme was discussed with the chair of the committee and the coordinator of the educational institute. As requested by QANU, the coordinators of the programmes carefully composed a select and representative panel for all interviews.

Site visit
During the initial meeting at the start of each site visit, the committee members discussed among themselves their findings regarding the critical reflection and the theses. They also discussed their task and working methods and the proposed domain-specific requirements (see Appendix 2).

During the site visit, interviews were held with representatives of the programme, students, staff members, the Board of Studies, the Board of Examiners and a student adviser. A consultation hour was scheduled to give students and staff of the programmes the opportunity to talk to the committee. No requests were received for the consultation hour.

The committee used part of the final day of the site visit to discuss the assessment of the programmes and to prepare a preliminary presentation of the findings. The site visit concluded with an oral presentation by the chairman of the general assessment and several specific findings and impressions of the programme.

Report
After the site visit the project manager wrote a draft report based on the committee's findings. The draft was first commented upon by the committee members and then sent to the faculty to check for factual irregularities. All comments made by the faculty were discussed with the chair of the committee and, if necessary, with the other committee members. After revision, the report became official.

Decision rules
In accordance with NVAO's Assessment Framework for Limited Programme Assessments (as of 6 December 2010), the committee used the following definitions for the assessment of each individual programme, both of the standards and the programme as a whole.

Generic quality
The quality that can reasonably be expected in an international perspective from a higher education bachelor or master programme.

Unsatisfactory
The programme does not meet the current generic quality standards and shows serious shortcomings in several areas.

Satisfactory
The programme meets the current generic quality standards and shows an acceptable level across its entire spectrum.

Good
The programme systematically surpasses the current generic quality standards across its entire spectrum.

Excellent
The programme systematically clearly surpasses the current generic quality standards across its entire spectrum and is regarded as an international model.

Summary judgement

This report provides the findings and considerations of the Earth Sciences committee on the bachelor's and master's programme in Earth Sciences at the Delft University of Technology (TUD). The committee assessment is based on information in the critical reflection, interviews during the site visit and a selection of theses. In general, the committee concludes that the programmes are unique in the Netherlands in focussing on Applied Earth Sciences with a technical component. It further applauds the international character of the master's programme. Through the strong connection with industry, students are well acquainted with the professional field. The main points requiring attention are the objectivity and transparency of the assessment system, the improvement of the students' progress towards completion, the enhancement of the international character of the bachelor's programme and the development of a safety assurance system.

Standard 1: Intended learning outcomes
The *bachelor's* and *master's programmes* in Earth Science at TUD have, as other academic programmes in Earth Sciences, the planet Earth as the object of study, and consider its genesis and its quality of life. These sciences are strongly interdisciplinary, with interaction between various factors, such as humans, fauna, relief, soil, water, lithology, atmosphere, hydrosphere and vegetation. Knowledge is gathered about its origin, current and former composition, and structure and the processes acting in and between the components of geosphere, hydrosphere, atmosphere and biosphere. Equally important is knowledge of how to manage and responsibly use the Earth's resources and understand the influence of human activity on the terrestrial system. It takes into account society's rapidly growing demand for well-trained Earth Scientists prepared to tackle scientific and societal issues. The bachelor's and master's programmes at TUD focus on Applied Earth Sciences with a strong technical component. The programmes are characterized by the strong synergy between the disciplines of geology and geophysics on one hand and petroleum engineering, geo-engineering and resources engineering on the other hand. The committee concludes that this focus is unique in the Netherlands.

The *bachelor's programme* aims to enable students to recognise, analyse and answer questions in the Applied Earth Sciences. Graduates are prepared as all-round engineers for the global market or a subsequent master's programme. Most of the graduates enrol into a master's programme. The committee understands this choice, although it notes that bachelor graduates are frequently recruited by companies in other countries. Therefore, the committee encourages the bachelor's programme to develop a more internationally oriented perspective, in order to also meet the requirements of international companies. Furthermore, in general, a programme with an international character is necessary to achieve the intention of preparing students for the global market.

The objectives of the *master's programme* are to enable students to practise their profession independently or to continue their training in scientific research. The orientation of the *master's* programme is mostly toward a professional career in industry or government. This orientation is well known and internationally appreciated. The academic research orientation is less prominent, but is nevertheless developed to an acceptable level. However, the committee advises that the research orientation of the programme should be made more visible because it is not well known and the programme management should have no reservations about being open to the world concerning what it offers.

The committee concludes that the *bachelor's* and *master's* programme closely relate to the domain-specific framework of reference. The framework is an effective and meaningful representation of Earth Sciences and offers enough anchor points for programmes to establish their own objectives. Derived from this framework of reference, the programmes have formulated intended learning outcomes. The intended learning outcomes are in line with the Dublin descriptors. The committee confirmed that the intended learning outcomes are in line with this framework and reflect the level and orientation of both the bachelor's and master's programmes. The committee nevertheless wishes to direct one comment to the bachelor's programme. The intended learning outcomes do not fully cover the intention to prepare students to act and communicate in an international society. The committee advises that several learning outcomes relating to this aspect should be reformulated more precisely, taking into account of the fact that bachelor graduates in Applied Earth Sciences should be able to communicate with society with great sensitivity.

Standard 2: Teaching-learning environment
Bachelor's programme
The bachelor's programme consists of 180 EC distributed over three years. The first two years of the programme consist of five different learning lines, which are brought together in the final semester of the third year. These lines consist of the basic sciences (i.e. geology, mathematics, physics, and chemistry) and their integration into the Applied Earth Sciences, along with reporting and societal skills. During the first two years, courses specific to the multidisciplinary domain of Applied Earth Sciences are of an introductory nature. During these years, students become acquainted with the disciplinary sub-domains of applied geology, geophysics and petrophysics, fluid-flow through porous media and the mechanics of porous media, as well as the engineering subdomains of petroleum and reservoir engineering, resource engineering (including mining and processing/metallurgy), and geo-engineering. In the final period of the second year, students participate in a *geological field assignment*, in which they must synthesise and apply their knowledge, in addition to sharpening their observational skills. In the third year, a minor (30 EC) and a thesis project (8 EC) are included in the programme. The minor provides the opportunity to study a topic that is completely different from the major of choice.

To lessen the heavy workload that students experienced in the past, improvements to the curriculum have been made. In the improved curriculum, that started this year (2012-2013), physics and mathematics courses are distributed better, and the total study load is more evenly balanced over all teaching periods. In addition, lecturers from the new department of Geosciences & Remote sensing are incorporated, in order to increase their visibility within the programme. The committee concludes that the new curriculum is seen as an improvement, especially in terms of the more logical scheduling of the physics and mathematics courses.

The committee holds the opinion that the old curriculum was composed in a well developed and structured way and that the new curriculum offers an even more balanced and effective structure. The courses cover the domain of Earth Sciences well and provide bachelor graduates with a good grounding in Applied Earth Sciences. The committee is pleased to observe that in the new curriculum the thesis project is extended to 10 EC, although it would prefer 12 EC.

The committee is convinced that the curriculum pays sufficient attention to the societal aspects of Applied Earth Sciences but that these societal aspects should be identified more visibly in the programme. Furthermore, the committee suggests that the bachelor's programme should be taught in English. This would attract more students from abroad and provide increased exchange opportunities for their own students.

The committee concludes that the moderate number of students enrolling annually during the last years (47) is a point of concern. It is pleased to note that the number of students doubled in 2012-2013, which can be seen as an encouraging sign.

Master's programme
The master's programme consists of four different tracks: *Applied Geophysics*, *Geoengineering*, *Petroleum Engineering and Geosciences* and *Resource Engineering*. A new track on Geoscience and Remote Sensing will start in 2012. For all four tracks, the course programme consists of a combination of theoretical and practical components and is concluded by an individual research project for which students deliver a thesis report and give a presentation in a colloquium. The credits for the thesis vary from 30 to 45 EC. Two tracks, *Applied Geophysics* and *Resource Engineering,* are international programmes offered jointly by other European Universities. The committee has the opinion that the content of the courses is of high quality and cover most of the intended aspects of Applied Earth Sciences. Each track offers a coherent programme. The committee's main concern is the division of the programme into a number of very distinctive tracks. The tracks deliver highly specialist training, whereas industry is possibly more interested in less specialised graduates. Also for efficiency reasons, the tracks could be organised in a more coordinated way. The committee welcomes the future plans to reduce the number of courses.

The committee applauds the offering of two international tracks. These tracks offer unique opportunities for students. The students gain increased experience by attending several universities, each with their own individual academic strengths and culture. The strong link with industry means that industry requirements are well integrated into the curriculum. The committee's only advice relates to the assurance of a formal approach to ensuring the quality and coherence of the overall programme.

Bachelor and master programme
The committee stresses the importance of improving students' study progress. Of all the bachelors students, 20-25% graduates within four years. Of all the master's students, 80% graduates within three years. The committee noted that in order to improve the success rate, the didactic concept will be changed in several ways per September 2013. Firstly, the total number of contact hours (+/- 800 hours each year) will be reduced per week to allow students more time for self study. Secondly, more mid-term assessment periods during courses are being introduced in the current programme of 2012-2013 and will remain in the new programme per September 2013. Thirdly, a stronger integration of mathematics, chemistry and physics will be accomplished. The committee questions the didactics and the recent decision to decrease the number of contact hours per week by more self study. The committee appreciates that self study is accompanied by more individual-based feedback, but wants to draw attention to the risk that students can squeeze through. The committee strongly supports the introduction of the mid-term assessments.

The committee concluded that the programmes are provided by motivated lecturers who are both willing and able to pay close attention to the students. It is positive about the research qualities of the lecturers and very positive about the strong connections between master lecturers and industry. The committee further concludes that the educational quality of the lecturers is clearly apparent. However, it suggests that this quality should be further guaranteed, by encouraging lecturers to follow courses and take advantage of the educational desk within the university.

Students receive support from lecturers, a tutor-mentor system and study advisor. Nevertheless, given the slow progress of many students, it seems that some students slip through the net of support. The committee therefore suggests to evaluate the support system and to organise it more proactively and effectively if needed.

The committee noticed that students and staff profit from excellent facilities. The laboratories are equipped in such way that research and educational goals are achieved.

The programmes include fieldwork and practical training. The committee learned that the programmes have no legally based safety assurance system for fieldwork. Although the programmes have a travel insurance policy and use well written guidelines, the overall legal signature is missing. Responsibilities are not clear and first aid courses are not obligatory. The committee strongly recommends that a safety assurance system should be developed as a matter of urgency, to legally protect faculty, staff and students. The committee suggests that a national system should be developed in cooperation with the other academic Earth Sciences programmes in the Netherlands. Furthermore, the committee advises obligatory first aid courses for both students and lecturers.

Standard 3: Assessment and achieved learning outcomes
The committee has evaluated the assessment system and methods of both the bachelor's and the master's programme as well as the achievement of intended learning outcomes by students.

The main concern of the committee is the lack of a clear assessment protocol for written exams that guarantees transparency and objectivity. It is therefore pleased to see that the Board of Examiners has already formulated such a protocol and is now in the process of fine-tuning and implementing. Nevertheless, it stresses the urgency of implementing such system as soon as possible to underpin the grading and content of assignments in an appropriate manner.

For the thesis project, the committee appreciates the appointment of a committee to supervise students during the thesis project. However, it is concerned by the absence of a form that guarantees a transparent and objective grading. The committee has noted that the programme has already started to develop such a form. The committee has formulated several recommendations for this thesis evaluation form, including the use of a standard weighting for individual grading criteria for all students, the inclusion of rubrics and provision of a narrative explanation of the grading.

To assess the achievement of the learning outcomes, the committee reviewed 15 bachelor and 16 master theses. Based on the theses and the information gathered about progress and success rates, the committee established that the level of the bachelor theses is adequate but not outstanding. The committee holds the opinion that this situation is likely to reflect the small amount of credits allocated to a thesis project (8 EC). An increase of the credits to 12 EC is needed to offer students the opportunity to produce a well written thesis report. The level of the master theses conformed to or was even above the expectations of the committee.

The committee assesses the standards from the Assessment framework for limited programme assessments in the following way:
Bachelor's programme Applied Earth Sciences:

Standard 1: Intended learning outcomes	satisfactory
Standard 2: Teaching-learning environment	satisfactory
Standard 3: Assessment and achieved learning outcomes	satisfactory
General conclusion	satisfactory

Master's programme Applied Earth Sciences:

Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	satisfactory
Standard 3: Assessment and achieved learning outcomes	satisfactory
General conclusion	satisfactory

The chair and the secretary of the committee hereby declare that all members of the committee have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 28 January 2013

Prof. M.A. Herber (chair)	Dr. Willemijn van Gastel (secretary)

Description of the standards from the Assessment framework for limited programme assessments

Standard 1: Intended learning outcomes
The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements. **Explanation**: As for level and orientation (bachelor's or master's; professional or academic), the intended learning outcomes fit into the Dutch qualifications framework. In addition, they tie in with the international perspective of the requirements currently set by the professional field and the discipline with regard to the contents of the programme.

Findings

The committee has evaluated the intended learning outcomes of the Earth Sciences bachelor and master of Delft University of Technology (TUD) with regard to content, level and orientation. It studied the domain-specific framework (1.1), the profile and orientation (1.2), the objectives and intended learning outcomes (1.3).

1.1 Domain-specific framework of reference

The domain-specific framework was created by the Chamber of Earth Sciences and educational administrators and/or heads of departments of the Dutch university institutions with degree programmes in the Earth Sciences (included in Appendix 2). This framework is a modified version of the one established in 2006. In updating the framework, use was made of 'Agenda 2020: perspectives of the Earth Sciences', the outcome of a series of consultation workshops organised in 2009 by the Council for Earth and Life Sciences (RAL) of the Royal Netherlands Academy of Arts and Sciences (KNAW).

According to the domain-specific framework, Earth Sciences have the planet Earth as their object of study, and consider its genesis and its quality of life. These sciences are strongly interdisciplinary, with interaction between various factors, such as humans, fauna, relief, soil, water, lithology, atmosphere, hydrosphere and vegetation. Knowledge is gathered about its origin, current and former composition, and structure and the processes acting in and between the components of geosphere, hydrosphere, atmosphere and biosphere. Equally important is knowledge of how to manage and sustainably use Earth's resources and understand the influence of human activity on the terrestrial system. It takes into account society's rapidly growing demand for well-trained Earth Scientists prepared to tackle scientific and societal issues.

