Impact of Climate Change on Urban Drainage Planning – Case Study Lucerne

Master Project Autumn Semester 2014

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Documentation

Figure 1: Aerial Photograph of the "Wartegg" Catchment (Lucerne) – Moy di Vitri, 2014.
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1. Aims

After the 2nd semester of the master studies, the lectures are completed and students should have acquired skills and tools necessary for their profession. The master project work offers a first opportunity to apply and adapt the knowledge in the different phases of a project.

It is the aim of the master project to find independent and professional answers to actual real-world problems and to present the obtained solutions in a professional manner. Students must be able to understand, analyze, and solve a problem with the proper tools. They must know how to deal with a large quantity of data, as this is the basis of most projects.

The goals for the Master Project are as follows:

**Content of the work:**
- In-depth insight into urban water management principles
- Application of tools as demonstrated in the lectures
- Assessment of limitations and uncertainties of suggested predictions
- Work with incomplete, missing, or inaccurate data basis

**Formal requirements:**
- Project- and team work
- Practice oral and written presentations
- Handling of professional literature and engineering reports
- Evaluating, reasoning, and presenting results
- Communication with lecturers, engineers, operating personnel, and politicians
- Get to know your own limits (time pressure and uncertainties)

It is important to work professionally throughout the entire project. Keep records of your ideas and project steps. Prepare a time-schedule of intermediate goals. Check your schedule regularly and revise your planning if necessary. Reserve yourself enough time for the final presentation and the technical report. Begin in good time with the writing of the different chapters. The results of your work are definite, can be passed on, and may serve a third party as a basis for another decision.
2. Background MP 2014

Ensuring drainage comfort and adequate wastewater treatment is an increasingly important task for municipalities especially against the background of growing urbanisation and climate change. Wastewater infrastructure objects have to be carefully planned, constructed, maintained, and eventually they also must be replaced. Sensible planning of wastewater infrastructure is particularly important. At this point a high impact on the arousal of future costs is observable. For example, dimensioning of pipe networks which have a supposed lifetime of about 50+ years should be adapted to future demands and must also fulfil – now and then – the technical and functional requirements.

The “climate change impact”-question is currently driving the underground civil engineering department of the city of Luzern (City of Luzern) to revise existing sewer network plans. The department commissioned the engineering consultant HOLINGER AG (HOLINGER Switzerland) to develop a so called GEP (“Genereller Entwässerungsplan”) for the city’s catchment that addresses potential future changes. Among other questions Luzern would like to know if i) climate change will occur and if so to what extent and ii) do they have to consider climate variability already nowadays in the planning process although climate change occurs within long-term periods.
3. Definition of Task

3.1. Task

The main goals of this project are:

Discuss the question: Is an adaptation of urban drainage infrastructure required to address a changing climate in central Switzerland? And if so, what are adequate strategies to do so?

Answers should be given by conducting a systematic model-based analysis to provide a solid basis, including an explicit consideration of modelling and evaluation uncertainties. Adequate performance indicators/evaluation criteria are to be defined to address present and future requirements.

The project is directly linked to the current revision of sewer network planning / operation (GEP planning) in the city of Lucerne. It offers the chance to work on real-life engineering problems and to cooperate with participating actors, i.e. local authorities (“Stadttiefbauamt Luzern”), responsible operators (“REAL Luzern”), engineering consultancies (HOLINGER AG, HUNZIKER BETATECH AG). Students have the opportunity to learn about actual project development and management. The project’s results will be considered in the final evaluation process.

Due to the large workload of this project and with regard to the available time, students will be split into three groups. Each group get a project specific sub task. The results of these subtasks again will be utilized within an conjoint group task. Finally all groups have to work together to i) explain their results to the other groups and ii) to achieve reasonable results for the project’s main goal.

