CIVL4511 CIVIL DESIGN 1
HYDRAULIC DESIGN OF WATERWAYS

Table of contents

Norman Creek in flood on 7 Nov. 2004 around 13:30

1. Presentation

The purpose of the design is to introduce undergraduate students to the complexity of hydraulic design and the interactions between hydraulics, geotechnical and structural engineering. The students will be confronted to prototype culverts and flood plains (i.e. full-scale); they will be able to compare these with models (e.g. long channel and culvert experiments) (CIVL3130 & CIVL3140). The assignment will show also practical details which must be considered during the design stages : e.g., low-flow channel, pedestrian access, backwater effects, interactions between successive structures. All the structures are located in the Brisbane area.

This assignment will be some group work to emphasise **team work, collaborative efforts and communication**. A total of 9 waterways and structures (culverts and flood plains) will be considered (Table 1-1). Each structure will be surveyed and analysed by one group of 8-10 students. The project will be concluded by a report submission on 29 April 2005 and an oral presentation on 4 May 2005 (Table 1-2). The latter will be assessed by both lecturers and peers.

Table 1-1 - Main site locations

Ref. No.	Description	Suburb	Road/Street	2003 UBD Refidex Map No.	1990 UBD Refidex Map No.	Comments
1	Culvert	Wellers Hill & Holland Park West	SE Freeway Parallel to Birdwood St	180 K16	--	MEL culvert including inlet and outlet waterways. Downstream of Marshall Rd.
2	Culvert	Annerley & Ekibin	SE freeway between Carter Pl & Willis St	180 E11	35	MEL culvert including inlet and outlet waterways.
3	Flood plain	Annerley & Greenslopes	between SE freeway & Armwood St	180 D10	35	Flood plain between SE freeway and Armwood St bridge. Note the confluence with Sandy Creek must be included.
4	Flood plain	Annerley & Greenslopes	between Armwood St & SE freeway	180 D10	35	Flood plain between Armwood St bridge and MEL waterway.
5	Channel & Flood plain	Annerley & Greenslopes	SE freeway & Ridge St	180 D9	35	MEL waterway & downstream flood plain up to the next culvert (i.e. u/s Ridge St MEL culvert).
6	Culvert	Annerley & Greenslopes	Ridge St	180 D8	35	MEL culvert including inlet and outlet waterways.
7	Flood plain	Stones Corner	between Ridge & Juliette St	180D8/E7	35	Flood plain between a MEL culvert and a bridge.
8	Flood plain	Stones Corner	between Juliette & Cornwall St	180 E7/E6	35	Flood plain between a bridge and a MEL culvert.
9	Culvert	Stones Corner	Cornwall St	180 E6	35	MEL culvert including inlet and outlet waterways.

Table 1-2 - Time table

Week	Date	Description	Remarks
1	Monday 28 February	Brief introduction of the topic.	Pre-requisite. and schedules.
5	Monday 4 April	Lecture on flood plain and culvert hydraulic calculations	Final selection on the group composition (12:00 noon)
6	Monday 11 April	Surveying trip	On site. Compulsory. Every student must attend.
7	Monday 18 April	Calculations, group work, report and oral preparation	
8	Tues 27 April	Calculations, group work, report and oral preparation	
8	Fri. 29 April	Report submission.	Deadline: 3:00 pm in Dr CHANSON's hands.
9	Wed. 4 May	Oral presentations for each group (from 1:00pm).	Compulsory. Every student must attend.

2. Field trip and survey

2.1 Surveying

The survey shall take place between Friday 8 April and Tuesday 12 April 2005. Mr Paul PEZZOPANE (Safety Officer), Mr Bill BOYCE and Dr Hubert CHANSON will be in Norman Creek catchment on Monday 11 April 2005 between 8:30 am and 11:30 am. They will circulate among groups to provide advice and assistance if needed.

Surveying equipments (one level & one tape per group) will be available from Mr Clive BOOTH (Hydraulics Laboratory) on Friday 8 April between 11:00am and 3:00 pm (Table 2-1). ALL the equipments must be returned un-damaged no later than Tuesday 12 April 2005 before 2:00pm to Mr Clive BOOTH (Hydraulic laboratory). (**Lateness in returning the equipment or damage to the surveying equipment shall be heavily penalised**.)