The committee studied the domain-specific reference framework and concludes that it is a well structured outline of the domain of Earth Sciences. Because the Dutch university institutions with degree programmes in Earth Sciences were involved in its creation, it is not surprising that such programmes fit readily into that framework, including the Earth Sciences bachelor and master at TUD. Although the framework is of Dutch design, the strong international research positions of the institutes guarantee its international relevance.

1.2 Profile and orientation

One of the recommendations of Agenda 2020 was to produce complementary Earth Sciences programmes in the Netherlands that together cover the entire domain. As a result, universities and their programmes will differ in their focus. The bachelor's and master's programmes at TUD focus on Applied Earth Sciences with a strong technical component.

The domain-specific reference framework stresses the necessity of providing a higher quality of life under the constraint of a growing global population. In the critical reflection, this necessity is further described as follows: 'Increasing pressures are being placed on our environment through the development of industry, infrastructure and agriculture. Increasing energy consumption is generating a strong demand to find new hydrocarbon reserves, explore new energy sources in the earth, find earth-scientific solutions related to global problems and enhance the recovery rates of known reservoirs, in addition to find new occurrences of raw materials and extracting the economic minerals and metals at lower cost. The bachelor's and master's programme of Applied Earth Sciences at TUD deal with understanding the impact and consequences of anthropogenic activities in the shallow subsurface and associated ecosystems in order to mitigate these effects. It therefore combines geosciences with engineering'.

According to the critical reflections, the core purpose of both the *bachelor's and master's programmes* is to strengthen the existing links between geology and engineering sciences and to create new ones. This is accomplished through a combination of knowledge development in the basic sciences (i.e. geology, mathematics, physics and chemistry) and the application of this knowledge in practical settings. The disciplines involved are geology, geophysics, petroleum engineering, geo-engineering and resources engineering.

The committee noted that the precise meaning of 'applied' is open to debate, because it can mean different things to different people. Moreover, the boundaries between fundamental and applied are sometimes nebulous. Nevertheless, the committee has no doubt that the TUD offers unique programmes integrating Geosciences with Engineering with a strong technical component.

The *bachelor's programme* is designed to prepare students for jobs on the global market or for entering a master's programme. The interviewed programme managers concluded that although they aim to deliver bachelor's students as well rounded engineers, students themselves do not feel prepared for industry. As a result, most graduates enrol into the master's programme. In addition, in the Netherlands, both industry and government employers seem to prefer master to bachelor graduates. The committee understands why students choose to continue in a master's programme, although it recognises that bachelor graduates are often recruited by companies abroad. Therefore, the committee encourages programme managers to develop a more international professional orientation. Furthermore, in general, the committee holds the opinion that a more internationally oriented programme could be offered to realise its intention to prepare students for the global market.

The *master's programme* educates students in the Applied Earth Sciences at such a level that they should be competitive in their field on the international labour market, and be able to occupy leading positions in trade and industry or government or continue in PhD programmes at international scientific institutions. The interviewed programme managers indicated that they promote an academic research orientation, though it seems that there is much more employment and need for master graduates in industry and government. The committee understands and is aware that certain Earth Sciences disciplines such as mining are more interested in professional than research oriented graduates. The programme managers are convinced that the graduates are also well prepared for a research career, considering the fact that graduates have no problems in obtaining PhD positions. The committee is pleased to hear this, but suggests that the programme should make the research strengths of the programme more visible because it is not well known. It reinforces this advice by stressing that, because of the programme's leading position in its discipline, it should have no reservations about being open to the world concerning what it offers.

1.3 Objectives and intended learning outcomes

Bachelor's programme
The bachelor's programme aims to impart knowledge, skills and an academic attitude to enable students to recognise, analyse and answer questions in the Applied Earth Sciences. Following this objective, the programme has formulated the intended learning outcomes in line with the Dublin descriptors (Appendix 3). The comparison with the Dublin descriptors shows that the learning outcomes are satisfactorily formulated at the bachelor's level. The learning outcomes are subdivided into: 1) knowledge 2) skills and 3) attitude. The committee studied these learning outcomes and established that they largely reflect the profile and orientation of the programme. The committee feels that Applied Earth Scientists should be able to communicate with cultural and societal sensivity. In line with this comment, the learning outcome that *students can clearly communicate in written form in the Dutch language* is too narrow. Students have to be able to communicate in English as well, in order to be prepared for the global market. Furthermore, in general, the intended learning outcomes concerning communication and attitude should be directed more clearly to societal demands.

Master's programme
The objectives of the master's programme are to pass on knowledge, skills and an academic attitude to enable students to practise their profession independently or to continue their training in scientific research. The programme has formulated the intended learning outcomes in line with the Dublin descriptors and has subdivided these into 1) knowledge 2) practical capability 3) mastery 4) communication and 5) learning skills (Appendix 3). The learning outcomes related to knowledge, practical capability and mastery are specified for each of the four tracks of the master; *Applied Geophysics, Geo-engineering, Petroleum Engineering and Geosciences,* and *Resourse Engineering.* The committee studied these learning outcomes and established that they are well formulated for the master's level. In contrast to the bachelor's programme, the learning outcome related to communication is internationally oriented. The committee expressed a minor concern regarding the intended learning outcome *required mastering a research project to add on fundamental scientific knowledge*. Within this programme, the committee expects the mastering of a research project to also add *applied* scientific knowledge. It is therefore that the committee recommends that the program clarifies expectations of mastering a research project in addition to applying scientific knowledge.

Considerations
The committee has studied the domain-specific framework of reference and profile and orientation of the programmes. The objectives derived from this profile and orientation are set in the formulation of intended learning outcomes. The committee has evaluated to what extent these outcomes meet the international requirements with respect to content, level and orientation. The committee concludes that the intended leaning outcomes of both the *bachelor's* and *master's programme* adequately meet these requirements.

The domain-specific framework of reference was developed by Dutch universities. The committee concludes that the framework offers a clear outline of the domain of Earth Sciences. The bachelor's and master's programmes at TUD fit well within this domain, and they position themselves clearly by focussing on the integration of geosciences and engineering.

The *bachelor's programme* aims to prepare graduates for the global market or enrolment in a master's programme. The committee is aware that most of the students choose a subsequent master's career, partly due to uncertainty about their opportunities in the global market. It suggests that the programme could be more internationally oriented, in order to prepare students better for the global market and to open the world for those students who want to pursue an international career in industry. The committee concludes that the level of the intended learning outcomes is adequate, but it suggests that some outcomes relating to societal aspects should be added.

The orientation of the *master's programme* is mostly geared toward a professional career in industry or government. This orientation is very well known and internationally recognised. The academic research orientation is less prominent, but is, as noted by the programme managers, still well developed. The committee recommends that this orientation could be expressed more explicitly. The academic level of the learning outcomes is good. The content of the learning outcomes is more than appropriate, although the applied research aspect could be given more emphasis. Therefore, the committee concludes that the content, level and orientation of the master's programme are good.

Conclusion
Bachelor's programme Applied Earth Sciences: the committee assesses Standard 1 as **satisfactory**.
Master's programme Applied Earth Sciences: the committee assesses Standard 1 as **good**.

Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Explanation:
The contents and structure of the curriculum enable the students admitted to achieve the intended learning outcomes. The quality of the staff and of the programme-specific services and facilities is essential to that end. Curriculum, staff, services and facilities constitute a coherent teaching-learning environment for the students.

Findings
In this standard, the findings of the committee regarding the extent to which the bachelor and master's curricula enable students to achieve the intended learning outcomes are described. The findings are directed to the curricula (2.1), didactic concept (2.2), quality assurance system (2.3), staff (2.4), intake and study load (2.5), facilities (2.6), support (2.7), internationalisation (2.8), and safety (2.9).

2.1 Curriculum
Bachelor's programme
The bachelor consists of 180 EC, uniformly distributed over three years. The academic year starts in September and consists of four lecturing periods each year. Seven to eight weeks are used for teaching, followed by a week without lecturers or contact hours and concluding with one or two weeks of examination. An overview of the courses is included in Appendix 4.

According to the critical reflection, the first two years of the programme consist of five different learning lines, which are brought together in the final semester of the third year. These lines consist of the basic sciences (i.e. geology, mathematics, physics, and chemistry) and their integration into the Applied Earth Sciences, along with reporting and societal skills. Geology is the integrating theme within the programme. The programme begins with the courses *General Geology*, *Mineralogy*, *Geological Map Reading,* and a *geological excursion* during the first year. This is followed by the second-year courses *Geology of the Netherlands*, *Sedimentology*, *Structural Geology* and *Geological Constructions*. In the final period of the second year, students participate in a *geological field assignment*, in which they must synthesise and apply their knowledge, in addition to sharpening their observational skills. The other three disciplines build upon the knowledge that students acquired in secondary school. The learning line in mathematics prepares students for courses in physics and chemistry. It comprises the courses *Calculus* and *Linear Algebra* in the first year; *Differential Equations*, *Applied Statistics*, *Matlab,* and *Geo-statistics and Data Analysis* in the second year, followed by *Numerical Analysis* in the third year. The physics and chemistry course are *Introduction to Chemistry*, *Chemical Thermodynamics,* and *Mechanics* in the first year; *Electricity and Magnetism*, *Signals and Systems*, *Analytical Chemistry,* and *Physical Transport Phenomena* in the second year.

During the first two years, courses specific to the multidisciplinary domain of Applied Earth sciences are of an introductory nature. During these years, students become acquainted with the disciplinary sub-domains of applied geology, geophysics and petrophysics, fluid-flow through porous media and the mechanics of porous media, as well as the engineering subdomains petroleum and reservoir engineering, resource engineering (including mining and processing/metallurgy), and geo-engineering.

In the third year, the first two periods are reserved for a minor. The minor can be used to broaden the student's perspectives and opportunities, as it provides the opportunity to study a topic that is completely different from the major of choice. It can also be used as extra preparation for the master's programme. The third period is used to deepen domain-specific knowledge through courses on petrophysics and fluid, flow, and the transfer of heat and mass, along with an elective course on specific master's tracks included in the master's degree programme in Applied Earth Sciences. In the fourth period, all of the knowledge and skills acquired in the programme are brought together in a project-based field-exploration course and in an individual research assignment in the bachelor's thesis project.

Through surveys done by quality care the programme received signals that the study load was too heavy. Based on these signals, a digital survey was performed among 160 bachelor's students. As a result of the digital survey, improvements to the curriculum are being made to reduce the student workload. Recently, physics and mathematics courses are better distributed, and the total study load is evenly balanced over all teaching periods. In addition, lecturers from the new department of Geosciences & Remote Sensing are being incorporated, in order to increase their visibility within the programme. In the new curriculum that will start next year, the schedule will be simplified by creating modules of 5 or 10 EC and the first-year and second-year courses will be offered in a disjointed schedule, such that courses missed in the first year do not interfere with second-year courses.

The committee noted that the previous curriculum was composed in a well developed and structured way and the new curriculum was seen to be even better. The content of both curricula is more or less the same, though the composition of the new curriculum is more balanced. The courses cover most of the Earth Science system, with a focus on knowledge and skills in Applied Earth Sciences.

The committee discussed with management, students and lecturers to what extent the programme prepares students to be able to easily and appropriately communicate with and within society about their research. The committee learned that the course *techniek en verantwoordelijkheid* was devoted to this aspect. However, the new curriculum does not offer this course any more. The interviewed programme managers explained that societal issues are interwoven into nearly every course. Moreover, students have to present their thesis for a broad audience of professionals, laypersons and occasionally journalists. The committee learned from students that most lecturers indeed take the initiative to discuss these issues in their course. Furthermore, students declared that the programme offers so many company visits and talks, that they become very familiar with the societal aspect of Applied Earth Sciences. The committee is convinced that the curriculum pays enough attention to this topic but still advises the programme to be more explicit about how and where it is addressed in the curriculum.

The committee has mixed feelings about the minor. On the one hand, it recognises that it can be used to broaden the student's perspective. Some students use this minor to explore other directions and as a result they are subsequently better placed to choose an appropriate master's programme. For other students, the minor can be seen as a break. Mostly, students choose an economic oriented minor. On the other hand, the committee feels that 30 EC spent on courses unrelated to Earth Sciences could threaten the sufficiency of coverage of the Earth Science domain. The committee is aware that offering the minor is university wide policy. Nevertheless, it feels that it would be wise to inform students about which minors will contribute to their study. Considering the programme's intention to prepare students for the global market, the committee suggests that students should be encouraged to follow Earth Sciences related minors taught abroad.

Bachelor thesis
The thesis project process involves designing a research proposal, conducting the research and reporting the results at a bachelor's level. The purpose of the final thesis project is to explore in depth a topic related to one of the research themes of the Department of Applied Earth Sciences. Most of the research topics link to the research programmes of the sections of the department. In the old curriculum, the thesis represents 8 EC, but in the new one it increases to 10 EC. The committee is concerned that 8 EC for a thesis project does not offer enough time to conduct a small research project and to subsequently write the report. Even 10 EC is probably insufficient to complete a thesis project that fulfils the requirements of a fully-fledged research report. The committee learned from the interviewed students that in most cases more time is spent on the thesis. Considering the risk of delays, the committee therefore recommends that the number of credits should be increased to at least 12 EC and this is taken into account in the scheduling.

Bachelor fieldwork
An essential part of all Earth Sciences programmes is fieldwork. Fieldwork in the bachelor's programme takes place in the final period of the second year when they undertake a three weeks geological field assignment in the French Pre-Alps. Selected areas of 40 km^2 are assigned to groups of two students, to be mapped independently. This results in a preliminary report on the geology in the studied area. This report will be graded and discussed upon return in Delft, after which the final report will be written.

Bachelor curriculum related to the learning outcomes
The critical reflection contains a table that summarises the contribution of courses and theses to the achievement of the intended learning outcomes. Based on the conversations during the visit and the studied material, the committee is convinced that the curriculum devotes sufficient attention to the societal aspects. However, the intended learning outcomes in the table and also course descriptions in the study guide are not explicitly directed to these

aspects. The committee suggests that these important strengths of the programme should be recognised more explicitly.

Master's programme

The master's programme consists of four different tracks: *Applied Geophysics*, *Geoengineering*, *Petroleum Engineering and Geosciences* and *Resource Engineering*. An overview of the courses is included in Appendix 4. The new track on *Geoscience and Remote Sensing* will commence in 2012. For all four tracks, the course programme consists of a combination of theoretical and practical components and is completed by an individual research project for which students deliver a thesis report and give a presentation in a colloquium.

