

CES-Related Defra/Agency R&D Projects

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Two Key Projects:

- Afflux at bridges and large culverts
- Fluvial model benchmarking update

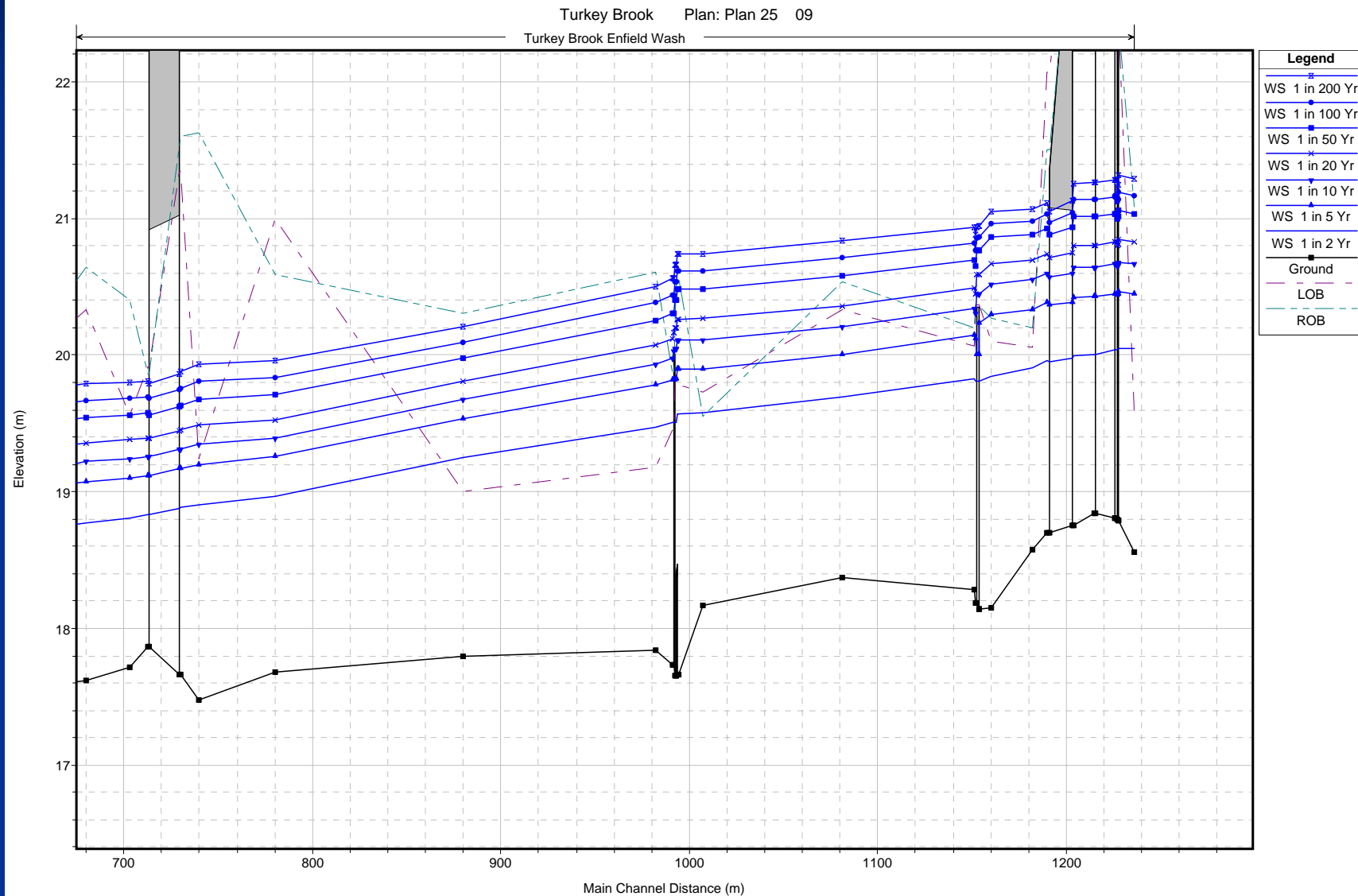
What causes flooding?



Water levels determined by:

- Flow in the river
- Capacity of channel (Conveyance)
- Effect of structures (Afflux)

Flow, Conveyance & Afflux



Flow in the River

- Widespread use of Flood Estimation Handbook
- Increasing lengths of flow records (hopefully!)
- Increasingly accurate climate change modelling (again, hopefully!)