Note that the surveying equipment was hired from UQ School of Geographical Sciences. It must be returned undamaged. **Students shall be personally liable for any damage to the equipment**.

Further the field works will be conducted in public places. Students are requested to take care to the environment during the field works. (**All refuse and litter generated by the activity MUST BE REMOVED from the parks and public places.**) Any damage attributable to the use of the parks shall be penalised.

Fig. 2-1 - Survey of Norman Creek by Civil Engineering students in May 2002

Table 2-1 - List of equipments provided by the University of Queensland

Equipment	Remarks
Level (Theodolite)	1 per group.
Tripod	1 per group.
Spirit level	1 per group.
Measuring tape	1 per group.
Staff picket	1 per group.

Preparation

- Groups are advised to visit the site at least one week before the survey and to plan all practicalities.

- **FIND THE NEAREST PERMANENT SURVEY MARK AND ITS COORDINATES**.

- Include photographs of the survey and of the permanent mark in your documentation.

- Groups may consider obtaining aerial photographs and detailed contour line maps.

- Find relevant flood studies of the area.

- Photographs of flood events ...

Practical considerations
ALL THE DATA shall be recorded in writing. These data will constitute a key component of the final report and of the groupwork assessment. Students are very strongly encouraged to think beforehand how they will record the data and to prepare relevant books and notepads. Any loss of field data is not acceptable. Use carbon copies (e.g. accounting books) to backup your data regularly.

Field observations will include some survey measurements and relevant information to conduct some hydraulic modelling.

The flood plains/culvert shall be surveyed at several longitudinal cross-sections, where a cross-section is defined as being normal the flow direction (incl. during floods). Sites for the surveys are listed in Table 1-2. The survey shall be conducted during day time for safety.

At each cross-section, observations shall include an assessment of the bed roughness, and its transverse distribution, which may change within a cross-section and between cross-sections.

All vertical elevations must be reported to the Australian Height Datum (AHD).

Access
The structures No. 1 to 9 are located in the southern part of Brisbane, next to the SE freeway.

+ By car, take the SE freeway from the city, and exit at Stones Corner. Continue to Ridge St.

+ By bus : The Greenslope bus expressway stop is located close to the various structures (e.g. Bus 111, 160 from the City).
{http://jp.transinfo.qld.gov.au/BTBuses.asp}

+ All the structures are located near the bicycle path from SouthBank to Griffiths University. (Do not use the bicycle path/footpath during flood periods). The bicycle path will take you along and through the four structures. (During the survey, be aware of and careful with cyclists using the bicycle path.) From the City, go to South Bank Park and join the bicycle path towards Griffith University. (You may also join the bicycle path coming from Dutton Park ferry along the bicycle roads). You will reach first the Cornwall St culvert. The bicycle path will drive through the structures from the downstream to upstream catchment (in that order when coming from South Bank).

Safety
Safety is uppermost important during all the field works.

+ **Students will be working in groups of no less than 3 people at any time on site.**

+ No work shall be attempted into water more than waist deep. Persons going into the water must wear a life line secured to the bank. Only confident swimmers are to do the work in the water.

+ Good common sense is recommended to avoid any injury : e.g., do not jump from walls, watch your steps.

+ It is strongly advised to wear adequate shoes or boots. Strong clothing is recommended, incl. shorts and trousers.

+ *Hat, sunglasses and sun screen are strongly advised*. Bring also mosquito/insect repellent.

+ Bring water to avoid dehydration.

+ During or immediately before the field works, DO NOT consume alcohol or other intoxicating substances.

+ Drive safely to and back from the field work.

+ Do not use the bicycle path/footpath during flood periods.

+ During the visit, be aware and careful of cyclists using the bicycle path.

Contact phones
A safety officer will be based at Norman Creek on Monday 11 April morning with a first aid kit and he will be on-call all day for emergency from 8:00am to 4:00pm. In case of emergency, he will be contactable at the following number :

Mob. Ph.: **04129 54163**

For emergencies, dial 000.