The *Applied Geophysics* track is a two-year international programme offered jointly by three IDEA League partners – ETH Zürich, TU Delft, and RWTH Aachen – since 2006. The IDEA League, founded in 1999, is a network of five leading universities of technology and science. The core of the programme focuses on techniques and methods of analysis to observe characterise and monitor structures and processes in the earths subsurface in a non-destructive way at different scales. Each partner university provides one semester (nominal 30 EC) of core modules in which students must obtain a minimum number of credits (12-16 EC). In addition, students can choose from a list of recommended courses according to their personal interests for a maximum of 25 EC. The work for the final thesis project including the colloquium represents an additional 30 EC, for a total of 12 EC.

The *Geo-engineering* track is a joint track with the Master Programme in Civil Engineering that has been offered since September 2006. The track is directed to the need to reassess the stability of existing structures: for example, due to rising sea levels and degradation of soils associated with changes in environmental conditions. It is also directed to the so-called new "soils" that need to be characterised, modelled and stored, for example waste materials arising from domestic and industrial processes. Initially, specialisations in Engineering Geology, Geomechanics, Geotechnical Engineering and Underground Space Technology were offered. Each specialisation had a package of compulsory courses in addition to a common core of courses. These specialisations were removed in September 2012 to simplify the structure of the programme. The geo-engineering track now comprises a common core of 26 EC, 34 EC for further specialisation in geo-engineering that can be chosen from a list of 69 EC, 20 EC of specific choice and 40 EC thesis work. Students can use the 20 EC of specific choice for geo-engineering fieldwork, an extended MSc-thesis, or free electives.

The *Petroleum Engineering and Geosciences* track has two specialisations: Petroleum Engineering and Reservoir Geology. Both specialisations have a common core course programme of 32 EC and each has specialised elective courses amounting to 34 EC, a 9 EC common synthesis project and 45 EC for thesis work and the colloquium.

The specialisation in *Petroleum Engineering* covers fundamental aspects, hands-on laboratory courses and field excursions. The coursework culminates in a field development project at the start of the second year. Following the field development project, students research and write a thesis on a topic within the area of Petroleum Engineering or Reservoir Geology. The task of a *reservoir geologist* is to understand, quantify and predict the spatial distribution of salient subsurface rock properties, such as porosity and permeability. This specialisation has a strong focus on quantitative sedimentary geology combined with numerical modelling. The combination of the two specialisations provides students with important insights into the role of geological setting in the effectiveness of the hydrocarbon production process.

The track *Resource Engineering* is part of a joint programme run by TU Delft and five other European universities in Europe; Aalto University, RWTH Aachen, Exeter University, Wroclaw University of Technology and University of Miskolc. Three specialisations are offered: *Mining Engineering through the European Mining Course (EMC)*, *Mining Geotechnical Engineering through the European Geotechnical and Environmental Course (EGEC)* and *Mineral Engineering through the European Minerals Engineering Course (EMEC)*.
In the first MSc year, a 60-EC programme is offered in English. The study plan comprises two semesters reserved for an eight-month joint curriculum at four of the six universities. The students spend half a semester at each of the partner universities in groups of approximately 20 students. The groups stay together for the entire eight-month period. Over 600 students have participated in the programme since its commencement in 1996. After the joint programme, students may choose to develop special expertise in one of the other aspects of Mining or Minerals Engineering. They carry out their individual programme under the guidance of their own university or in cooperation with the partner university that specialises most in that particular field. Industry is often involved in thesis projects at this stage. The programme is strongly supported by industry, with more than 35 multinational companies linked to the programme. Internships are frequently offered to participating students. The programme is coordinated by the Federation of European Mineral Programs (FEMP).

The committee has the opinion that the content of the courses is of high quality and covers most of the intended aspects of Applied Earth Sciences. The committee's main concern is the division of the programme in four tracks for organisational reasons and also for reasons of substance. From an organisational point of view, it would be more efficient to organise them in a more coordinated way. At this moment, it looks like there are four separate tracks without a common or complementary content. Furthermore, the tracks are very well defined and coherent but also very specialised. The committee questions whether this highly specialised approach is appropriate when industry is possibly more interested in graduates with a broader background. The interviewed programme managers mentioned plans to rearrange courses in the future for efficiency reasons. The committee can see the benefits of such a rearrangement with the intention of retaining coherence, but with an identifiable general backbone.

The committee applauds the two international tracks *Applied Geophysics* and *Resource Engineering*. The tracks offer exclusive opportunities for students. Students gain experience by attending several universities that expand their own academic and cultural horizons. The strong link with industry provides good integration of industrial requirements within the curriculum. Finally, the tracks give students the opportunity to cooperate with a group of students from many different countries. The committee also noted that the interviewed master students were very positive about both tracks. They reported that transitions between universities are arranged very smoothly. With respect to the track *Resource Engineering*, they liked the concept of moving as a group from university to university.

Fieldwork
Fieldwork is used to bring together the theoretical knowledge into the real context. For example, the fieldwork of *Petroleum Engineering* covers a project based on real data from a North Sea oilfield. Students evaluate a prospect from the geophysical data, geological environment and logging data in order to derive a static model of the resource. Student groups then use this model as a basis for the creation of dynamic flow models for testing a variety of development plans. Finally, they optimise their design, evaluate the economics and make recommendations on field development in both an oral presentation and a substantial written report.

Thesis
The thesis projects are research oriented, though industry is often involved in thesis projects. Depending on the track, credits for a thesis vary from 30 to 45. There are no specific rules about the time spent on the thesis. The programme managers explained that the international tracks force students to finish their thesis within six months, though it is not a requirement. The committee advises that students should be discouraged from spending more time on their thesis than scheduled, for example by penalising late submission through reduced marks.

According to the critical reflection, many students find the thesis protocol unclear and vague. Most of the time, students turn to fellow students to learn what is expected from them. The committee was told by the interviewed students that they have problems with selecting a research topic, finding a company to work with and assessing whether the selected topic is fitting university/industry expectations. At the same time, students put their comment in perspective by stating that lecturers are always open and willing to help. The committee welcomes a recent initiative to develop a thesis instruction form.

The thesis should contribute to the preparation of students for the global market. Firstly, most theses projects are conducted either in or in cooperation with industry. Secondly, the results are presented for a broad audience, even broader than in the bachelor's programme. The committee concludes and appreciates that the thesis projects are indeed organised in such a way that they prepare students for their subsequent career in industry.

Master curriculum related to the learning outcomes
The critical reflection contains a table that summarises for each track the contribution of the curriculum to the achievement of the intended learning outcomes. The committee studied this table and concluded that it was confusing. For example, some geo-engineering courses do not, or seem to only slightly, contribute to the achievement of intended learning outcomes. Based on the studied content of the course material together with the conversations during the site visit, the committee concludes that the curricula of all tracks contribute sufficiently to the achievement of the intended learning outcomes. The committee advises that the table should be revised to express more precisely the contribution of each course to the intended learning outcomes.

2.2 Didactic concept and methods
According to the critical reflection, the bachelor's and master's curricula offer a combination of theory and practical work and where possible, theoretical concepts are used in practical work. In general, the courses are built on knowledge derived from previously scheduled courses. During the site visit, students expressed the presence for a strong connection between theory and practice.

The teaching methods used are lectures, instructions for exercises, laboratory work, project work and fieldwork, thesis and self study. The large amount of lectures and project work is a key feature of the *bachelor's programme*. Together, they make up 75% of the contact hours. In the *master's programme*, most of the time is spent on self study. The committee applauds the many opportunities in both programmes for training in oral presentations to a range of audiences.

In order to improve the success rate, it has been decided to change the didactic concept in the new curriculum in several ways. Firstly, the total number of contact hours in the *bachelor's programme* (+/- 800 hours each year) will be reduced per week to allow students more time for self study. Secondly, in the bachelor's programme, more mid-term assessment periods and more project-based education will be offered. The committee is appreciative of the intended project-based education and mid-term assessments. However, the committee is less positive about the intention to reduce the contact hours per week to improve the success rate, as it appears contradicting. The committee learned from the programme managers that increasing self study is a proven method of improving success rate. They stress that a substantial proportion of students do not spend sufficient time on their studies during the courses. Self study, initiated by practical work or a small lecture classes will force them to study more actively. An active student attitude is further promoted by the continuous assessment system. Furthermore, in the new curriculum that will start in 2013-2014, courses will be spread over 10 weeks instead of 7 or 8 weeks while the assessment preparation period will be diminished. As a result, the total number of contact hours for each course will remain more or less the same. The interviewed students were not over enthusiastic about the self study concept, although they indicated that 'it is no fun, but it works'. The interviewed lecturers stated that the concept implies less lectures and more opportunity for individual feedback. In other words, the nature of the contact hours will become more individual, whereas the number of contact hours will not decrease dramatically. The committee appreciates the benefits of tailor made education, though wishes to emphasize that the system becomes vulnerable with increasing intake of students. It is also conscious of the risk that students can squeeze through. It strongly advises that the new didactic concept should be closely monitored with respect to both success rate and delay.

2.3 Quality assurance

The committee explored the extent to which students and lecturers are involved and their views taken into account in the evaluation and improvement of the quality of the programme. According to the critical reflection, the quality assurance takes place *ex ante* and *ex post*.

Ex ante, lecturers evaluate the teaching plans before the start of the lecturing period. Lecturers of the *bachelor's programme* use this evaluation to compile an overall schedule for the students and to provide an insight into the study load. If the study load results in periods for which the overall study load is excessive, the plan is modified. In the *master's programme,* the evaluation is conducted for each track, with the attendance of the master's track organiser, the director of studies and the Board of Studies. Furthermore, the Board of Studies evaluates the description provided by the study guide. *Ex post*, students evaluate all courses. At the end of every course, students fill in a survey covering the content of the courses and the general quality of the education. The Board of Studies discussed these results with lecturers, and the director of studies. There is also a committee of students (STARO), with student representatives for each *bachelor's* year. The Board of Studies meets on a regular basis and reports on all problems regarding the bachelor's programme from the student's point of view to the management. In the *master's programme*, students are also invited to participate in the track evaluation. The committee appreciates the way this quality control system is developed and executed.

The Board of Studies indicates that their advice is based on their contact with students on the one hand, and teachers and management on the other. The committee noted that the Board of Studies is very motivated to keep track of the curriculum, but suggest that its position could be strengthened by expanding their pro-active role. In the coming years, changes to the curricula will be implemented and evaluated and the didactic concept will be enhanced further. The Board of Studies can fulfil a valuable role in receiving feedback from students on the one hand and in advising the management on the other hand.

The committee also discussed the quality assurance of the *international master tracks*. It can be questioned to what extent the quality and coherence of the courses provided by the participating universities is guaranteed. The interviewed programme managers clarified that the participating universities use similar quality assurance systems. Every university assesses its own courses and once a year, the whole curriculum is assessed. However, these assessments are undertaken on an informal basis. Lecturers emphasised the close contact between the contributing universities for research purposes. The committee advises that the coherence and quality of these tracks needs to be guaranteed by a formal quality assurance system. Although potentially complex, there is a need to maintain an overview of the entire curriculum of these tracks.

2.4 Staff

The committee evaluated the quality and quantity of the staff. According to the critical reflection, the scientific quality of the staff is apparent from their active participation in research, and most of them hold doctorate degrees. Considering the number of contact hours, the committee calculated that the lecturers dedicate considerably more time to research than to education. It therefore questioned whether research priorities dominate at the expense of education. The interviewed programme managers agreed that the lecturers are research driven. However, considering the positive attitude of the lecturer's toward the increasing number of students, they are also very committed to education. The interviewed lecturers agreed with the programme managers. In their opinion, there is a good balance between research and education.

According to the critical reflection, master lecturers have good contacts with industry. Therefore, they are in a position to inject a combination of fundamental and applied research into the programme.

In conformance with faculty policy, recently appointed lecturers follow a didactic and educational course (BKO). Senior lecturers are not obliged to obtain a BKO, but are encouraged to enter course programmes to improve their educational quality. The committee learned from lecturers that they can also get support from 'Black Board' or from an educational desk within the university. The committee encourages the lecturers to maintain this quality by following courses and making use of the educational desk within the university if needed.

Based on the critical reflection and the interviews conducted during the site visit, the committee ascertained that the lecturers are inspired and have the correct expertise and level. The committee considers it positive and significant that the lecturers are closely involved in the teaching of the bachelor's and master's programmes.

2.5 Intake and study load

Appendix 5 shows the figures for enrolment, efficiency and drop-out.

Bachelor's programme

According to the critical reflection, students are admitted on the basis of their pre-university qualifications. For the *bachelor's programme*, applicants with the secondary school profile Nature & Engineering or Nature & Health are admissible. If necessary, these students are required to address any deficiencies in mathematics or physics. Students who have completed a bachelor's degree from an university of applied sciences can follow customized bridging courses in order to catch up.

The table in the appendix shows that first-year enrolment of the programme has increased slowly to 47 in 2011. The percentage of drop outs is around 25% in the first bachelor's year. Surprisingly, the number of first year students in 2012-2013 had doubled. In the next few months, interviews will be conducted to help understand this sudden growth. The results of the interviews may help the programme to sustain a substantially increased number of students. The committee also advises cooperation and sharing of students with other universities. The programme managers have their reservations regarding such cooperation, considering the poor fit between the applied character of their programme and the programmes of other Dutch universities in Earth Sciences. The committee understands this point of view, but, nevertheless, encourages management to unlock their programme and look for opportunities to share students with other programmes.

The committee noted that on average 20 to 25% students graduate in four years. It is aware that the percentage is biased by the fact that some students start with their master before they get their bachelor's degree. Nevertheless, the committee sees this low percentage as a serious problem. Programme managers, lecturers and study advisers and the students themselves indicated that the delay reflects an attitude of not being in a hurry and emphasis on enjoying a great social life. They all agree that the introduction of a *binding study recommendation* and the *bachelor before master rule* in 2009 encourages to complete the programme on time. However, the committee stated that in addition to such penalties, further efforts are required within the programme to improve study progress. It is aware that efforts are already being made to improve it, by changing the didactic concept. The committee strongly recommends that the results of these efforts should be evaluated and adjustments made if necessary.

The percentage of female students is less than 30%. In the semester 2012-2013, the enrolment of females is around 36%. The committee holds the opinion that the programme should strive for an equal enrolment of male and female students and it is encouraged by the increased number of females in the last semester.