The groups and its members are defined as:

**Group A: Statistical Rain Analysis (“SWW-MP01”)**
- David FitzGerald
- Philippe Gerber

**Group B: Catchment Surface Characteristics Analysis (“SWW-MP02”)**
- Jing Huo
- Simon Schegg

**Group C: Hydrodynamic Model Implementation (“SWW-MP03”)**
- Nathalie Bruttin
- Nina Gubser
- Urs Schönenberger
The subtasks can be defined as follows:

**Group A** – Comparative evaluation of current and future rainfall variability with regard to model-based analysis of sewer system performance.

**Goals:**
- Can you observe changes regarding precipitation characteristics due to climate change for the period from 2035 to 2065 compared to the period of 1981 to 2010. Characterize the ‘signal’ changes and discuss them regarding their effects on urban drainage.
- Propose and provide rain data that should be used as input for the GEP relevant simulations.
- How do you assess the use and value of different rain input (historical rain series, stochastically modelled rain data, future rain series, synthetic design storm, …) for the development of urban drainage systems. Make a recommendation what should be used for which tasks.

**Tasks:**
- Study fundamentals regarding: climate modelling, downscaling of rainfall data, analysis of rain series, creation of model rain events.
- Evaluation of the spatial variability of rainfall in the Lucerne region (see location of rain gauges in the region -> rainGaugesRegionLuzern_GUJER_1994.png).
- Verification and statistical analysis of historical rainfall series.
- Comparative analysis of historically observed rainfall, corresponding simulations (disaggregation) and prediction of future rainfall.
- Detailed rain data investigation with regard to rainfall variability and uncertainties of modelled rainfall series.
- Evaluation of the sewer model response for different rainfall signals (in coordination with group C).

**Group B** – Comparative analysis of aerial photographs generated by two different techniques and its consequences for urban drainage modelling.

**Goals:**
- Identify the different surface characteristics in the Wartegg catchment based on available data sources to provide input data for hydrodynamic simulations.
- Perform a thorough analysis and comparison of the results from the drone pictures and the available orthophotos. Make a clear statement which approach you would recommend for future projects.

**Tasks:**
• Study fundamentals regarding: aerial photography, incl. analysis techniques.
• Comparative analysis of aerial photographs of two different sources (orthophotos vs. UAV images (drone pictures)).
• Utilize scripts available in ArcGIS and members of the Chair of Photogrammetry and Remote Sensing for ArcGIS evaluation of aerial photographs.
• Derivation of input data relevant for urban drainage model application.
• Assessment of hydraulic model performance with regard to input data from the two different data sources (catchment characteristics). Coordinate with group C!

**Group C** – Development of an urban drainage model for the “Wartegg” catchment in Lucerne including model building, calibration, validation.

**Goals:**
• The primary result is a calibrated, if possible validated, hydrodynamic model of the Wartegg catchment which can be used for the simulation of adaptation strategies.
• Provide a general overview about the hydraulic situation in the sub catchment. Where are the main hydraulic bottlenecks? How much effort is required to improve the situation?
• Provide a functioning model implementation to analyze the hydraulic model performance for different model inputs. Cooperate with other groups!

**Tasks:**
• Study fundamentals of hydraulic sewer modelling, calibration and validation.
• Characterize the sub catchment within the context of Lucerne’s sewer network.
• Model building based on available data.
• Analysis and verification of measured/observed reference data.
• Investigate actual (status quo) hydraulic system performance (e.g. build-up of a hydraulic scheme, overview about network constructions, etc.).
• Comparative analysis of measured data from different sources (check plausibility).
• Model calibration and validation.
• Definition of performance indicators resp. evaluation criteria (in coordination with other groups).
The conjoint task can be defined as follows:

**Conjoint Task** – Discuss the question: Is an adaptation of urban drainage infrastructure required to address a changing climate, i.e. changing rainfall characteristics in central Switzerland? And if so, what are adequate strategies to do so?