Fig. 2-2 - Norman Creek in flood on 31 Dec. 2001 around 6:00 am

General issues
All field works will be conducted in public places. Staff and students are requested to take care to the environment during the field works.

+ All refuse and litter generated by the activity MUST BE REMOVED and placed in designated rubbish bins

+ Noise and disturbance associated with the field works must be kept at a level which has no negative impact upon the environment (e.g. birds, fish), geenral public and surrounding properties.

+ Damage to the parks, river banks and engineering structures is not acceptable.

+ Any damage attributable to the field activities will be rectified at cost and the relevant group(s) shall be heavily penalised.

Fig. 2-3 - Field study of Norman Creek in August 2000 (Courtesy of Professor LEE Jaw-Fang, National Cheng Kung University)

3. Assignment

A culvert is a covered channel of relatively short length designed to pass water through an embankment (e.g. highway, railroad, dam). It is a hydraulic structure and it may carry flood waters, drainage flows, natural streams below earthfill and rockfill structures. The design can vary from a simple geometry (i.e. box culvert) to a hydraulically-smooth shape : i.e., the Minimum Energy Loss (MEL) design (CHANSON 1999,2004).

In the coastal plains of Queensland (North-East of Australia), torrential rains during the wet season place a heavy demand on culverts. Further the natural slope of the flood plains is often very small (S_o ~ 0.001) and little fall (or head loss) is permissible in the culverts. Professors G.R. McKAY and C.J. APELT developed and patented the design procedure of minimum energy loss waterways. Professor C.J. APELT presented an authoritative review of the topic (APELT 1983) and a well-documented documentary (APELT 1994). Dr H. CHANSON showed detailed illustrations (CHANSON 1999, pp. 363-368, 383-397, & 421-430) and he discussed some specific design features (CHANSON 2000, 2001).

In the late 1960s, a new South-East Freeway connecting the Gold Coast to Brisbane was built Norman Creek in southern Brisbane. The Norman Creek catchment from Mt Gravatt is 14 km long and the catchment area is 28.6 km², hilly and, today, highly urbanised with a moderately dense drainage network. Channelisation is widespread with significant areas of adjoining parkland. The headwaters of this creek are in the bushland associated with Toohey Forest. The lower reaches of Norman Creek are tidal, and mangroves occur upstream as far as Logan Road (Stones Corner). Flooding in this catchment can be severe from the Brisbane River (into which this creek empties). The catchment is a complex of three watercourses (Norman, Ekibin and Sandy Creeks) which traverse intensely developed industrial, commercial and residential areas. This system is highly modified for flood mitigation purposes.

Table 3-1 - Internet resources on Norman Creek

Website	Url
BCC Brisbane's waterways	{http://www.brisbane.qld.gov.au/ourcity_andsuburbs/brisbanes_waterways/norman_creek.shtml}
Norman Creek Catchment Coordinating Committee	{http://www.n4c.powerup.com.au/}
Norman Creek - A meandering story	{http://www.stonescorner.net/Pages/Creek1.html}
9 March 2001 Flash flood	{http://members.ozemail.com.au/~jamestorm/reports/mar09_01.html}
Queensland Waterwatch	{http://www.qld.waterwatch.org.au/}

Table 3-2 - Internet resources on culvert design and hydraulic structures

Website	Url
Minimum energy loss culverts and waterways	{http://www.uq.edu.au/~e2hchans/mel_culv.html}
Photographs of culverts	{http://www.uq.edu.au/~e2hchans/photo.html#Culverts}
Photographs of hydraulic structures	{http://www.uq.edu.au/~e2hchans/photo.html#Hydraulic%20structures}

During the construction of the SE Freeway, several major culverts were built along Norman Creek. These, and associated flood plains connecting them, are topics of the hydraulic design component of the CIVL4511 Civil Design subject. These structures are still operating today, and their successful operation for more than 30 years (at the exception for two ([1])) demonstrates the soundness of the hydraulic concepts (CHANSON 2003).