The nominal study load comprises 60 EC per year, representing an average study load for students of 42 hours per week for ten weeks in each period. Results of a digital survey in 2012 indicate a high perceived study load in the first semester of the second year. Partly based on these results, the new curriculum provides a more balanced workload.

Master's programme
Admission to the master programme is restricted to students who have a bachelor's degree in *Applied Earth Sciences* or another TU Delft engineering discipline*, Engineering* from another Dutch or foreign university or students with a degree n *Physics, Mathematics* or *Geology* from another Dutch or foreign university. Admission is also granted to students who have completed a bachelor's degree in Engineering from an university of applied sciences. If necessary, these students can follow customized bridging courses in order to catch up.

The table in Appendix 5 shows that the number of master students is around 70. The number of international students has increased to 67% in 2011. The percentage of dropouts is around 15%. The committee is pleased to note the high percentage of international students. For the most part, the two international tracks are responsible for this high ratio. The percentage of female students is less than 30%. The committee advises that increased effort should be directed to attracting more female students.

Success rates are close to 80% within three years. The vast majority have graduated within two years. The committee holds the opinion that this percentage is acceptable.

2.6 Facilities

Based on written documentation and a guided tour, the committee is convinced that the facilities are very good. The laboratories are characterized as an impressive resource not only for research but also for teaching purposes.

2.7 Support

The committee noted that during the programme the study advisor is not in a position to keep track of the content and performance of individual curricula due to the heavy workload (more than 1000 students). The advisor focuses on students with serious delay issues or those who make an appointment themselves. During the site visit, the study advisor indicated that experiments with social media were being conducted to maintain contact with students as much as possible. The study advisor also stated that language barriers and problems such as homesickness are complicating factors in offering international student full support.

During the site visit, the committee noted that lecturers are very accessible and students do not hesitate to contact them if needed. There is also a mentor-tutor system. New bachelor students are mentored by a second-year student and a staff member as a tutor. Each mentor group, which consists of eight or nine students, has weekly meetings with its mentor during the first teaching period. After this period, the frequency decreases. Students in a mentor group have meetings with their tutor once or twice during each teaching period. The committee recognises the importance of this kind of support.

The committee concludes that the study advisor puts a lot of effort into the guidance of students. Furthermore, lecturers provide support on the content side of the programme, whereas tutors are useful in guiding students through the programme. Nevertheless, given the slow progress and the percentage of drop outs, it seems that some students slip through the net of support. The committee therefore recommended that the support system should be organised more proactively and effectively. This may involve increasing the complement of study advisors.

2.8 Internationalisation

The bachelor's and master's programmes have an opposite international character. The *bachelor's programme* has a national orientation. The language is Dutch and only a few students have an international background. The committee recommends that the programme should develop a more international perspective. The aim of the programme is to prepare students for the global market. This aim can never be reached without an international character. The interviewed programme managers agreed, and confirmed that they are looking for opportunities to internationalise the programme. Not only with the intention to offer a preparation for the global market but also as a way to attract more students. The committee is pleased to note that internationalisation is on the agenda, but encourages the programme to realise its plans. For example, it is a missed opportunity that the new curriculum is still in Dutch. The committee suggests that the bachelor's programme could be taught in English. This would attract more students from abroad and provide exchange opportunities for TUD students.

In the *master programme*, the two tracks *Applied Geophysics* and *Resource Engineering* have a strong international orientation. The interviewed students greatly value this international character. They learn to cooperate with students from several backgrounds and they have the opportunity to study abroad for a while. The committee gained the impression that the strong international research contacts are used in an effective way to promote the international profile of the programme. The committee is convinced that the programme will be very successful in its efforts to increase its international dimension.

2.9 Safety

An important issue related to fieldwork is safety. The programmes have a travel insurance policy. Furthermore, to guarantee that students are aware of the risk, dangerous situations and safety rules, they have to sign a form before each fieldtrip. The committee has studied those forms and concludes that for example *Msc Fieldwork Reservoir Geological Fieldwork 2012* is a well written document but it has no legal status. During the visit, the committee discussed this topic with the management, lecturers and students. It learned that the management, lecturers and students are not fully aware of the legal position of the faculty, staff and students during fieldwork. Fieldwork has its risks, accidents may occur, and the consequences can be immense. Therefore, it is necessary to carry out fieldwork with a legally based safety assurance system. The committee strongly recommends that 1) the legal position of the faculty, staff and students should be established and 2) a safety assurance system based on legislation and including a record of accidents should be developed. It suggests developing this system in cooperation with other Earth Sciences programmes in the Netherlands. Furthermore, it advises provision of an obligatory first aid course for both students and lecturers.

Considerations

The committee concludes that the content and level of the *bachelor's programme* are adequate to guarantee that students achieve the intended learning outcomes. The committee finds the curriculum to be highly structured and well organised. The new curriculum is seen as an improvement, especially in the more logical scheduling of the physics and mathematics courses. The committee is convinced that the curriculum pays enough attention to the societal aspects of the curriculum, but holds the opinion that these societal aspects should be presented more visibly in the programme. It is suggested that the credits for the thesis report should be increased, to provide the opportunity to produce a comprehensive research report.

The committee feels that the bachelor's programme lacks international orientation. As a result, it fails in its intention to prepare bachelor students for the global market. Furthermore, it does not fully provide the opportunity for students to follow an international career in industry after their graduation. With respect to the relatively low intake numbers, an internationally oriented bachelor's programme should attract an increased number of students from abroad.

The committee concludes that the content and level of the *master's programme* are sufficient to guarantee that students achieve the intended learning outcomes. The committee is of the opinion that the content of the courses is of high quality and covers most of the intended aspects of Applied Earth Sciences. The committee's main concern is the emphasis on essentially independent and highly specialised tracks. The tracks deliver specialists, whereas industry is possibly more interested in less specialised graduates. Furthermore, the tracks can be more efficiently organised, within an overall structure which is currently lacking. The committee is pleased to note the future plans to rearrange the courses in a more efficient way.

The committee applauds the offering of two international tracks and the way the tracks are organised in such a way that students attend several universities. Although the committee is aware that the assurance of the quality and coherence of the whole programmes can be improved, it is convinced that the programmes devote already much effort to these aspects.

The committee has its reservations about the recently introduced didactic concept for the new bachelor's curriculum in which the number of contact hours is decreased. A transition from lectures to more individual based feedback is to be encouraged, although this should not result in a reduction of the total number of contact hours. The committee encourages the introduction of mid-term assessments.

The committee concludes that the quality assurance is satisfactory. However, considering the changes in curricula and didactic concept, together with the increasing number of students, a more proactive role for the Board of studies is required. It concludes that the assurance of the quality and coherence of the international tracks can be enhanced.

The committee concludes that the programmes are provided by motivated lecturers who are both willing and able to pay close attention to the students. It is positive about the research qualities of the lecturers, which enable them to deliver state of the art knowledge. It is also very positive about the strong connections between master lecturers and industry. The committee further concludes that their educational quality is apparent.

The committee concludes that the intake numbers and slow progress of students in the bachelor programme represent a weak point of the programme. It is pleased to note that the intake for the current year (2012-2013) has doubled, which can be seen as a positive indicator. With respect to the student's progress, the committee is aware that the programme has already introduced changes in the didactic concept to increase the proportion of students that graduate on time. A more proactive support system would probably also be of help.

The committee concludes that no legally based safety assurance system for fieldwork currently exists. The committee strongly recommends that such a system should be developed, together with obligatory first aid courses for both students and lecturers.

Conclusion
Bachelor's programme Applied Earth Sciences: the committee assesses Standard 2 as **satisfactory**.
Master's programme Applied Earth Sciences: the committee assesses Standard 2 as **satisfactory**.

Standard 3: Assessment and achieved learning outcomes

The programme has an adequate assessment system in place and demonstrates that the intended learning outcomes are achieved.

Explanation:
The level achieved is demonstrated by interim and final tests, final projects and the performance of graduates in actual practice or in post-graduate programmes. The tests and assessments are valid, reliable and transparent to the students.

Findings

3.1 Assessment system and methods

The committee studied the examination policy, the role of the Board of Examiners and the quality of several assignments. Special attention was paid to the procedure to assess the students' performance during the thesis project.

The committee learned that the Board of Examiners is responsible for maintaining the set entrance qualifications and intended learning outcomes for both Applied Earth Sciences and Civil Engineering. It is responsible for the supervision of the overall academic level of the bachelor's and master's programme and its components. Furthermore, the Board approves the individual curricula of students. It is not involved, however, in setting the course criteria for grading. The Board reports to the director of education and the dean.

The programmes use several means of assessment, including written exams, reports and oral presentation. The committee concludes that the variety of the assessments is appropriate. It applauds the oral presentation at the end of the bachelor's and master's thesis project, because this presentation is given to a broad audience of both professionals and lay persons. The committee also welcomes the introduction of mid-term assessments. The interviewed lecturers and students are convinced that this kind of system helps to keep students on track.

For the committee, it is hard to establish the quality of the content of the written assessments and the appropriateness of the grading. The committee learned and observed that currently lecturers are setting and grading assessments on a personal basis. The committee disapproves of this procedure, because of the lack of transparency and objectivity. Furthermore, it is unclear to which intended learning outcomes the assessments are related. Currently, the Board of Examiners is producing a document that will ensure that lecturers set compose objective and transparent written assessments. During the site visit, the committee studied this document and concluded that it represents a step in the right direction. It encourages the Board of Examiners to introduce this system. The committee noted that the interviewed lecturers were not unanimously positive about the new protocol. They disagree that working with an explicit grading system will enhance the quality of assessment methods because such a system does not guarantee objectivity. The committee agreed with lecturers that such a system cannot avoid subjectivity completely but it promotes consistency. The committee welcomes the already existing initiative of lecturers to discuss their assessments informally with colleagues. As an improvement, these discussions can be formalised.

For the *bachelor's* and *master's* thesis project, students are required to write a research proposal, including a description of the problem, the objectives, the research questions and the methodology for data collection. At the end, they hold a presentation for a broad audience. According to the critical reflection, the theses are assessed primarily according to the work performed, the written report and, in some cases, the following three aspects; 1) attitude, initiative and independence; 2) the results in relation to the research question; 3) oral presentation and response to questions from the audience and assessors. The findings and final grading are communicated orally to the student. A committee is involved during the thesis project to guide and assess the student. This committee is composed of both lecturers and professionals who serve as internal and external assessors. A form, aimed at ensuring transparent and objective grading is not currently used. The Board of Examiners is at present designing such form.

The committee is very positive about the instalment of a thesis-committee to guide and assess the students during the thesis project. The committee was very concerned about the absence of an assessment protocol for theses, although it learned that the Board of Examiners has started to develop such a form. The committee has seen their draft and concluded that it should be seen as representing a good start but not a definitive final version. To improve the form, the committee strongly recommends that the following issues should be addressed. Firstly, the committee disapproves of giving a variable weighting to the components representing attitude, results and oral presentation. From the committee's point of view, there should, to ensure fairness, be a uniform grading system for all students with no difference between tracks or lecturers in the weighting of these aspects. Secondly, rubrics should be formulated to make clear the boundaries between a pass and fail grade. Thirdly, narrative feedback should be provided within the form or as addendum. Oral grading can be sufficient, but for the student it is important to be able to read and re-read the comments.

3.2 Success rate and performance

Based on the theses and the careers of both bachelor and master graduates, the committee established that the intended learning outcomes are achieved.

Bachelor's programme

Prior to the site visit, the committee received 15 bachelor theses selected from a list in the critical reflection containing the theses completed in the last two years. The theses were selected to cover the range of the research topics. Emphasis was placed on the theses graded with a six. The committee concludes that the quality of the theses is acceptable but not outstanding. Some theses had more of the character of a lab report than a research report. The committee is aware that the credits of the thesis are only 8 EC and from that perspective it is willing to conclude that the quality of theses is meagre but adequate. In the new curriculum, the credits for a thesis project will be increased to 10 EC. The committee advises that the credits should be increased to at least 12 EC to allow students to perform a good research project at the bachelor's level.

According to the critical reflection, the majority of the bachelor graduates (more than 95%) continue their studies with a master's programme. The graduates who follow the Applied Earth Sciences master encounter no identified problems. This indicates that bachelor students achieve the intended learning outcomes and are well prepared for a master.

Master's programme

The committee selected 16 master's theses in the same manner as described for the bachelor's programme. The committee studied the theses and concluded that their quality either conformed to or exceeded their expectations. The theses show convincingly that students acquire the programme's intended learning outcomes. The committee gained the impression that most of the students were mastering their research subject very well.

The committee is aware that industry is keen to recruit graduates from the master programme in Applied Earth Sciences at TUD. Careers in scientific research, although less common, are, nevertheless, documented in the critical reflection.

Considerations

The committee verified the assessment system and methods as well as the achievement of intended learning outcomes by students. It concludes that the assessment system leaves room for improvement. However, it is convinced that these improvements will be made, bearing in mind the ongoing efforts of the Board of Studies and the Board of Examiners.

The main concern of the committee is the lecturer's freedom to develop assessment methods and criteria. Although it is aware that the lecturers involved have the best of intentions and aim to provide an appropriate assessment and grading, the current approach hinders transparency and objectivity. The committee encourages the efforts already taken to develop a framework for assessment policy but underpins the need to implement it in the near future.

For the thesis project, the committee values the creation of a committee to supervise students during the project. The lack of a thesis assessment form is, however, seen as a serious problem. It is aware that the Board of Examiners has started to develop such form. The committee holds the opinion that the form currently under construction can be strengthened by integrating their recommendations.

To assess the achievement of the learning outcomes, the committee has studied several theses. Based on the theses and the information gathered about progress and success rates, the committee confirmed that bachelor and master students achieve the learning outcomes to a satisfactory level. The committee holds the opinion that the programme should allocate more credits for the bachelor thesis. The 8 EC credits are not enough to enable students to achieve fully the requirements of a research report. The committee is impressed with the quality of the master theses.

Conclusion
Bachelor's programme Applied Earth Sciences: the committee assesses Standard 3 as **satisfactory**.
Master's programme Applied Earth Sciences: the committee assesses Standard 3 as **satisfactory**.

General conclusion

The committee concludes that the bachelor's and master's programme offer an unique curriculum in Applied Earth Sciences. The committee is very positive about the international character of the master's programme. The strong connections with industry mean that students are prepared very well for this professional field.

