CHANSON, H. (2004). "Environmental Hydraulics of Open Channel Flows." *Elsevier Butterworth-Heinemann*, Oxford, UK, 483 pages (ISBN 978 0 7506 6165 2; ISBN 0 7506 6165 8).

PRÉFACE

Rivers play a major role in shaping the landscapes of our planet (Table P-1, Fig. P-1). Extreme flow rates may vary from zero in drought periods to huge amount of waters in flood periods. For example, the maximum observed flood discharge of the Amazon river at Obidos was about 370,000 m^3/s (HERSCHY 2002). This figure may compared with the average annual discharges of the Congo river (41,000 m^3/s at the mouth) and of the Murray-Darling river (0.89 m^3/s at the mouth) (Table P-1). Even arid, desertic regions are influenced by fluvial action when periodic floodwaters surge down dry watercourses (Fig. P-1A).

Hydraulic engineers have had an important role to contribute although the technical challenges are gigantic, often involving multiphase flows and interactions between fluids and biological life. These engineers were at the forefront of science for centuries. For example, the arts of tapping groundwater developed early in the Antiquity in Armenia and Persia, the Roman aqueducts, and the Grand canal navigation system in China. In the writer's opinion, the extreme complexity of hydraulic engineering is closely linked with :

(1) the geometric scale of water systems : e.g., from less than 10 m^2 for a soil erosion pattern (e.g. rill) to over 1,000 km^2 for a river catchment area typically, and ocean surface area over 1 E+6 km^2,

(2) the broad range of relevant time scales : e.g., less than 1 second for a breaking wave, about 1 E+4 s for tidal processes, about 1 E+8 s for reservoir siltation, and about 1 E+9 s for deep sea currents,

(3) the variability of river flows from zero (dry river bed during droughts) to gigantic floods,

(4) the complexity of basic fluid mechanics, with governing equations characterised by non-linearity, natural fluid instabilities, interactions between water, solid, air and biological life, and

(5) Man's (and Life's) total dependence on water.

Table P-1 - Characteristics of the world's longest rivers

River system (1)	Length (km) (2)	Catchment area (km^2) (3)	Average annual discharge (m^3/s) (4)	Average sediment transport rate (tons/day) (5)
Amazon-Ucayali-Apurimac (S. America)	6,400	6,000,000	180,000	1,300,000
Congo (Africa)	4,700	3,700,000	41,000	--
Yangtze (Asia)	6,300	1,808,500	31,000	--
Yenisey-Baikal-Selenga (Asia)	5,540	2,580,000	19,800	--
Parana (South-America)	4,880	2,800,000	17,293	--
Mississippi-Missouri-Red Rock (N. America)	5,971	3,100,00	17,000	--
Ob-Irtysh (Asia)	5,410	2,975,000	12,700	--
Amur-Argun (Asia)	4,444	1,855,000	10,900	--
Volga (Europe)	3,530	1,380,000	8,050	--
Nile (Africa)	6,650	3,349,000	3,100	--
Huang Ho (Yellow river) (Asia)	5,464	752,000	1,840	4,400,000
Murray-Darling (Australia)	3,370	1,072,905	0.89	--

Notes : Average annual discharge : at the river mouth.

Fig. P-1 - Photographs of natural rivers

(A) Small flood in the Gascoyne river, Carnarvon WA (Australia) (Courtesy of Gascoyne Development Commission and Robert PANASIEWICZ) - The Gascoyne river has catchment area of about 67,770 km^2 and it extends 630 km inland - Average annual rainfall is less than 250 mm throughout the basin and this is an ephemeral river - There are typically one to two flow periods per year following seasonal rainfall or cyclone activity, but it may fails to flow at all once every five or six years

(B) Tingalpa Creek, Redlands QLD (Australia) on 21 Jan. 2003 at high tide at about 9 km from the river mouth - Looking upstream -