In this project, the class will investigate the hydraulics of Norman Creek during flood events. Both flood

[1] That is, Cornwall Street culvert since construction, and Marshall Rd culvert inlet more recently (CHANSON 2003,2004).

plains and man-made structures will ve considered. Hydraulic calculations will be performed for three water discharges corresponding to design flow conditions, less than design flow conditions and a flood event larger than present design flow conditions.

At the end of the project, each group will produce :

1- a detailed survey of the structure (culvert, waterway or flood plain) and dimensioned drawings ([2]),

2a- complete hydraulic calculations (incl. free-surface profiles) for a 110 m^3/s flash flood,
2b- complete hydraulic calculations and free-surface profiles for a 220 m^3/s extreme flood, and

3a- a detailed new, optimum design for a 300 m^3/s flood (for culverts and waterways) with complete hydraulic calculations for a MEL (zero afflux) design and associated costing ([3]), **OR**
3b- complete hydraulic calculations and free-surface profiles for a 300 m^3/s flood (flood plain).

In parts 2 and 3, the quantitative results shall be justified with relevant explanations of the selected methodology and basic equations.

Table 3-3 - Typical construction costs

Extension of a two-lane bridge :	$18,000	per metre length
Excavation cost :	$15	per cubic metre
Embankment cost :	$35	per cubic metre

Fig. 3-1 - CIVL3140 field study at Norman Creek on 8 Sept. 2004

Remarks : Culvert optimum design
The optimum refurbishment of the culvert is a delicate balance between hydraulic performances (afflux, discharge capacity) and costs. For the purpose of the CIVL4511 design, a refurbishment design is considered optimum hydraulically if it prevents overtopping of nearby roadways (with a 0.5 m allowance for shock and

[2]For example, plan and longitudinal sections, key cross-sections ... All elevations must be expressed in metres AHD !
[3]Costs of additional excavation, embankment reconstruction, cell costs, ...

standing waves) and of surrounding housing for the 300 m^3/s flood.

Both MEL culvert and standard culvert designs must be considered but you will realise rapidly that a MEL design is still an optimum design in 2005.

4. Assessment

4.1 Presentation

The assessment of Hydraulic design section will take place as :

- a group work during the semester (**25% of CIVL4511/CIVL4512 subject**), and
- some individual examination at the end of semester examination (**10% of CIVL4511 subject**).

During the semester, students will work in group of 8-10 people ([4]). The groups will be finalised no later than Monday 4 April 2005 by 12:00 noon. Nine sites will be investigated at the locations listed above. This gives room for personal preference in the choice of group number (i.e. site number) (Table 1-1).

Each student has the responsibility to examine the list of sites (above), to find his/her preferred group and to sign up in this group. (The composition of a group shall remain un-changed after Monday 4 April 12:00noon, unless exceptional considerations after discussion with Dr CHANSON.)

4.2 Assessment

The group work will be assessed as a combination of report submission and oral presentation. The group report will be assessed by the lecturers. The oral presentation will be assessed by the lecturers and by the other groups.

Group report	50% (Note the penalty for lateness below)
Presentation (lecturers' assessment)	32%
Presentation (peers' assessment)	18%

Note that peer assessment within a group may be conducted by the lecturer in response to individual(s) or groups(s) request.

4.3 Instructions for report submission

Each report will be assessed upon :

the field data of the group including the creek cross-sectional surveys (20%),
the drawings' accuracy and presentation (20%),
the technical contents, accuracy and soundness, incl. the hydraulic modelling (30%),
the technical data quality and presentation (15%),
the presentation style (15%)

Report submission and instructions

For each group, three copies of the report must be submitted to Dr CHANSON by 29 April, 2005. The report will be reviewed by the lecturers.

+ Page Limits

Each report must be complete within a limit of 20 pages including front page, table of contents, main text, figures and references (but excluding appendices and drawings attachments). Reports that exceed this limit will be penalised by **5% penalty per extra page**. Shorter reports of significance may be given preferences.
Each report will be single-sided. Each page must be numbered. The text is to be **single-spaced, 12 pt** Times Roman or similar. The paper is to be printed on plain A4 size paper. The manuscripts must be typed within the area of 255 mm by 170 mm. With a normal A4 size paper, the distances between the edge of the sheet and the text become as follows:

top: 2.0 cm
bottom: 2.0 cm
sides: 2.0 cm

+ Layout of Text

The front page must follow the template given in Appendix I.