The committee has identified four main issues needing special attention. The most important issue is the assessment system. The system does not currently guarantee objectivity and transparency. It firmly recommends adjustment of the system in line with the suggestions as contained in this report. Secondly, the slow study progress is of concern. The committee noted that efforts are already being made to improve this rate. Further monitoring is needed to evaluate these efforts. Thirdly, the bachelor's programme can be improved by giving it a more international character. The committee holds the opinion that a bachelor's graduate in Applied Earth Sciences, should be well prepared for the international market. Fourthly, the committee strongly recommends that a legally based safety assurance system should be developed as a matter of urgency, to legally protect faculty, staff and students. Inherent to this, teaching staff should ensure that safety rules are enforced in the field. In addition, obligatory first aid courses for both students and lecturers are recommended.

The committee is convinced that the quality of the bachelor's and master's programme is maintained by the highly motivated and capable lecturers and other persons who are responsible for the programmes.

Conclusion
The committee assesses the *bachelor's programme Applied Earth Sciences* as **satisfactory**.
The committee assesses the *master's programme Applied Earth Sciences* as **satisfactory**.

Appendices

Appendix 1: Curricula vitae of the members of the assessment committee

Prof. Rien Herber holds the position of professor in Geo-Energy at the Energy and Sustainability Research Institute of the University of Groningen. After graduating as a geophysicist in Utrecht University in 1979 he started his career in Shell in the research lab in Rijswijk. Following assignments in Brunei, Thailand and the Netherlands he moved northward to Norway as exploration manager for Norske Shell, during which period the deep water Atlantic Margin was opened. In 1998 he moved back to NAM as exploration manager. Still based in Assen, he was appointed in 2003 as Vice President Exploration for Shell in Europe. In this capacity he was responsible for the Shell operated exploration activities in the UK, Netherlands, Norway, Ukraine, Sweden and Ireland, non-operated Shell interests in Germany, Denmark and Italy as well as new exploration opportunities outside these countries. In addition to these responsibilities he has been Deputy General Manager of NAM since 2004 until mid 2009 when he left Shell to take up the professorship in Groningen. Herber is a member of the Dutch Mining Council since 2010.

Prof. Jan Hopmans is Professor of Vadose Zone Hydrology at the University of California, Davis. He graduated with a Master degree in Hydrology at Wageningen Agricultural University (Netherlands) in 1981 and received his PhD in 1985 at Auburn University (USA) in soil physics. He accepted a faculty position at the University of California, Davis, USA, in 1988. His research and teaching activities focus on the development of experimental and mathematical methods to better understand the fundamental processes controlling soil water flow and transport in the vadose zone across spatial scales, and include interests in pore-scale processes, soil water-plant relationships, irrigation water management at field and basin scale, and climate change impacts on CA hydrology. He has about 150 peer-reviewed publications in soil science and water resources journals. He is fellow of the Soil Science Society of America and the American Geophysical Union, and he received the 2003 Soil Physics Don and Betty Kirkham Award. He was past-chair of Department of Land, Air and Water Resources at UC Davis, and is currently Associate Dean of the College of Agricultural and Environmental Sciences, and Co-Editor of Vadose Zone Journal.

Prof. Desmond E. Walling recently retired as Reardon Smith Professor of Geography at the University of Exeter, UK and he is currently Emeritus Professor of Physical Geography within the College of Life and Environmental Sciences at Exeter. His research and teaching interests lie at the interface of Hydrology and Geomorphology, with particular reference to erosion, sediment transport and sediment budgets at both the catchment and global scale. He has a special interest in the use of fallout radionuclides for sediment tracing. He has published 34 books and edited volumes and more than 500 papers in journals and conference proceedings. He has maintained a strong involvement in international scientific activities throughout his career and he has served as President of the International Commission on Continental Erosion (ICCE), the International Association of Sediment Water Science (IASWS) and the World Association of Sedimentation and Erosion Research (WASER). He is currently a member of the Steering Committee of the UNESCO International Sediment Initiative. He was the recipient of the IAHS/UNESCO/WMO International Hydrology Prize in 2007 and the AGU Hydrological Sciences Award in 2008.

Prof. Martin Landrø is Professor of applied geophysics at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. His main fields of interests are reservoir geophysics (including time lapse seismic), seismic inversion methods, rock physics, four-component seismic, marine seismic acquisition, analysis of CSEM data, and gravimetric methods for monitoring purposes. He is leader of the ROSE consortium at NTNU. This consortium is focused on rock physics, geomechanics and various seismic methods. Present research activities include time lapse seismic in general, time lapse refraction methods, time lapse tomographic inversion, monitoring of CO2-storage, rock physics, modelling of air gun sources, using CSEM-data for monitoring purposes, and research related to improve understanding of salt. In 2009 Landrø launched a research project focusing on long term monitoring (LOSEM) of an old underground blow out (from 1989), where the objective is to investigate long term migration of gas through shallow sediments. Landrø currently serves as a member of the programme committee for the Norwegian Academy of Technical Sciences.

Drs. Renate Prenen is educational advisor and independent entrepreneur in educational advice. She studied Applied Educational Sciences at Twente University. She worked at Randstad employment agency as advisor and programme manager. Later, she worked at the Academic Medical Centre (AMC) of the University of Amsterdam, where she was educational advisor for the Board of the AMC. In September 2009 she started as an independent educational advisor. She has been a committee member on other QANU assessment committees.

Maaike Cazemier MSc completed the Master's programme in Hydrology and Water Quality at Wageningen University in September 2012. In 2006 after finishing her pre-university education (VWO) at RSG De Borgen in Leek, she started her Bachelor Soil, Water, Atmosphere at Wageningen University. During the first two years in Wageningen, she was an active race-rower for Students Rowing Association Argo. In the following years, she was an active member of Study Association Pyrus where she was a board member (2009-2010) with responsibility for study matters. Furthermore, she was active in a number of committees both for the rowing association and the study association. In 2010 she was chairwoman of the committee that organised the 51st Argo short track races, a national rowing competition featuring some 250 rowing teams.

Appendix 2: Domain-specific framework of reference

Realization of the domain-specific reference framework for Earth Sciences
The domain-specific reference framework was created by the Chamber for Earth Sciences and educational administrators and/or heads of departments of university institutions with degree programs in the Earth Sciences. It evolved out of a number of joint meetings. The Chamber decided to formulate a general domain-specific reference framework applicable to all Earth Science programs in the Netherlands. Each institute is responsible for its own self-evaluation against the Dublin descriptors for the international positioning of its programmes. The current domain-specific framework is a modified version of the framework established in 2006. It takes into account society's rapidly growing demand for well-trained Earth scientists prepared to tackle scientific and societal issues. In updating the framework, use has been made of "Agenda 2020: Perspectives of the Earth Sciences", the outcome of a series of consultation workshops organized in 2009 by the Council for Earth and Life Sciences (RAL) of the Royal Netherlands Academy of Arts and Sciences (KNAW). Successful implementation of innovative fundamental and applied research often relies on input from various scientific disciplines, enabling cross fertilization of ideas. However, deepening of knowledge of a discipline is often one of the means to seek its boundaries. It is precisely at the interface between separate disciplines that crucial breakthroughs may be made. Both mono- and interdisciplinary training and education, as is the case for Earth Sciences, should therefore be stimulated. Demand for highly educated persons is currently strong and is expected to increase, with correspondingly good job opportunities for Earth scientists. The Dutch government has recently identified a number of key economic sectors in which industry, academia and (semi)governmental institutions should collaborate in fields relevant to society. Earth Sciences has a strong position in two of these nine key economic sectors: energy and water.

System Earth
Earth Sciences have the planet Earth as their object of study, its genesis and its quality of life. Knowledge is gathered about its origin, its current and former composition, structure, and the processes acting in and between the components geosphere, hydrosphere, atmosphere and biosphere. Equally important is knowledge of how to manage and sustainably use Earth's resources and understand the influence of human activity on the terrestrial system. It is of vital importance to gain insight into the wide range of time and spatial scales on which earth processes operate and are manifest. The study of Earth Sciences combines aspects of observation in different forms, via remote-sensing (air and land surface), field studies (surface/outcrop observations and measurements), measurements from within the Earth (e.g. seismology, earth material), analysis of data using laboratory methodology and techniques, and through developing and testing of concepts via computational modelling and simulations. Over the last couple of decades, increasing attention has been paid to the relationship between the Earth Sciences and society. The impact is clear in the fields of natural resource (energy – raw materials – water) evaluation, global climate evolution, the environment and natural and man-induced hazards. In The Netherlands, Earth Science knowledge is widely employed in the design of infrastructure in our heavily populated delta and in the use and management of the shallow and deep subsurface. This development has led to a replacement of the question "what does the Earth mean for humans?" by the question "what do humans mean for the Earth?" In other words: What roles do anthropogenic factors play in terrestrial and atmospheric processes and how can this knowledge be translated into governmental policies and societal action? Also, which measures can we take to incorporate, absorb or mitigate the consequences of man-induced changes in the Earth system? The rapid technological and computational innovations of recent years have created important new

challenges and opportunities for the development of Earth Sciences in general and for the training of a new generation of students and young scientists in particular. These technological innovations, partly initiated and stimulated by advances in the field of IT, in modern forms of observation, analysis and experimentation, visualization, simulation and modelling, along with improvements in data mining, technical data processing and data assimilation, have led to a broader and deeper insight into how the Earth system works and how we can be more effective in the use and management of the planet. Science is no longer conducted exclusively within the limits of one discipline and this applies equally to Earth Sciences, where physics, chemistry, biology/microbiology/ecology and applied mathematics/informatics are integrated. In an even wider perspective, Earth Sciences research is increasingly incorporating knowledge from the social sciences. The practice of the various Earth Science disciplines themselves is also characterized by an increasing integration and by multidisciplinary collaboration. Going beyond the boundaries of the Earth Sciences disciplines does not mean, however, that the role of specializations will decrease. Integration and specialization both demand attention if further development is to take place. Specialist depth remains essential to multidisciplinary research at high levels. Likewise, a good connection is essential between fundamental aspects and applied aspects.

The Earth system contains the following four subdomains:

Geosphere

The geosphere encompasses the solid part of planet Earth, from depths of a few 100s of meters, through the Earth's crust and mantle to its core. Most of it is inaccessible for direct, *in-situ* observation; hence predicting its architecture and physico-chemical properties is a challenging task. Large- and small-scale cycles and processes, heat exchange and movement of material take place between the different subcomponents and towards the surface and atmosphere, on a wide range of time and spatial scales. Plate tectonics, mountain range formation and erosion, geochemical differentiation and cyclicity, terrestrial material formation and deformation, strength and tension of and within materials, along with resources like energy, water and ores are all aspects of the Earth system that are directly linked to solid or deep Earth. Knowledge of the solid Earth comes from geological, geophysical and geochemical research in the following subdisciplines: tectonics, structural geology, seismology, experimental materials science and deformation, sedimentology, paleomagnetism, petrology, volcanology, thermodynamics and isotope geochemistry.

Surface

The subdomain 'Surface' covers the shallow subsurface, to a maximum depth of several hundred meters, the Earth's surface and the lower part of the atmosphere (Troposphere). Processes and developments in the deep Earth (endogenous processes) serve as boundary conditions for the working and effectiveness of physical, chemical and biological processes at the Earth's surface. Exogenous near-surface processes between the atmosphere and the Earth's surface layer involve complex, non-linear interactions acting on a wide range of temporal and spatial scales. Flow of matter plays a crucial role in this subdomain, whether in the form of particles or in the form of solutes or gasses. Such flows, via surface and groundwater in the biosphere and soil, are responsible for the further development of the terrestrial relief through erosion and sedimentation, the development and maintenance of natural ecosystems and changes in physico-chemical properties of soils. The Earth's surface is the habitat of man, where there is a strong link between human activities and natural processes, e.g. concerning the use of the underground to realize infrastructural projects, the production of agricultural crops and, on a larger scale, concerning the consequences of "climate change" for landscape and society, in the form of sea level rise and changes in land use. Relevant subdisciplines include soil science, physical geography, geology, biogeochemistry, sedimentology and hydrology. Further distinctions can be made: soil chemistry and physics, geomorphology, hydrodynamics, Quaternary geology, hydrology/geohydrology/ecohydrology, soil and microbiology, landscape ecology, geo-informatics and geostatistics.

Biosphere-hydrosphere-atmosphere
Physical and chemical processes determine the status of the atmosphere and the water and element cycles that interact directly with the Earth's surface (vegetation, soil, surface water). This interaction is partly determined by climate variability and change, and partly by land use. Water infiltrating into the surface not only provides a means of subsistence (store of drinking water, irrigation water), it is an important conditioning factor for a large series of linked physical, chemical and biological/microbiological processes in the soil and shallow subsurface. The flow of the water at the land surface ensures the transport of particulate and dissolved substances (nutrients, contaminants, trace elements) from the land surface via the rivers to the oceans. Water and climate processes, acting over a range of temporal and spatial scales, are vital to the Earth's biosphere. This is also true for the interaction between the lithosphere and the biosphere. An important element is the crucial role played by the biosphere in maintaining or changing the biogeochemical functioning of the Earth. The primary subdisciplines of this domain are: meteorology, air quality/atmospheric chemistry, climatology, physics and soil physics, hydrogeology, hydraulics, environmental hydrology, landscape ecology, ecology (including aquatic ecology), geobiochemistry, biology/microbiology, paleontology, geoinformatics, and paleoceanography/marine sciences.

Applied Earth Sciences
Applied Earth Sciences are concerned with the part of the Earth that interacts strongly with society, namely the upper few kilometres of the Earth's crust. This layer hosts the largest part of our resources (from water to ore minerals) and supports an increasing number of infrastructural interventions. In this domain, sedimentological, tectonic, and other natural processes have a profound impact on engineered and other manmade structures, ranging from tunnel building to excavations and constructions. Sustainable management of this delicate outer shell of the Earth requires a combination of highly sophisticated tools to image the Earth's subsurface at depths of tens to thousands of meters, and a profound understanding of the phenomena involved. Exploration and exploitation, as well as processing and recycling, of terrestrial materials (including oil and gas) require the ability to develop and employ prudent and environmentally friendly engineering approaches to the use of the Earth and its subsurface resources. This means that not only geological processes and systems, but also the fundamentals of processes imposed by man, like fluid flow through porous media, geophysical and petrophysical exploration techniques, geomechanics for deformation, strength and tension in rocks and soil, chemistry for mining, metal production, and recycling of materials should be taught. To study these processes, considerable attention is paid to the observation, analysis, and processing techniques themselves. The study of Applied Earth Sciences has a strong geological component and involves the primary subdisciplines: applied geophysics, petroleum engineering, reservoir geology, geo-engineering and resource engineering.