- Development of different future adaption scenarios.
- Integrate the intermediate results of all groups in the conjoint hydrodynamic model.
- Evaluation of simulation outcomes and subtasks’ findings.
- Discussion of robustness/sensitivity of obtained results with regard to data and model uncertainties.
- Simulation of future adaption scenarios.
- Review important findings which allow giving recommendations to the city of Lucerne regarding possibly necessary adaption to the overall GEP planning process and/or sewer design procedure.

It is essential that all groups coordinate in an open and result orientated way with each other. All groups are together responsible for a successful completion of the conjoint task which is the main goal of this Master Project. Although each group has a specific task all students should have some general overview and knowledge about the other group’s data, applied methods and results.
4. Dates

The beginning of the master project should be coordinated with the supervisor and the professor. The submission date is fixed by the secretariat of IfU (S. Schirrmacher) and is 7 work weeks after begin.

The dates for the intermediate review questions and the final presentation of the project work are listed here. Changes still could take place. This would be communicated by the assistants.

<table>
<thead>
<tr>
<th>Event</th>
<th>Day</th>
<th>Date</th>
<th>Time</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>General introduction</td>
<td>Wed</td>
<td>17.09.</td>
<td>13.00 - 15.00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>Discussion Time Schedule</td>
<td>Mo</td>
<td>23.9.</td>
<td>15.00 - 16.00</td>
<td>HIL C 42.2</td>
</tr>
<tr>
<td>Field Trip</td>
<td>Fr</td>
<td>26.09</td>
<td>Open</td>
<td>Luzern</td>
</tr>
<tr>
<td>1st Intermediate Meeting</td>
<td>Wed</td>
<td>08.10.</td>
<td>09.00 - 12.00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>2nd Intermediate Meeting</td>
<td>Wed</td>
<td>22.10.</td>
<td>14.00 - 17.00</td>
<td>HIL G 36.1</td>
</tr>
<tr>
<td>Final Presentation</td>
<td>Wed</td>
<td>29.10.</td>
<td>14.00 - 17.00</td>
<td>LochNess (HXE)</td>
</tr>
<tr>
<td>Submission Report</td>
<td>Wed</td>
<td>05.11.</td>
<td>16.00</td>
<td>HIL G 31.2</td>
</tr>
</tbody>
</table>
5. Organization

5.1. Supervision

The project will be supervised by the assistants and is in charge of Prof. M. Maurer.

5.2. Intermediate Meetings

During the master project there will be two intermediate meetings of each 45 minutes. In the first 15 minutes students will present their intermediate results (short lecture, overhead projector und a board are at disposal) and outline their procedure up to that stage. In the following half an hour pending questions will be discussed with the supervisors.

Intermediate meetings will not be graded. However, the presentation can be shortly discussed if a student wishes so (This must be agreed upon with the assistants, before the presentation!).

It is important to have your questions to the master project properly prepared so that you can benefit by the expert knowledge of all present.

5.3. Submitted Results

Report (max. 25 p)

Submission of reports at the assistants’ office is on the last day of the planning schedule, by 4 p.m. latest. It includes:

- Two paper copies of the report (incl. Annex). Printing costs of one copy are paid by the students themselves. Further required copies will be paid by the chair, upon presentation of the receipt for printing costs. If the master project was developed in cooperation with several external partners (i.e., community, engineering office, Eawag) then more copies need to be printed.

- A CD-ROM with all data (report, incl. annex in PDF-format, models, data, etc.)

The form, “statement regarding plagiarism when submitting written work at ETH Zurich” (http://www.umwelting.ethz.ch/download/index) is to be placed directly after the title page of the Master Project, on the right-hand side.

If the decision is made to provide all group results in one single report the permitted page number is 20 pages per group. Please note: It must be possible to clearly differentiate which group has contributed to which parts of the report due to evaluation reasons.