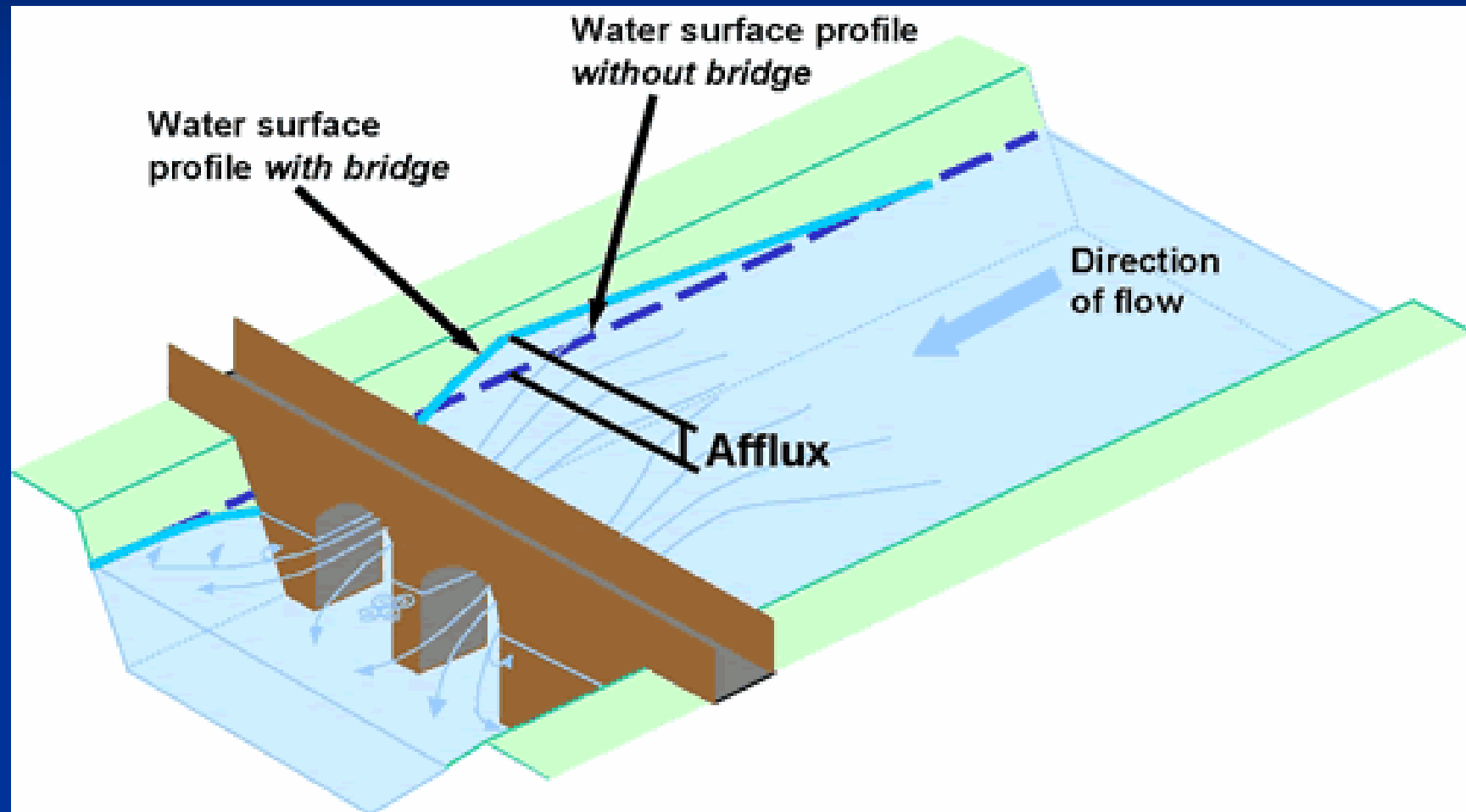
Capacity of the channel

- Need physical data, e.g. representative survey of channel and floodplain.
- Assessment of effect of vegetation growth in channel and on floodplain.
- Use CES to determine flood level for any given flow.

Effect of discrete structures



Afflux at a structure



Afflux Project – Key Players

■ Phase 1 – Scoping Study

- JBA Consulting, with specialist papers from a number of experts

■ Phase 2 – Development of new software

- JBA Consulting, with input from technical reviewers, and Wallingford Software to incorporate into CES

Afflux Phase 1 - Scoping Study

- Objectives included:
 - Identify and review current knowledge and research on afflux at bridges and large culverts
 - Identify any further work required to deliver robust algorithms for simulating afflux at bridges and large culverts in hydraulic modelling packages
 - To identify the general benefits, and to specify further R&D and information dissemination
 - To advise on the format and synergies of any future research.