On the front page, each student must sign next to his/her name. Absence of signature shall indicate that the individual did not contribute to the group work.

The report should contain as a minimum :

[4] Each group shall have no less than 8 people and no more than 10 students.

- the front page (see Appendix I), followed by
- a table of contents,
- an introduction followed by the text,
- conclusions,
- list of references (bibliography)
- the appendix I containing all survey data in a tabular manner
- the appendix II containing the dimensioned drawing
- the appendix III containing all numerical modelling results

+ Figures and tables
Figures and tables must be placed in the text next to the first reference. These figure and table would be referred to as "Figure 1" and "Table 1". Titles of figures and tables are to be in 12pt Times Roman.

+ Format for references
Reference should be listed at the end of the paper and should include the following information: Author's family name, Initials. : Paper title, Journal's title, Volume No., (year), pages.
For example :

APELT, C.J. (1983). "Hydraulics of Minimum Energy Culverts and Bridge Waterways." *Australian Civil Engrg Trans.*, I.E.Aust., Vol. CE25, No. 2, pp. 89-95.

CHANSON, H. (1999). "The Hydraulics of Open Channel Flows : An Introduction." *Butterworth-Heinemann*, Oxford, UK, 512 pages. (Reprinted in 2001)

+ **Digital data**
Each group is asked to submit at least one CD containing all their data set in a digital form. Students should consider either or both digital formats CD-R and DVD+/-R. (Only these two formats shall be assessed.)

The CD-ROM/DVD+/-ROM will also include relevant photographs (JPEG format), some data analysis, the numerical modelling and a copy of the group report (e.g. PDF format).

The digital data must be properly presented. The material may be sub-divided into sub-directories while a text file, acting as map of the CD-ROM contents, must be placed of the top of the directory tree.

Note : Each group will record a lot of information. For example, on the field work day, during the surveying, and with the hydraulic modelling. All the information needs to be recorded, including relevant handwritten comments, ... (The CD-ROM/DVD+/-ROM may include a scanned version of the handwritten log-in sheets, relevant photographs, tabulated data sheets, a copy of the report, ...)

The digital information constitutes an integral part of the report supporting material.

Deadlines
The group reports are due on **Friday 29 April 2005 before 3:00pm**. The report must be submitted directly to Dr Hubert CHANSON who will write down, on the cover page, the submission date and time. (It is the responsibility of each group to find the lecturer and to hand him the report.)

Penalty for lateness are 10% per hour of lateness on Friday 29 April 2005 and 60% for submission on Tuesday 3 May 2005. Note that no assignment/report will be collected on Sat., Sun. nor Monday 30, 1 and 2 May 2005 and that no report will be accepted after Tuesday 3 May 2005 8:00am.

4.4 Instruction for oral presentation
Presentations will take place on Wednesday 4 May 2005 between 1:00pm and 3:30pm in Room (***to be advised***). Each group will be given **10 minutes for presentation followed by up to 4 minutes for discussion**. Lecturers and fellow students will contribute to the discussion. Note the discussion is worth 40% of the group presentation. Lengthy presentations which will reduce the time available for discussion will be penalised acordingly.

Groups may use Powerpoint presentations, overhead projector transparencies and/or slides. (The Powerpoint files must be provided to Dr Hubert CHANSON no later than Tuesday 3 May 2005 2:00pm, while 35-mm slides must be provided to Dr Hubert CHANSON no later than Wednesday 4 May 2005 8:00 am.)