Final Presentation

The final presentation of your master project is the highlight of your research. You have 15 minutes (each group) to hold your lecture and additional 10 minutes for final conclusions regarding overall project objectives. The target group is an expert audience. They
are the focus of your presentation. Each group member must have the same amount of speaking time.

5.4. Evaluation

The master project thesis will be evaluated and graded according to the criteria of evaluation in the annex.

Report

The report will be corrected by your advisor. After the correction, usually the advisor will set up a written feedback which will be returned to the students, together with the corrected copy.

Final Presentation

Directly after the presentation, the final presentation will be evaluated and graded by the advisor, assistants and head of master project. The assistants will set up a written feedback.

5.5. Office Hours

The office hours of Prof. Maurer (HIL G 32.1) for the master project are listed in the following. Students are welcome to contact Prof. Maurer (max.maurer@ifu.baug.ethz.ch) with questions during this period or walk in if the door is open. If necessary, individual meetings can be additionally arranged.

- Tuesday, 23.09., 13:30 – 15:00
- Tuesday, 30.09., 13:30 – 15:00
- Tuesday, 07.10., 11:00 – 13:00
- Thursday, 16.10., 10:30 – 12:00
- Wednesday, 22.10., if necessary after 2nd intermediate meeting

The consultation hours (HIL G 31.2) are:

- Thursdays, (25.09. to 30.10. – NOT 23.10.), 14:00 – 17:00
- Mondays, (22.09. to 03.11.), 14:00 – 17:00

You can also write an e-mail to arrange an additional appointment or ask questions: beutler@ifu.baug.ethz.ch.

5.6. Tools, Data, Documentation

The most important documents and project records are found on our homepage:

http://www.ifu.ethz.ch/SWW/education/projects

At the end of this documentation, there is a list of literature with interesting and useful publications.
Required (proprietary) software and data are provided through an ETH network drive, requiring authorization.

5.7. Working Place

There are twenty PCs in room HIL C 42.2 for the master project work. The regulations in the following subchapters must be read and all users are requested to respect the rules.

5.7.1. General rules

Room C 42.2 is at your disposal as a working place. In order to ensure a smooth course in this computer room, we request our user to keep to the following rules:

- The last person in the room must switch off all computers and lights, and close the door. The room must never remain open if nobody is in there.
- The participants will receive an electronic access to the computer room for the length of the master project. The access to the room is with their activated student card. The card reader will recognize the activated card automatically.
- To allow fast working, it is necessary to work on the local drive D:\. Do not forget to back up your data on the server. **ATTENTION: DATA SECURITY IS NOT GUARANTEED ON THE LOCAL DRIVE!**
- The study-oriented work has the highest priority for using the computer. All other activities (i.e. surf, game, etc.) are of a lower priority.

5.7.2. Login

Each group gets an account on the server. The group accounts are named SWW-MP01 etc. After starting the computer you must register yourself by pressing the buttons Ctrl+Alt+Delete.
The login screen appears as follows:

<table>
<thead>
<tr>
<th>Username</th>
<th>e.g. SWW-MP01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password</td>
<td>1234.abcd</td>
</tr>
<tr>
<td>Domain</td>
<td>IFU</td>
</tr>
</tbody>
</table>

### 5.7.3. Data protection

While working with Word, Excel, etc. you must always save your data locally on the hard disk. At the end you have to back up your data.

If further programs are required which are not installed, inquire at the assistance. The hard disk is write-protected, e.g. you cannot download programs from the network.
6. References

This list does not claim to be complete. Certain publications can be found in the general documentation of the master project, others can be lent from the assistants. Additionally, at the assistance more specialist books can be lent out.

Information to laws and regulations can be downloaded from the internet (www.admin.ch).

Literature:

- DWA (2006): Hydraulische Bemessung und Nachweis von Entwässerungssystemen. Hennef, DWA-A 118. [only in German available]
- DWA (2012): Starkregen in Abhängigkeit von Wiederkehrzeit und Dauer. Hennef, DWA-A 531. [only in German available]
- Material about methods for temporal rainfall disaggregation can also be found at the Hydrology group’s website of „Hydrology II“ (http://www.ifu.ethz.ch/hydrologie/education/master_courses/hydrologyII).