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Discussion

Armed conflicts around water systems have been plenty. In the Bible, a wind-setup effect allowed Moses and the Hebrews to cross shallow water lakes and marshes during their exodus. Droughts were artificially introduced : e.g., during the siege of the ancient city of Khara Khoto ('Black City') in AD 1372, the Chinese army diverted the Ezen river ([1]) supplying water to the city ([2]). Man-made flooding ([3]) of an army or a city was carried out by the Assyrians (Babylon, Iraq BC 689), the Spartans (Mantinea, Greece BC 385-84), the Chinese (Huai river, AD 514-15) ([4]). A related case was the air raids of the dam buster campaign conducted by the British in 1943. Artifical flooding created by dyke destruction played a role in several wars : e.g., the war between the cities of Lagash and Umma (Assyria) around BC 2,500 was fought for the control of irrigation systems and dykes.

The 21st century is facing political instabilities centred around water systems, and freshwater system issues might be the focal point of future armed conflicts. For example, the Tigris and Euphrates river catchments and the Mekong river. The scope of the relevant problems is broad and complex : e.g., water quality, pollution, flooding, drought. An example is the disaster of the Aral Sea with the formation of the permanently-dry isthmus between the northern small Aral Sea and the southern big Aral Sea since 1987 (e.g. WALTHAM and SHOLJI 2001).

This book was developed to introduce students, professionals and managers to the challenges of open channel flows and environmental hydraulics. After a concise introduction (Part 1), the second section (Part 2) deals with mixing and dispersion of matter in natural river systems. Part 3 presents an introduction to unsteady open channel flows, and the interactions between flowing water and its surroundings are discussed in Part 4.

Mixing and dispersion of contaminants in natural systems is developed in Part 2. Applications include release of organic and nutrient-rich wastewater into the ecosystem (eg. from treated sewage effluent), smothering of seagrass and coral, stormwater runoff during flood events, and injection of heated water from an industrial discharge (e.g. at a cooling power plant). For example, during an accidental release of waste occurs in a streams, the water resource scientist needs to predict the arrival time of the contaminant cloud, the peak concentration of solute and the duration of the pollution. Basic theory of molecular diffusion and advection is extended to turbulent advective diffusion in channels.

Gradually-varied flow calculations are developed in Part 3. First the basic equations of one-dimensional unsteady open channel flows are presented. That is, the Saint-Venant equations and the method of characteristics in Chapter 3-1 ([5]). Later simple applications are developed. The propagation of waves, positive and negative surges is presented in Chapter 3-2, while the dam break wave problem is discussed in Chapter 3-3. Simple numerical models are presented and explained in Chapter 3-4.

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[1]also called Hei He river ('Black River') by the Chinese.

[2]Located in the Gobi desert, Khara Khoto was ruled by the Mongol king Khara Bator (WEBSTER 2002).

[3] by building an upstream dam and destroying it.

[4] It may be added the aborted attempt to blow up Ordunte dam, during the Spanish civil war, by the troops of General Franco, and the anticipation of German dam destruction at the German-Swiss border to stop the crossing of the Rhine river by the Allied Forces in 1945.

[5]It is acknowledged that, in Chapter 3-1, the basic derivation of Saint-Venant equations and method of characteristics presents some similarities with sections of another textbook (CHANSON 2004b).

There are strong interactions between turbulent water flows and the surrounding environment. Part 4 introduces the basic concepts of the transport of solids (Chapter 4-2), and of the mixing of air and water at free-surfaces (Chapter 4-3).

At the beginning of the book, the reader will find the table of contents, a list of symbols and a glossary of technical terms and names. After the conclusion, a detailed list of references is presented. The last section presents a correction form. Readers who find an error or mistake are welcome to record the error on the page and to send a copy to the author. Corrections and updates will be posted on the Internet at :

{http://www.uq.edu.au/~e2hchans/reprints/book7.htm}

Discussion

The lecture material is based upon the writer's experience at the University of Queensland, and at other universities. It is designed primarily for undergraduate students in Civil, Environmental and Hydraulic Engineering. The writer has taught Part 1 in Years 2 and 3, and Parts 2 and 3 as part of advanced undergraduate electives in Year 4. Some material of Part 4 is usually introduced in the advanced hydraulics elective subject, and the course is further developed at postgraduate levels.