Place of Earth Sciences in society
It is very important that degree programs reflect the current working environment and the application of the Earth Sciences in modern society. Potential employers include universities, government and semi-government agencies, consultancy firms and industry. The different fields of application are:

Natural resources
This covers the application of existing, as well as development of new technologies for the geological and geophysical exploration of natural resources present in the continental subsurface and below the sea, and the sustainable, environmentally responsible management and use of these resources. Examples of natural resources include: industrial minerals, water for human consumption and food production, energy, raw materials and soil (food supply). In the future, particular attention will be paid to the scarcity of resources and to the energy transition.

Terrestrial space
Sustainable management of the subsurface, natural ecosystems and aboveground space are essential to man's future existence. The shallow underground is being increasingly used for laying infrastructural facilities (cables, tunnels, transport lines, etc.), the building of utilities (storage of goods, shopping centers, waste products, etc.) and the storage of energy (thermal, potential, etc.), of energy carriers (e.g. gas) or of residues (CO2, etc.). In many regions the use of land is intensifying and changing. On a global scale there is excessive population growth in deltas, coastal areas and along rivers. This creates intense pressure on the use of these areas and the atmosphere. Earth Science expertise is essential to the management of these areas. Given the many possible uses for the subsurface (e.g. support for constructions, substrate for agriculture and nature, source of minerals, ecological cleansing of groundwater and contaminated soil, etc.), there is also a connection with environmental planning.

Functioning of terrestrial (eco)systems
This field covers, on the one hand, the influence of human activities on soil, water and atmosphere and, on the other hand, natural variations in the quality of the terrestrial environment, including undisturbed (eco)systems. Earth Science expertise and knowledge are essential for both aspects, as well as to our ability to sustain the quality of life and our environment. For the management and removal of contaminants in the terrestrial environment, like the cleaning up of polluted terrains or waste disposal, knowledge and expertise in the fields of civil, chemical and microbiological technology are required.

Natural and man-induced hazards
This field covers the study and analysis of natural hazards like earthquakes, tidal waves, hurricanes and tornadoes, floods and droughts, tsunamis and volcanic eruptions, as well as risks resulting from human activities, like subsidence due to the extraction of groundwater or oil and natural gas, interventions in the courses of rivers, creating recreational and residential areas in vulnerable regions, etc. Most importantly, the risks resulting from climate change belong to this field of application. It is particularly in this area that sound Earth Science knowledge is required input for policy measures at local authority, provincial and national government levels. Safety is an increasingly important dimension in our society.

Earth Sciences as auxiliary science
Another field of application of the Earth Sciences is as an auxiliary science. Modern Earth Sciences (with its tendency towards exact, quantitative aspects) form a foundation for other disciplines, like ecology, archaeology and geobioarchaeology, agricultural and environmental sciences, oceanography and meteorology, in the same way as e.g. physics, chemistry and biology have affected the Earth Sciences.

General objective of a degree programme in Earth Sciences

The general objective of the university programmes is to produce graduates capable of conducting activities appropriate to the broad field of Earth Sciences at the academic level. These activities include research (fundamental, strategic or applied science), development, advisory, didactic or implementation activities. The modern Earth scientist should be equipped with knowledge of terrestrial processes in order to i) determine or predict the present architecture and physico-chemical properties at the surface, lower atmosphere and shallow to deep subsurface and how this controls human activities, and ii) understand and predict how natural and/or man-induced processes will impact our environment. The need for further insight into terrestrial processes requires understanding of a broad spectrum of spatial and time scales and an approach which pays attention to the interaction of and between the various terrestrial subdomains.

Objective of a bachelor degree programme in Earth Sciences

Earth Sciences is a broad science, which examines the processes and patterns found on the Earth's surface in the deep and shallow subsurface and in the atmosphere. This science is strongly interdisciplinary, with interaction between various factors, such as humans, animals, relief, soil, water, lithology, atmosphere, hydrosphere and vegetation. The three-year bachelor's programme in Earth Sciences teaches the student knowledge and skills in the field of the 'Earth system' in a broad sense, and in one of the four subdomains in particular. The programme focuses on learning to understand patterns and processes, including applications, using modern techniques like geo-informatics, simulation and modelling. It is very important that a bachelor graduate in Earth Sciences has experience with both field and laboratory studies. After completing a bachelor's programme in Earth Sciences the student has:

• Knowledge and insight into terrestrial and/or atmospheric processes, the fundamental mechanisms underlying these processes, and the resulting patternsand systems.
• Insight into the place that the Earth Sciences occupy in relation to other fields of science.
• Insight into the activities and responsibilities of an Earth scientist.
• Knowledge of techniques used in the description and interpretation of Earth Science phenomena in and on the Earth's crust: sampling, analysing, simulating and modelling data.
• Skills in application of the research techniques most commonly used in the Earth Sciences and an ability to learn new techniques. This refers especially to measurement techniques used in the laboratory or in the field, and analysis techniques and software used for the acquisition, storage, analysis and modelling of the data.
• Basic skills in preparing a research plan, defining and formulating a problem, collecting relevant background information (literature search) and collecting and processing data.
• Ability to report clearly on scientific research both orally and in writing.
• Ability to work independently as well as in a team.
• Ability to collaborate with scientists from allied disciplines.
• Ability to defend own viewpoint and willingness to revise that standpoint after scientific discussion.
• A socially responsible attitude towards the sustainable use of natural resources and the terrestrial environment.

Objectives of a master's degree programme in Earth Sciences

The objectives of a master programme in Earth Sciences are to impart to the students the knowledge, attitudes, skills, and insights which render the graduate master (1) capable of practicing his/her profession independently, or (2) qualified for continuing training in scientific research. The graduate master should be competitive in his/her field on the international labour market, both for employment in trade and industry or government and within PhD-research programs at international scientific institutions. After completing a master's programme in Earth Sciences the student:

• Has specific theoretical and practical knowledge of the Earth Sciences, notably within the field of his/her specialization, such that he or she can start and successfully complete a PhD thesis or to take up a position at an academic level with government or government-related institutions, with private companies, or elsewhere.
• Is experienced in carrying out research. This experience has been gradually developed through the confrontation with research and with active researchers, and through active participation in research, in a manner that enables the student to consciously decide whether he/she prefers to continue his/her studies in order to obtain a PhD degree or to take up a position outside the academic world with or without a doctoral degree.
• Is able to function in his/her discipline at an academic level, both in way of thinking and in daily practice; has been stimulated to work on his/her personal development, notably regarding consciousness, independence, communicative behaviour and attitude towards co-operation.
• Has recognized the need to continue his/her education; the graduate is aware of the need to keep in touch with relevant developments within his/her discipline, and is prepared to realize this (lifelong learning).
• Has gained insight into the broad historical, philosophical and social context of the discipline and aspects concerning the intellectual integrity and moral and ethical dimensions of scientific research and its applications.
• Is able to successfully compete on the international labour market.

In the Master programme the students should obtain three levels of expertise:

• *Knowledge*: This comprises a basic understanding of the theory and scientific principles behind the theme or techniques taught, and an appreciation of when and how it can be appropriately used or applied. It does not imply that the student will work intensively with it in the programme itself. The group of courses that reach only the *knowledge*-level are generally restricted to the first year of the master.
• *Practical capability*: This means that at some point during the programme, usually at the beginning of the second master year, the student will have achieved a deep enough knowledge of a (group of) theme(s) or technique(s) that the student can demonstrate that he/she is in a position to apply this knowledge. In essence this means that this particular theme or group of themes will lie in the student's specialist direction.
• *Mastery*: Students will be expected to demonstrate that in at least one theme, they have carried out a research project (e.g. a field-based project) and produced a thesis document. This project may be done in Critical reflection BSc Soil, Water, Atmosphere 2011 | Wageningen University | 33 cooperation with other students but needs to comprise results adding to fundamental scientific knowledge. It should demonstrate the use of intellectual and creative skills as well as a working familiarity with current expertise in the subject, thereby contributing to it, for instance through the modification and further development of existing modelling tools. The mastery level is applicable to the master-thesis.

Appendix 3: Intended learning outcomes

Bachelor's programme

General

• Have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study.
• Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competencies typically demonstrated through devising and sustaining arguments and solving problems within their field of study.
• Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgements that includes reflection on relevant social, scientific or ethical issues.
• Can communicate information, ideas, problems and solutions to both specialist and nonspecialist audiences.
• Have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy.

Knowledge

• Students have obtained broad, basic, applied-scientific knowledge in the disciplines of geology, mathematics, physics and chemistry.
• Students have obtained knowledge specifically dedicated to the exploration, extraction, processing and recycling of energy carriers and raw materials, as well as the environmentally conscious use of the shallow and deeper subsurface.
• Students have obtained broad knowledge of methods for the collection and processing of data.

Skills

• Students are capable of analysing an applied earth-science problem and formulating creative and innovative solutions, both individually and in teams.
• Students are able to acquire insight into applied earth-science processes and transform them into abstract conceptual models.
• Students are able to communicate clearly in writing in the Dutch language.
• Students are able to deliver captivating and convincing oral presentations of research results.
• Students have obtained a wide variety of computer skills. The programme allows them to become acquainted with various proprietary software packages used in industry.

Attitude

• Students have a positive critical attitude towards the use of raw materials, energy and space.
• Students feel a sense of responsibility for the future development of science and Technology.

Master's programme

Knowledge
A basic understanding of the theory and scientific principles behind the theme or techniques taught, and an appreciation of when and how they can be appropriately used or applied. This does not imply that students will work intensively with these theories in the chosen Master's degree track itself.

Practical capability
Students will have achieved a sufficient depth of knowledge of a theme or technique, or group of themes or techniques, to enable them to demonstrate that they are in a position to apply this knowledge. In essence, this means that this particular theme or group of themes will be part of the students' specialisation.

Mastery
Students will be expected to demonstrate that they have carried out a research project (e.g. a field-based project) and produced a thesis document on at least one theme. The results of this project must add to fundamental scientific knowledge. It should demonstrate working familiarity with, and contribute to, current expertise on the subject, for instance through the modification and further development of existing modelling tools. The mastery level is applicable to the Master's thesis.

Communication
Students achieve the language and communications skills to work in an international environment, and to demonstrate social and cultural sensitivity. These skills are acquired by following an English course programme with a student population with diverse cultural backgrounds, and through experience working in teams and study periods abroad. Students demonstrate the ability to present conclusions and the underpinning knowledge and rationale to specialist and non-specialist multi-cultural and multidisciplinary audiences in both oral and written forms in the English language.

Learning skills
Throughout the course programme, students are expected to maintain a high degree of self-study. All tracks devote a considerable amount of time to thesis project work in which students largely study a research topic on their own. Students demonstrate their ability to learn independently, autonomously and in a self-directed manner. Students are aware of the necessity of lifelong learning in order to stay up to date on new developments in the field of their specialisation.

In addition:

Petroleum Engineering and Geosciences
specialisations: Petroleum Engineering (PE) and Reservoir Geology (RG)
Graduates at the Master's degree level should have obtained the following levels of expertise:
Knowledge
Of the basic geological processes that have formed the Earth: structural geology, stratigraphy, sedimentology, mapping, mineralogy and hydrocarbon generation and migration; of the physical and chemical processes governing the interaction between rocks and fluids, multiphase flow and primary and enhanced recovery techniques; of seismic and interpretation techniques, borehole logging and petrophysics;
PE: of hydrocarbon properties and oilfield fluids; working knowledge of drilling and well operations; basic knowledge of operational aspects of drilling and production;

RG: of the origin of primary (sedimentary) heterogeneity at various scales and its effects on dynamic reservoir properties and structural geology (fractures).

Practical capability

The capability to make quantitative predications based on knowledge of earth-forming geological processes and physical and chemical rock-fluid interaction processes;

PE: the capability to use the techniques of borehole flow simulations and apply them to reservoir management problems;

RG: the capability to acquire and process sedimentological and reservoir geological data and be able to make quantitative reservoir models from a wide range of geological, geophysical and petrophysical data.

Mastery

Graduates should demonstrate the ability to integrate and synthesise geological and rock-fluid interaction process knowledge with geophysical and petrophysical data for reservoir production optimisation and to formulate reservoir management strategies based on this knowledge and available data. They should also demonstrate the ability to further their knowledge and understanding in either PE or RG through independent and original research.

Applied Geophysics

Graduates at the Master's degree level should have obtained the following levels of expertise:

Knowledge

Of advanced seismic and electromagnetic wave propagation, diffusion and electric potential fields; of data acquisition and processing techniques; of seismic and interpretation techniques, borehole logging, and petrophysics; of sedimentology, hydrocarbon generation and migration and rock-fluid interaction; of the role of geophysical measurement techniques in hydrocarbon exploration and production, environmental and engineering and/or geothermal applications.

Practical capability

The capability to acquire and process geophysical field data; apply the knowledge of wave propagation, diffusion and potential fields in geophysical imaging, characterisation and inversion; design new field acquisition geometries for a given exploration or monitoring study and apply modern geophysical concepts such as passive seismics and interferometry.

Mastery

Graduates should demonstrate the ability to apply the concept of wave propagation to real seismic and ground-penetrating radar data and to characterise the subsurface based on geophysical and petrophysical data. They should also demonstrate the ability to further their knowledge and understanding in applied geophysics through independent and original research.

Geo-Engineering

specialisations: Geo-Engineering (GE) and Geotechnical and Environmental Engineering (EGEC)

Graduates at the Master's degree level should have obtained the following levels of expertise:

Knowledge

Able to explain using terms that are understandable to other engineers' past, and current geological processes affecting the site under study; have deep knowledge on geomechanics (soil mechanics, discontinuous rock mechanics, numerical geomechanics); on fluid flow in porous and fractured media; on processes of ground contamination and its remediation; on fundamentals required for engineering analysis, design, and construction.

Practical capability

The capability to manipulate, with dexterity, geological mapping techniques, databases and geoinformation systems; identify potentially hazardous grounds for a given engineering application or natural risk mitigation and to apply the above basic competences on actual field data and synthesise all available information in a subsurface model.

Mastery
Graduates should demonstrate the ability to apply site investigation techniques for exploring land and rock masses, both onshore and offshore, in the laboratory and in-situ and to provide a subsurface model that is meaningful to its users varying from geotechnical, mining or petroleum engineers and geophysicists or hydrogeologists to planners, politicians, economists or lawyers. They should also be able to demonstrate the ability to further their knowledge and understanding in geo-engineering through independent and original research.