Laws and Regulations:
- Bundesgesetz über den Umweltschutz (Umweltschutzgesetz) vom 7. Oktober 1983, SR 814.01
- Gewässerschutzverordnung (GSchV) vom 28. Oktober 1998, SR 814.201

Useful Links:
Laws and regulations: http://www.admin.ch/
Homepage of the Association of Swiss Experts in Wastewater and Water Pollution Control: http://www.vsa.ch/
Federal Office of Statistics http://www.statistik.admin.ch/
Do not hesitate to search for further information at the ETH library (www.nebis.ch). Also the books at the assistants’ office (HIL G 31.1) are at your disposal (use loan-out list).

Another useful source for scientific publications is the Web of Science (http://isiknowledge.com). Web of Science is an internet database where many abstracts of published papers are deposited. There, you can search for papers by using specific criteria such as keywords, author, citations, etc. Note that free access to the Web of Science requires that you are part of the ETH network or that you link to the ETH network via VPN. The ETH-library (http://www.library.ethz.ch/) has online-subscriptions for many scientific journals so that you can download necessary articles in full length.
7. **Annex**

7.1. **Criteria for Evaluation of Master Project**

**REPORT AND ANNEX**

<table>
<thead>
<tr>
<th>Layout</th>
<th>20 %</th>
</tr>
</thead>
</table>
| **Form**
The actual report may not exceed 25 pages (not counting the index and appendix).
Is the layout clear and appealing?
Is the text comprehensible and easy to read?
Are the quotations and references correct and unitary?

| Text structure
Is the report without the annex easy to understand?
Are the chapters organized in a logical sequence? Is each chapter in itself complete?
Is the abstract of the report concise, clear, and conveying the major findings of the report?
Are the figures and charts informative? Are they well incorporated into the text?
Are report and annex sufficiently linked?
Does the annex contain all data for an in-depth study of the work?

**CONTENT**

| Proposed tasks addressed in report
Were the focus areas of the task recognized? Was the aim consequently formulated?
Was the concept of procedure direct and did it fit into the time schedule of the master project?
Were the main theoretical basics properly developed and presented?

| Critical discussion of data and results
Does the description of the practical work allow an evaluation and repetition of the data assessment?
Are the assumptions adequate and correct?
Were the basic principles from the obtained calculations/results completely listed?
Did a critical evaluation of the data quality occur?

| Calculations and results
Was the data analyzed with the appropriate process and with the necessary care?
Are the assertions and calculations correct?
Were all essential results shown?
Were all models referring to an application correctly compiled?
Were all models properly applied, in relation to the calibrated and validated problem?
Discussions and conclusions
In the discussion, were the results critically evaluated and compared with the corresponding literature?
Were the individual tasks connected to the overall project (importance of the results within the over-all summary)?
Is the discussion relevant for the purpose?
Are the conclusions clear and justified?
Are conclusions linked to the purpose defined in the introduction?
Have the unresolved questions been identified as recommendations for further study?
Were useful suggestions made for a further procedure?

Summary
Does the report contain a concise, clear and complete summary (max. one A4-page with the set task, aim and purpose of the report, important results and conclusions and references).

PRESENTATION 20%

GENERAL IMPRESSION 20%
Validity: Are the statements in the presentation clear? Are these well prepared by way of explaining the procedure or by displaying the results? Are the statements well communicated to the audience? Are the contents convincing?

Conclusions: Are the conclusions of the master project comprehensible and correct? Are constructive suggestions made for a future procedure?

Answer to questions: Are the questions clearly and explicitly answered? Are the statements correct?

TECHNICAL CONTENT 20%
Information content: Are necessary assumptions presented? Have the models been correctly explained? Are the results interpreted and also drawn into the conclusion?