The writer wants to stress, however, that field studies are a necessary complement to traditional lectures in environmental hydraulics. In the context of undergraduate subjects, design applications in classroom are restricted to simple flow situations and boundary conditions for which the basic equations can be solved analytically or with simple models. Field work activities (Fig. P-2) are essential to illustrate real professional situations, and the complex interactions between all engineering and non-engineering constraints

The writer has organised undergraduate field works in hydraulic engineering for more than 10 years involving more than 1,000 undergraduate students. Figure P-2 illustrates recent examples. Figure P-2A shows Mixing and Dispersion class students conducting an ecological assessment of the estuarine zone of a small subtropical creek. For 12 hours, students surveyed hydrodynamics, water quality parameters, fish populations, bird behaviours and wildlife sightings at four sites (CHANSON 2003 et al.). They concluded their works with a group report and an oral presentation in front of student peers, lecturers, professionals and local community groups. Figure P-2B shows Hydraulic design students in front of the fully-silted Korrumbyn Creek dam disused since 1926. The dam and reservoir were accessed after a 45-minute bushwalk guided by National Park and Wildlife rangers in the dense sub-tropical rainforest of Mount Warning National Park (NSW). The field works was focused on sediment processes in the catchment. Students surveyed both upper and lower catchments, the fully-silted reservoir and discussed its possible use as touristic attraction and potential source of aggregate for the local construction industry. Figure P-2C presents Civil design students surveying a flood plain in the heart of Brisbane. Students working in groups surveyed eight sections of the creek including culverts and wide flood plains. Each group conducted hydraulic computations for design and less-than-design flow rates, and prepared newer designs for a larger flood.

Anonymous student feedback demonstrated the very-significant role of field works in the teaching of hydraulic engineering (CHANSON 2004b). 78% of students believed strongly and very-strongly that "field work is an important component of the subject". 84% of students agreed strongly and very strongly that "all things considered, field wrks and site visits are a vital component of Civil and Environmental engineeirgn curricula". 96% of students believed that "field works play a vital role to comprehend real-word engineering" and 100% of interviewed employers stressed that field works under academic supervision was a basic requirement for civil and environmenetal engineering graduates. Lecturers and professionals should not be complaisant with university hierarchy and administration clerks to cut costs by eliminating field studies. Although the preparation and organisation of field works with large class sizes are a major effort, the outcome is very rewarding for the students and the lecturer. From his own experience, the writer has had great pleasure in bringing his students to hydraulics field work for more than a decade and to experience first-hand their personal development (Fig. P-2D).

Fig. P-2 - Photographs of undergraduate student field trips

(A) Mixing in estuary field work (39 students) at Eprapah Creek on 4 April 2003 - Students conducting sampling tests in the mangrove (Courtesy of Ms Joyce H.)

(B) Field study on 4 Sept. 2002 with Hydraulic design class (24 students) - Students in front of the fully-silted Korrumbyn Creek dam in a dense sub-tropical rainforest

(C) Civil design students (73 students) surveying a flood plain in 2002 (Courtesy of L. CHEUNG)

(D) Group bonding at the end of 12 hours of estuarine field study (4 April 2003) (Courtesy of Ms Joyce H.)

Internet resources

General resources	
Gallery of photographs	{http://www.uq.edu.au/~e2hchans/photo.html}
Reprints of research papers	{http://www.uq.edu.au/~e2hchans/reprints.html}
Internet technical resources	{http://www.uq.edu.au/~e2hchans/url_menu.html}
NASA Earth observatory	{http://earthobservatory.nasa.gov/}
NASA rain, wind and air-sea gas exchange research	{http://bliven2.wff.nasa.gov/index.htm}
USACE Inlets on-line	{http://www.oceanscience.net/inletsonline/}
Estuaries in South Africa	{http://www.upe.ac.za/cerm/}
Whirlpools	{http://www.uq.edu.au/~e2hchans/whirlpl.html}
Mixing and dispersion in rivers	
Rivers Seen from Space	{http://www.athenapub.com/rivers1.htm}
Aerial photographs of rivers	{ftp://geology.wisc.edu/pub/air}