Resource Engineering
specialisations: Mining Engineering (EMC), Minerals Engineering (EMEC) and Geotechnical and Environmental Engineering (EGEC)
Graduates at the Master's degree level should have obtained the following levels of expertise:

EMC:
Knowledge
In-depth knowledge of geomechanical processes relevant for mine behaviour; of the critical area of automation and maintenance, and their impact on the total economy of mine operation; of the environmental impact of acid mine drainage and an overview of basics and methods of underground waste disposal and backfilling; of mine ventilation: calculation and design of mine ventilation networks; an understanding of how to approach excavation in a systematic manner; of the financial parameters and understand present value concepts and cash surplus/deficit in estimating several important money streams.
Practical capability
The capability to apply numerical modelling techniques for computer-aided mine planning (design, stability analysis, data management, investigations and visualisation); use the awareness of key issues, related to the knowledge domains described above, in underground and surface excavations; in consideration of mine ventilation requirements in the design of underground mines.
Mastery
Graduates should demonstrate the ability to apply computer-aided engineering concepts to open pit and subsurface mining; apply net present value concepts for evaluating and ranking mine projects and quantify and produce mineral resources in an economical and sustainable manner. They should also demonstrate the ability to further their knowledge and understanding in mining engineering through independent and original research.

EMEC:
Knowledge
Of sampling, sensor controlled sorting and automated quality control of bulk streams; of the factors, including legislation, that determine the economy of raw material flows; of the various material cycles linking metals, plastics, waste products and end-of-life scenarios and of physical and chemical separation processes.
Practical capability
The capability to apply process modelling tools for the simulation and control of physical separation processes; to analyse systems and the material cycle; to design and manage an economically and ecologically feasible raw material flow and to develop and design physical separation process equipment.
Mastery
Graduates should be able to evaluate the potential of material resources (ores and solid waste) from an economic and ecological perspective and design processes that realise and optimise this potential; design tools for evaluating the industrial ecology of services and products and create innovative technology for production of raw materials. They should also demonstrate

the ability to further their knowledge and understanding in mineral engineering through independent and original research.

EGEC:
Knowledge
Of the fundamentals needed for engineering analysis, design and construction as well as geomechanical processes relevant for mine behaviour with a strong knowledge of geomechanics (soil mechanics, discontinuous rock mechanics and numerical geomechanics).
Practical capability
The capability to assess geo-engineering structures to determine if they are stable and whether exploitation is environmentally acceptable; an understanding of the related technologies, as well as economic, safety and environmental issues and an understanding of geo-engineering principles which are essential for excavation, tunnels, foundations, ground contamination and seismic analysis. Graduates should master site investigation techniques, including shallow-depth geophysics and geo-environmental techniques, for exploring soil and rock masses, on land and offshore, in the laboratory and in situ. They should also be able to apply the basic competences listed above to actual field data and synthesise all information available in a ground model that is meaningful to users with different backgrounds and they should be able to demonstrate the ability to identify potentially hazardous grounds in relation to a given engineering application or natural risk mitigation.

Appendix 4: Overview of the curricula

Bachelor's programme
2012-2013

Year	1st Quarter	EC	2nd Quarter	EC	3rd Quarter	EC	4th Quarter	EC
1st year	Introduction to Applied Earth Scienc	3	Introduction to Applied Earth Sciences	3	Introduction to Applied Earth Sciences	3	Introduction to Applied Earth Sciences (	3
	Minerals & Rocks I (TA1900-1/3)	2	Minerals & Rocks II (TA1900-2/4)	2	Minerals & Rocks III (TA1900-5)	1		
	General Geology (TA1910-1)	2					Geological Excursion (TA1913)	2
	Geological map reading (TA1911)	1			General Geology (TA1910-2)	2		
	Mathematics/Calculus (WI1300ta-1)	3	Mathematics/Calculus (WI1300ta-2)	3	Mathematics/Calculus (WI1300ta-3)	3	Mathematics/Calculus (WI1300ta-4)	3
			Lineair Algebra (WI2273ta)	3	Lineair Algebra (WI2273ta)	3		
	Introduction to chemistry for AES (ST	3	Mechanics 1 (TN4110ta dl 1)	4			Mechanics 2 (TN4120ta dl 2)	4
					Chemical Thermodynamics (MST1211t	2	Chemical Thermodynamics (MST1211ta	3
	Oral presentation (WM0203)	1			Written presentation (WM0201)	1		
		15,0		15,0		15,0		15,0
2nd year	Geology of the Netherlands	2	Sedimentology	2	Geological constructions	2	Geological Fieldwork (France)	6
	Structural Geology	2	Practical Sedimentology	1				
	Practical Matlab	2			Applied statistics	4	Data analysis & geostatistics	3
	Differential Equations	3						
	Instrumentation and Signals	3	Electricity & Magnetism	4				
			Physical transport phenomena	2	Physical transport phenomena	2		
			Analytical Chemistry incl Practical	3				
	Subsurface Characterization	3	Intr. Rock Mechanics	3	Intr. Reflection Seismics	3	Intr.Resource and Geo-Engineering	3
					Flow in Rocks and Soils CT3325/TA337	4		
							Technics and Responsibility	3
		15,0		15,0		15,0		15,0
3rd year	MINOR		MINOR		Fluid, flow, heat and mass transfer	4	Field Exploration	5
					Petrophysics	4	Bachelor Thesis / Individual project	10
					Numerical analysis	4		
					Elective, choose from: Petroleum Engineering Fields & Waves Special projects Eng. Geology	3		
		15		15		15		15

Master's programme: track applied geophysics

Code	Omschrijving	ECTS
AES Track Applied Geophysics (AG)		
AES Track Applied Geophysics 1st Year		
TU Delft semester 1; a minimum of 25 EC should be passed		
At least three out of four TUD courses must be passed		
AES1510	Geologic Interpretation of Seismic Data	3
AES1540-11	Electromagnetic Exploration Methods	6
AES1560	Advanced Reflection Seismology and Seismic Imaging	6
AES1890	Sedimentary Systems	3
Additional TUD courses		
AES1011	Matlab / Programming	2
AES1550-06	Geophysics Special Subjects	6
AES1590-11	Seismics resolution	4
AES3520	Introduction to Reflection Seismics	1
AES3820	Petroleum Geology	3
ETH Zürich semester 2; a minimum of 25 EC should be passed		
At least two out of three blocks must be passed		
Block 1 Modeling and inversion		
Block 2 Field courses		
Block 3 Processing		
Additional ETH courses		
AES Track Applied Geophysics 2nd Year		
RWTH Aachen semester 3; a minimum of 25 EC should be passed		
At least four out of five RWTH courses should be passed		
Additional RWTH courses		
Semester 4		
AES2005	Colloquium	1
AES2506-11	Thesis Applied Geophysics	29

Master's programme: track Geo-Engineering

Code	Omschrijving	ECTS
AES Track Geo-Engineering (GE)		
Compulsory Geo-engineering courses (26 ECTS)		
CIE4361	Behaviour of Soils and Rocks	6
CIE4365	Coupled Processes in Subsurface	4
CIE4366	Numerical Modelling in Geo-Engineering	6
CIE4395	Risk and Variability in GeoEngineering	4
CIE5320	Site Characterisation, Testing and Physical Model	6
Elective Courses to be selected for Geo-engineering profile (34 ECTS out of 69 ECTS)		
AES1630	Engineering Properties of Soils & Rocks	4
AES1640-11	Environmental Geotechnics	4
AES1650-07 D1	*Part 1 Shallow depth geophysics- theory*	*4*
AES1650-07 D2	*Part 2 Shallow Depth Geophysics- fieldwork*	*2*
AES1710	GIS Applications in Environmental Engineering Geology	3
AES1720-11	Rock Mechanics Applications	5
CIE3300-09	Use of Underground Space	4
CIE4353	Continuum Mechanics	6
CIE4362	Soil Structure Interaction	3
CIE4367	Embankments and Geosynthetics	4
CIE4780	Underground Space Technology, Special Topics	4
CIE5305	Bored and Immersed Tunneling	4
CIE5330	Foundations and Deep Excavations	4
CIE5340	Soil Dynamics	3
CIE5360	Special Topics in Geo-Engineering	3
CIE5741	Trenchless Technologies	4
OE4624	Offshore Soil Mechanics	3
Choose 2 of the possibilities listed below (20 ECTS)		
AES2602	Geo-Engineering Fieldwork	10
CIE4040-09	Traineeship	10
CIE4061-09	Multidisciplinary Project	10
CIE5050-09	Additional Graduation Work	10
Free electives (10 EC)		
MSc graduation thesis (40 ECTS)		
AES2606-40	Thesis Geo-Engineering	40
Convergence courses (to be taken if course content(s) not part of student BSc programme).		
AES1750-09	Geology for Engineers	4
CIE3325	Mechanics and Transport by Flow in Poreus Media	4
CIE4364	Introduction to Geotechnical Engineering	4
WM0312CIE	Philosophy, Technology Assessment and Ethics for CIE	4

Overview of courses MSc track Geoscience and Remote Sensing

1. The study programme for the Geoscience and Remote Sensing track consists of:
   - a common compulsory Geoscience and Remote Sensing block of 68 credits and Geoscience and Remote Sensing electives adding up to a total of 100 track-linked credits, as laid down in subsections 2 and 3
   - electives, 20 credits, as laid down in subsection 4.

2. Common compulsory block Geoscience and Remote Sensing
   All students opting for the track Geoscience and Remote Sensing must complete the following subjects adding up to 68 credits:

code	subject	ECs
CIE4601	Physics of the Earth and Atmosphere	5
CIE4603	Geo-signal Analysis and Interpretation	5
CIE4604	Simulation and Visualization	5
CIE4606	Geodesy and Remote Sensing	5
CIE4611	Geo-measurement Processing	5
CIE4615	GRS Fieldwork	3
AES2640	Final Thesis	40

3. Geoscience and Remote Sensing electives
   Students are required to complete a selection of the following subjects adding up to a total of 32 credits.

   If the Bachelor's phase did not include WM0325TA, Technics and Responsibility, the following subject is compulsory:

code	subject	ECs
CIE4613[1]	Climate Change: Science and Ethics	5

Choose at least 12 credits out of:

code	subject	ECs
CIE4602	Observation of Land-surface Processes	4
CIE4605	Atmospheric Science	4
CIE4607	Oceans, Sea-level and Bathymetry	4
CIE4608	Atmospheric Observation	4
CIE4609	Geodesy and Natural Hazards	4
CIE4610	Mass Transport in the Earth's System	4
CIE4614	Land Surveying and Civil Infrastructure	4

and choose adding up to a total of 32 credits out of:

CIE4612	Research Seminar Geoscience and Remote Sensing II	1
CIE5601	Advanced Topics in Geoscience and Remote Sensing	3
CIE5602	Research Seminar Geoscience and Remote Sensing I	1
Any Master's degree course subject Applied Earth Sciences or Civil Engineering		

4. Electives
   Choose two out of:

AES0404-10	Traineeship	10
AES4011-09	Additional thesis	10
CIE4061-09	Multi-disciplinary project	10
Any Master's degree course subject Applied Earth Sciences or Civil Engineering		10
Free Master of Science electives		10

Code	Omschrijving	ECTS
AES Track Petroleum Engineering & Geosciences (PE&G)		
AES Specialisation Petroleum Engineering (PE&G-PE)		
AES Specialisation Petroleum Engineering 1st Year		
AES0102	Image Analysis	1
AES1011	Matlab / Programming	2
AES1300	Properties of Hydrocarbons & Oilfield Fluids	3
AES1304	Introduction to Petroleum Engineering and NAM Visit	3
AES1310-10	Rock Fluid Physics	3
AES1320	Modelling of Fluid Flow in Porous Media	3
AES1330	Drilling & Production Engineering	4
AES1340	Reservoir Engineering	2
AES1350	Reservoir Simulation	2
AES1360	Production Optimisation	3
AES1500	Fundamentals of Borehole Logging	4
AES1510	Geologic Interpretation of Seismic Data	3
AES1520	Log Evaluation	2
AES1802	Geological Fieldwork (+ EM Methods)	3
AES1820-09	Reservoir Characterisation & Development	4
AES1890	Sedimentary Systems	3
AES1920	Geostatistics	2
AES1930	Quantification of Rock Reservoir Images	1
WI4012ta	Mathematics, Special Subjects	4
AES-PE Convergence Courses / Electives (2 ec)		
AES Specialisation Petroleum Engineering 2nd Year		
AES1303	Company Visits / Excursion	1
AES2005	Colloquium	1
AES2006	Graduation Thesis	44
AES2009	Field Development Project	9
AES-PE Electives (5 ec)		
AES1370	Non-Thermal Enhanced and Improved Oil Recovery	2
AES1380	Petroleum Engineering, Special Topics	3
AES1460	Heavy Oil	2
AES1470	Geothermics	2
AES1490	Advanced Reservoir Simulation	2
AES Specialisation Reservoir Geology (PE&G-RG)		
AES Specialisation Reservoir Geology 1st year		
AES0102	Image Analysis	1
AES1011	Matlab / Programming	2
AES1300	Properties of Hydrocarbons & Oilfield Fluids	3
AES1310-10	Rock Fluid Physics	3
AES1320	Modelling of Fluid Flow in Porous Media	3
AES1340	Reservoir Engineering	2
AES1510	Geologic Interpretation of Seismic Data	3
AES1520	Log Evaluation	2
AES1800	Exploration Geology (including Remote Sensing)	3
AES1802	Geological Fieldwork (+ EM Methods)	3
AES1820-09	Reservoir Characterisation & Development	4
AES1830	Reservoir Sedimentology	3
AES1840	Advanced Structural Geology	3
AES1850	Geological Modelling	4
AES1860-05	Analysis of Sedimentological Data	3
AES1890	Sedimentary Systems	3
AES1902	Reservoir Geological Fieldwork (Huesca)	6
AES1920	Geostatistics	2
AES1930	Quantification of Rock Reservoir Images	1
PE&G-RG Convergence Courses / Electives (6 ec)		
AES Specialisation Reservoir Geology 2nd Year		
AES2005	Colloquium	1
AES2006	Graduation Thesis	44
AES2009	Field Development Project	9
PE&G-RG Elective Courses (6 ec)		