Fairness to audience: Is the content of the presentation suited to the audience?

Comprehensibility: Are the contents presented in a simple and logical way? Is a central theme noticeable and are parts of the statements relevant to the presentation?

Quality: Are the models applied suitable? Are the calculations correct? Has the data used been queried? Are there any inquiries as to uncertainties?

PRESENTATION TECHNIQUE 20%
Structure: Is the structure understandable and logic? Is the structure conform to the content? Did it help to present the content as plain and as complete as possible?

Introduction / Conclusion: Is there a clear introduction in the presentation so that everybody in the room knows: it has started? Is the conclusion of the presentation well-stated?
**Introduction:** Is the audience properly introduced into the task? Is the context of the work obvious? Is the aim of the thesis stated? → gain their attention!

**Main part:** Are the main statements explicit? Are they easy to understand? Are the statements well prepared by the methods and models explained? → Convey main statements clearly!

**Conclusion:** Is the content of the presentation well summarized? Are the main statements repeated (take home message)? Is a possible prospect useful? → emphasize main statements!

**Time frame:** Was the given time frame of 25 minutes kept?

---

**USE OF MEDIA 20%**

**General:** Was appropriate media applied for the information transfer? Is the presentation livelier because of the use of media? → Media can support the lecture, but does not replace it.

**Handling of media:** Was the media properly handled? Is the projection sharp, the picture straight? Is the flip chart visible for all in the audience? Can the text written on the wall chart be read from the very back of the room? Is the use of pointer efficient?

**Transparencies:** Is the layout simple so that the listener is not distracted? Does it support what is being said? → Limit yourself to „need to have“. Is the writing readable? Are the shown graphics quick to understand (axis label, legend, use of color, differences of symbols)? Are transparencies introduced („These are the results of a stream experiment …“, what do you see? Guide the listener through the transparency!)?

**Wall chart:** Is the writing big enough and readable? Make sure not to stand in front of the wall chart, otherwise important statements might not be seen. Pay attention to the 3 T (Touch, Turn, Talk).

**Flip chart:** Is the writing big enough and readable? Keep in mind the 3 T (Touch, Turn, Talk).

**Handouts:** It can be useful to make handouts of important transparencies and distribute these. Are they included in the presentation? Attention: Handouts can distract the listener from the lecture. → Hand out in due time.

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**EXPRESSION 20%**

**Language:** Is the language fluent? Are the sentences simple and short? Is there a pause within the sentence when important statements are made so that the audience can notice them? Are terms clearly defined and placed unitary and correct?

**Presence/Contact with the audience:** Is the audience spoken to? Is the presence convincing and professional? Was this „platform“ used (movement makes the lecture lively, animates the listener)?

**Mimic/Gesticulation:** Where are the hands, are these under control (do not cross the arms → appears to be defensive, do not put your hands in the trouser pockets → seems casual, but is in fact unprofessional)? No gestures of embarrassment (i.e. scratch the back of your head, place fingers in front of your mouth, etc.)!

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**PRACTICAL WORK 20%**
PROJECT MANAGEMENT 100%

**Time schedule:** Was a time schedule set up? Are important work stages documented? Was enough time planned for the documentation of the work?

**Problem identification:** Is the problem critically queried? Is the task within a relevant context?

**Goal:** Is the goal in spite of the problem identification correct? Does the goal fit in with the context of the master project?

**Organization of work:** Is the work place properly furnished? Does the candidate work independently? Does the candidate cooperate with the supervisor and other persons? Is there a control of the work progress?

**Group work:** Was the inter-group task properly coordinated within the groups? Are the formerly prepared data and obtained results as well as the group-intern conclusions communicated to the other groups? Was the final inter-group task well done?

*This catalogue of criteria is not complete. The above-listed questions just serve as indications for the evaluation of the thesis.*