Each presentation will be judged upon :

the technical content (40%)
the presentation style (20%)
the expertise and ability to answer questions during the discussion (40%)

4.5 Deadlines

Monday 4 April 2005 12:00 noon	Group composition
Friday 29 April 2005 before 3:00 pm (in Dr CHANSON's hands)	Complete hydraulic design report Note Penalties for Lateness
Wednesday 4 May 2005 between 1:00pm and 3:30pm	Group presentation
Room (***to be advised***)	Penalty for lateness : - Presentation time and marks reduced accordingly - Presentation cancelled and zero marks for any group not ready 10 minutes after the official start time. - Discussion marked reduced accordingly for lengthy presentations

Fig. 4-1 - Survey of Norman Creek by Civil Engineering students in May 2002

5. References

APELT, C.J. (1983). "Hydraulics of Minimum Energy Culverts and Bridge Waterways." *Australian Civil Engrg Trans.*, I.E.Aust., Vol. CE25, No. 2, pp. 89-95 (ISSN 0819-0259).
{http://www.uq.edu.au/~e2hchans/reprints/apelt_83.pdf}

APELT, C.J. (1994). "The Minimum Energy Loss Culvert." Videocassette VHS colour, Dept. of Civil Eng., University of Queensland, Australia, 18 minutes.

CHANSON, H. (1999). "The Hydraulics of Open Channel Flows : An Introduction." *Butterworth-Heinemann*, Oxford, UK, 512 pages (ISBN 0 340 74067 1). (Reprinted in 2001)
{http://www.uq.edu.au/~e2hchans/reprints/errata.htm}

CHANSON, H. (2000). "Introducing Originality and Innovation in Engineering Teaching: the Hydraulic Design of Culverts." *European Journal of Engineering Education*, Vol. 25, No. 4, pp. 377-391 (ISSN 0304-3797).
{http://www.uq.edu.au/~e2hchans/reprints/ejee00.pdf}

CHANSON, H. (2001). "Teaching Hydraulic Design in an Australian Undergraduate Civil Engineering Curriculum." *Jl of Hyd. Engrg.*, ASCE, Vol. 127, No. 12, pp. 1002-1008 (ISSN 0733-9429).
{http://www.uq.edu.au/~e2hchans/reprints/jhe_01hc.pdf}

CHANSON, H. (2003). "Minimum Energy Loss Structures in Australia : Historical Development and Experience." *Proc. 12th Nat. Eng. Heritage Conf.*, IEAust., Toowoomba Qld, Australia, N. Sheridan Ed., pp. 22-28 (ISBN 0-646-42775-X).
{http://www.uq.edu.au/~e2hchans/reprints/heritg03.pdf}

CHANSON, H. (2004). "Enhancing Students' Motivation in the Undergraduate Teaching of Hydraulic Engineering: the Role of Field Works" *Journal of Professional Issues in Engineering Education and Practice*, ASCE, Vol. 130, No. 4, pp. 259-268 (ISSN 0733-9380).
{http://www.uq.edu.au/~e2hchans/reprints/jpieep04.pdf}

CHANSON, H. (2004). "The Hydraulics of Open Channel Flows : An Introduction." *Butterworth-Heinemann*, Oxford, UK, 2nd Edition (ISBN 0 7506 5978 5).
{http://www.uq.edu.au/~e2hchans/reprints/book3_2.htm}

CHANSON, H. (2004). "Environmental Hydraulics of Open Channel Flows." Elsevier-Butterworth-Heinemann, Oxford, UK, 483 pages (ISBN 0 7506 6165 8).
{http://www.uq.edu.au/~e2hchans/reprints/book7.htm}

Internet resources

CHANSON, H. (2000). "Hydraulics of Minimum Energy Loss (MEL) Culverts and Bridge Waterways." *Internet resource*.
(Internet address : http://www.uq.edu.au/~e2hchans/mel_culv.html)

Fig. 5-1 - Survey of Norman Creek by Civil Engineering students in May 2002

Appendix I - Template of the report front page

Hydraulic study of the MEL culvert underneath the SE freeway parallel to Birdwood St

Location Ref. No.	Description	Suburb	Road/Street	Comments
1	Culvert	Wellers Hill & Holland Park West	SE Freeway Parallel to Birdwood St	MEL culvert. Downstream of Marshall Rd.

	Initials	Family name	Student ID No.	Signature
1	I.R.	WOOD	20021978	
2				
3				
4				
5				
6				
7				
8				
9				

Submission date	Time	H. CHANSON's initials