Code	Omschrijving	ECTS
AES Track Resource Engineering (RE)		
AES Specialisation Mining Engineering (RE-EMC)		
AES Specialisation Mining Engineering (EMC) 1st Year		
EMC-A/EI-00	Environmental Issues	3
EMC-A/MV-04	Mine Ventilation	6
EMC-A/OP-05	Open Pit Mining	6
EMC-D/AL-07	Alluvial Mining and Marine Mining	5
EMC-D/CS-07	Case Study	6
EMC-D/IM-00	Industrial Minerals	2
EMC-D/ME-06	Mineral Economics	2
EMC-E/ED-07	Surface Excavation Design	7,5
EMC-E/PA-07	Project Management, Finance and Appraisal	7,5
EMC-H/AR	Applied Rock Mechanics for Hard Rock Mining	3
EMC-H/EX	Excursion	3
EMC-H/MA-04	Automation and Maintenance of Mining Equipment	3
EMC-H/ME-00	Mining Technology and Economics	3
EMC-H/MM	Numerical Mine Modelling	3
AES Specialisation Mining Engineering (EMC) 2nd Year		
AES2005	Colloquium	1
AES2006	Graduation Thesis	44
AES-EMC Elective Courses 15 EC		
AES Specialisation Mineral Engineering (RE-EMEC)		
AES Specialisation Mineral Engineering (EMEC) 1st Year		
EMEC-A/MR	Metal Recycling	8
EMEC-A/RM-06	Recycling Metallurgy	7
EMEC-E/ES	Process Design & Equipment Selection	7,5
EMEC-E/PS	Physical Separation Technology	7,5
EMEC-H/PD-10	Plant Design	8
EMEC-H/PO	Process Optimization	7
EMEC-W/BM	Biomining	2
EMEC-W/HY	Hydrometallurgy	4
EMEC-W/ME	Mineral Economics	2
EMEC-W/PM	Pyrometallurgy	4
EMEC-W/PR	(Wroclaw) Plastic Recycling	3
AES Specialisation Mineral Engineering (EMEC) 2nd Year		
AES2005	Colloquium	1
AES2006	Graduation Thesis	44
AES-EMEC Elective Courses 15 EC		
AES Specialisation Geotechnical and Environmental Engineering (EGEC)		
AES Specialisation European Geotechnical and Environmental Course (EGEC) 1st Year		
EGEC-D/EG	Environmental Geotechnics	4
EGEC-D/RM	Rock Mechanics Applications	5
EGEC-D/SR	Material Models for Soil and Rocks	6
EGEC-E/ED	(Exeter) Surface Excavation Design	7,5
EGEC-E/TU	Tunnel and Underground Excavation Design	7,5
EGEC-M/BP	(Miskolc) Bioprocessing of Contamined Soil, Air and Waste Water	4
EGEC-M/EL	(Miskolc) Environmental Geology	3,5
EGEC-M/EP	(Miskolc) Environmental Geophysics	3,5
EGEC-M/ER	(Miskolc) Environmental Risk Assessment	3
EGEC-W/CM	(Wroclaw) Computer Aided Geological Modelling & Land Reclamation	3
EGEC-W/GM-08	Theory and Practice in Geomechanics	4
EGEC-W/GT-08	Geothermal Energy	4
EGEC-W/HU	HSE & Underground Practice	2
EGEC-W/UW-08	Underground Waste Management	3
AES Specialisation European Geotechnical and Environmental Course (EGEC) 2nd Year		
AES2005	Colloquium	1
AES2006	Graduation Thesis	44
AES-RE-EGEC Electives 15 ECTS		

Appendix 5: Quantitative data regarding the programmes

Data on intake, transfers and graduates

Bachelor's programme

Cohort	Total intake	Average duration of study	Total number of graduates	Total number of dropouts
2005-2006	35	4.3*	14	9
2006-2007	31	4.0*	13	8
2007-2008	36	3.6*	5	10
2008-2009	43	2.9*	5	6
2009-2010	46			12*
2010-2011*	48			11^
2011-2012*	47			6^

Table based on VSNU data, reference date 1 October
* TU Delft data, reference date 1 December
^ TU Delft data, reference date 31 May 2012

Master's programme

Cohort	Total intake	Average study length (years)^	Total number of graduates	Drop-out
2005-2006	49	2,1*	40	9
2006-2007	69	1,7*	46	20
2007-2008	72	1,9*	58	8
2008-2009	68	1,9*	31	12
2009-2010	94	-	33*	6
2010-2011*	72*	-	2*	1*
2011-2012*	67*	-		

Table based on VSNU data, reference date 1 October
* TU Delft data, reference date 1 December
^ Data are based on students who entered the master programme for the first time and had no other enrolment at TU Delft

Teacher-student ratio achieved

Bachelor's programme

Applied Earth Sciences staff in the BSc	Number of fte	% Education	Total fte in education	Number of active students	Number of students per fte education
Professor	3,6	40	1,4		
Associate/assistant professor	11,2	50	5,6		
Senior lecturer	1,75	90	1,6		
Total	**16,55**	**40**	**8,6**	**184**	**21**

Note: it is not easy for the programme to calculate the precise staff-student ratio. Many staff members are active in more than one course. Besides that, in the bachelor's programme many lecturers from other faculties participate in the programme.

Master's programme

It is not easy to calculate the precise staff-student ratio. Many staff members are active in more than one course; besides that, for the internationals programmes students study partly here and partly at the partner universities. The staff-student ratio may therefore not very reliable. Total formation (fte) of the academic staff in education is 19,3. In study year 2011-2012 there are 196 active students in the Master's programme. The staff-student ratio therefore is 19,3:196+1:10.

Average amount of face-to-face instruction per stage of the study programme

Bachelor's programme

Average number of contact hours for each phase
a. First year: 27 hours per week
b. Second year: 23 hours per week
c. Third year: 20 hours per week; the Bachelor's Thesis is a six-week project

Master's programme

The study load of each track in the Master's degree programme is 120 EC. This means that the programme requires two years with a full time study load in order to obtain the required competences.

Appendix 6: Programme of the site visit

Dag 1
Zondag 16 september

16.00- 19.00	Startbijeenkomst	*Met toegang tot leestafel*

Dag 2
Maandag 17 september

8.30- 9.30	Management	Prof. dr. ir. Bert Geerken, Dean, Prof. ir. Frank Sanders, Director of Education, Prof. dr. ir. Evert Slob, Director of Studies, Drs. Ellen Touw, Head of the Department Education & Student Affairs
9.30-10.30	Studenten bachelor en master	1e) Mathijs Groenewegen (11/12) 60EC Martijn Warnaar (11/12) 38EC 2e) Wokke Wijdeveld (10/11) 49+26EC Martijn Bijmolt (10/11) 60+23EC 3e) Suzanne Boekhout (09/10) 60+112EC Harm Nolte (09/10) 60+74EC MSc: Henk van Oeveren (PE), 2e jaars (06/07) BSc+52EC Joelle Langeveld (RG), 2e jaars (07/08) BSc+79EC Stephanie Lier (RE) (05/06) BSc+75EC Boris Boullenger (AG, ir) (10/11) graduated aug 2012
10.30-11.30	Docenten bachelor en master	Dr. ir. Leon van Paassen Section Geo-Engineering, lecturer BSc and MSc Ir. Hans de Ruiter Section Resource Engineering Dr. ir. Guy Drijkoningen Section Applied Geophysics, lecturer BSc and MSc Prof. dr. Pacelli Zitha Section Petroleum Engineering, lecturer BSc and MSc Drs. Jan Kees Blom Section Applied Geology, lecturer BSc and MSc Dr. Rick Donselaar Section Applied Geology, lecturer BSc and MSc
11.30-12.15	Pauze	
12.15-12.45	OLC studenten en docenten	Mw. Nadine van Dijk (GE) Daan van Berkel (RE) Mw. Henneke de Vries (BSc)

		Dr. Gert Jan Weltje (chair Mw. dr. Ir Dominique Ngan-Tillard Dr. Ranajit Ghose
12.45-13.30	Examencie en studieadviseur	Prof. dr. ir. Timo Heimovaara (chair) Mw. drs. Maaike van Tooren Mw. mr. Luuk Minnigh Drs. Pascal de Smidt (study counselor)
13.30-14.30	Pauze	
14.30-15.00	Alumni	Mw. ir. Laura Konstantaki (PhD, MSc AG) Mw. ir. Donata Liuzzi Fernandez (MSc RG) Siavash Kahrobaei, MSc (MSc PE) Ir. Steef Steneken, (Nyrstar, Budel, MSc RE) Ir. Bart Hogeweg (IHC, MSc RE)
15.00-15.30	Voorbereiden eindgesprek	
15.30-16.15	Eindgesprek met management	Prof. dr.ir. Bert Geerken, Dean, Prof. ir. Frank Sanders, Director of Education, Prof. dr.ir. Evert Slob, Director of Studies, Prof. dr.ir. Jan Dirk Jansen, Chair of the Department GeoScience and Engineering Drs. Ellen Touw, Head of the Department Education & Student Affairs
16.15-18.15	Opstellen voorlopige bevindingen	
18.15-18.30	Mondelinge rapportage voorlopige bevindingen	

Appendix 7: Theses and documents studied by the committee

Prior to the site visit, the committee studied the theses of the students with the following student numbers:

Bachelor's programme

1165903	1148664	1098780
1241168	1307339	1383574
1173898	1280252	1181645
1183168	1266357	1270052
1308955	1314823	1357891

Master's programme

1154192	1531239	1542222
1381903	4053494	4053389
1534963	1537288	1537148
1543210	4053435	1542168
1335952	1535005	1313568
1531271		

During the site visit, the committee studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

Minutes Board of Studies 2009/2010 2010/2011 2011/2012	Sunday 16th September
Minutes Board of Examiners 2009/2010 2010/2011 2011/2012 Year report Board of Examiners 2010-2011	Sunday 16th September
System of Assessment, concept version 6 september 2012	Sunday 16th September
Guidelines Geological Fieldwork BSc Fieldwork, 2nd year MSc Fieldwork: Petroleum Geology (1st year), Reservoir Geology (1st year), Geo-engineering (1st year)	Sunday 16th September
Graduation forms (aanvullende vraag commissie)	Sunday 16th September

Intake by track (aanvullende vraag commissie)	Sunday 16th September
Curriculum overview BSc Programme 2012-2013	Sunday 16th September
Curriculum overview BSc redesign Concept May 2012	Sunday 16th September
Overview of course material and exams (see list at the end of this document)	Room 03.270, table, on the right
Curriculum overview BSc redesign Concept May 2012	Room 03.270

Appendix 8: Declarations of independence

nvao
nederlands-vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: PROF. M.A. HERBER

HOME ADDRESS: VIADUCTWEG 10, 9751 HR HAREN

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS; CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO; HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: HAREN DATE: 25/6/12

SIGNATURE:

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: MARTIN LANDRØ

HOME ADDRESS: K.O. THORNÆS V.1, 7033 TRONDHEIM, NORWAY

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS; CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO; HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: WAGENINGEN DATE: 25 June 2012

SIGNATURE: Martin Landrø

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Jan W Hopmans

HOME ADDRESS: 1508 Eligio Lane DAVIS CA 95618 USA

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS; CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO; HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: Wageningen DATE: June 25 2012

SIGNATURE:

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Professor Desmond E. Walling

HOME ADDRESS: Orchard Close, Lynch Road, Thorverton, EXETER, EX5 5PS, Devon, UK

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

Earth Sciences

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS; CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO; HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: Wageningen. DATE: 25.6.12

SIGNATURE: D. E. Walling

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Renate Prenen

HOME ADDRESS: Simon Stevinweg 21 Bussum

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

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PLACE: Delft

DATE: 17-09-'12

SIGNATURE:

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: M.M. Cazemier

HOME ADDRESS: Haarweg 117, 6709 PX, Wageningen

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / ~~SECRETARY:~~

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

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PLACE: Wageningen DATE: 13-09-2017

SIGNATURE:

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: W.v. Gastel

HOME ADDRESS: Riverforel 35 2318 MG Leiden

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN ~~EXPERT~~ / SECRETARY:

SEE ATTACHMENT

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

SEE ATTACHMENT

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

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PLACE: Wageningen DATE: 25.06.2012

SIGNATURE:

Attachment composition committee Earth Sciences

	Wagening University	Utrecht University	University of Amsterdam	VU Amsterdam	TU Delft
Visit	**25-26 June 2012**	**27-28 June 2012**	**29 June 2012**	**18-19 September 2012**	**16-17 September2012**
Chair	Prof. M.A. Herber	Prof. M.A. Herber	Prof. M.A. Herber	Prof. M.A. Herber	Prof. M.A. Herber
Member	Prof. M. Landrø	Prof. M. Landrø	Prof. M. Landrø	Prof. M. Landrø	Prof. M. Landrø
Member	Prof. J.W. Hopmans	Prof. J.W. Hopmans	Prof. J.W. Hopmans	Prof. J.W. Hopmans	Prof. J.W. Hopmans
Member	Em. Prof D.E. Walling	Em. Prof D.E. Walling	Em. Prof D.E. Walling	Em. Prof D.E. Walling	Em. Prof D.E. Walling
Member	Dr. M.A. Ossevoort	Dr. M.A. Ossevoort	Dr. M.A. Ossevoort	Drs. R.L. Prenen	Drs. R.L. Prenen
Student	E. Rost	E. Rost	M. Weekenstroo	M. Cazemier	M. Cazemier
Secretary	dr. W. van Gastel	dr. W. van Gastel	dr. W. van Gastel	dr. W. van Gastel	dr. W. van Gastel

Institution:	**Programme (CROHO)**	**Mode of study**	**Final date accreditation**
Technische Universiteit Delft	B Technische Aardwetenschappen (56959)	Full time	31-12-2013
	M Applied Earth Sciences (60360)	Full time	31-12-2013
Universiteit Utrecht	B Aardwetenschappen (56986)	Full time	31-12-2013
	M Earth Sciences (66986)	Full time	31-12-2013
Universiteit van Amsterdam	M Earth Sciences (66986)	Full time, part time	31-12-2013
Vrije Universiteit Amsterdam	B Aardwetenschappen (56986)	Full time	31-12-2013
	M Earth Sciences (66986)	Full time	31-12-2013
	M Hydrology (60807)	Full time	31-12-2013
Wageningen Universiteit	B Bodem, water, atmosfeer (56968)	Full time	31-12-2013
	M Earth and Environment	Full time	31-12-2013