Methods of calculating afflux

Pier bridges:	D'Aubuisson (1840)	Nagler (1917)	Yarnell (1934)
Embankment bridges:	Kindsvater et al (1953)	Bradley (1978)	
Arched bridges:	Biery and Delleur (1962)	HR Wallingford (1988)	
Computational methods:	Schneider et al (1977)	HEC-RAS energy (1995)	HEC-RAS momentum (1995)
High flow methods:	Sluice gate flow	Orifice flow	Weir flow
Culvert methods:	HEC-RAS	ISIS	MIKE 11

Key Findings (1):

- There is confusion as to the definition of afflux and how it differs from head loss
- There is a general lack of confidence by users when estimating afflux
- Existing guidance is poor
- The most typical structures analysed are existing arched bridges and arched culverts

Key Findings (2)

- The most critical locations are considered to be in urban areas or reaches with formal flood defences
- The most typical tools available for estimating afflux are hand calculation or a 1-D river model
- Some of the most important users of afflux information are development control officers

Key Findings (3)

- The implementation of existing afflux formulae in river modelling software is poor
- The available datasets on afflux are largely from laboratory studies and are poorly documented

Afflux Phase 2 will produce:

- **Afflux Advisor** – A spreadsheet tool
- **Afflux Estimator** – A more rigorous modelling tool
- Good practice guidance note
- Project Record and Technical Summary

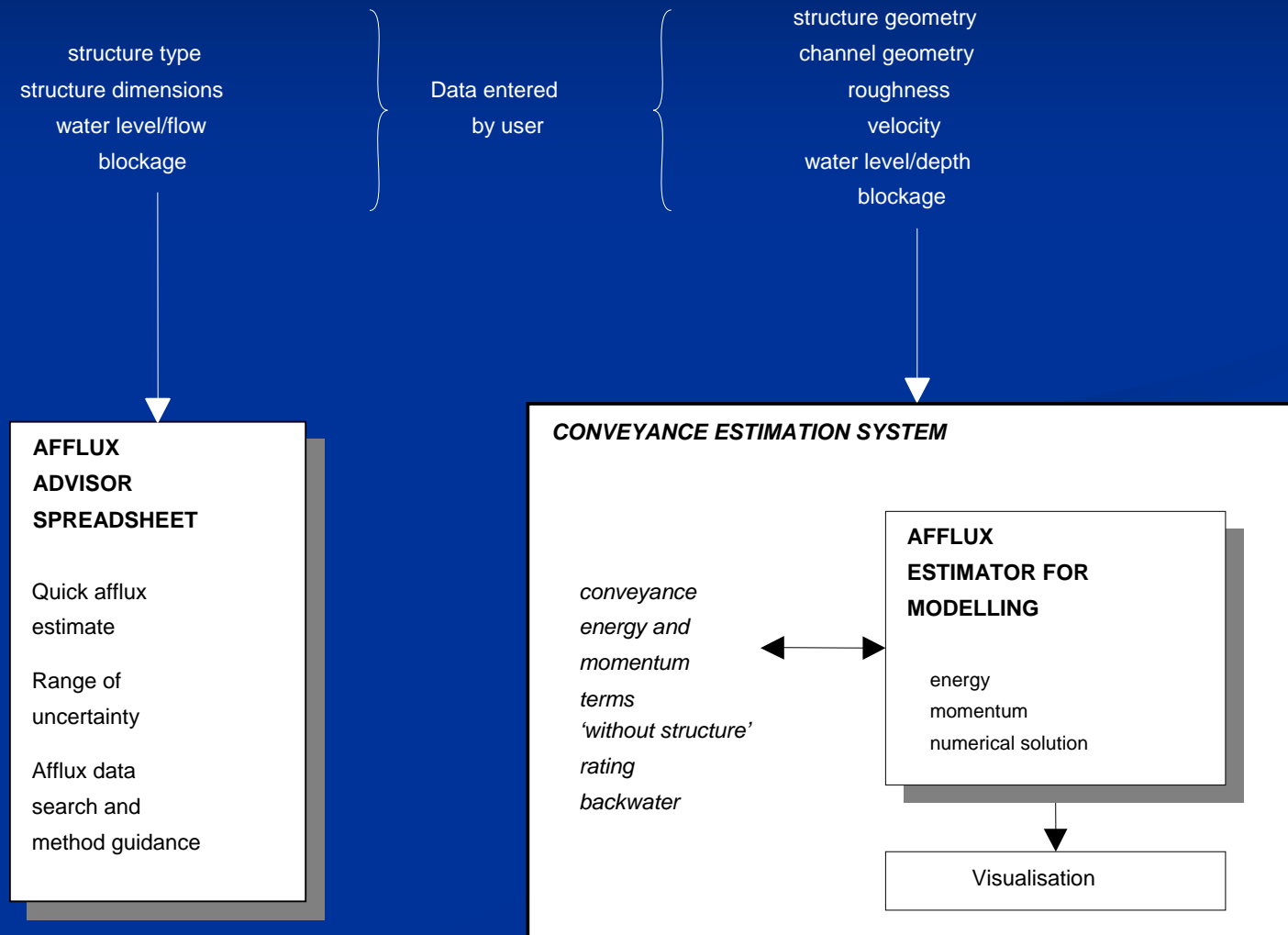
Afflux Advisor

- A spreadsheet application for rapid, initial estimation of afflux based on empirical formulae.
- It will require only a simple representation of bridge or culvert dimensions, provide guidance on method choice, and is aimed at wide but occasional use by non-specialists.

Afflux Estimator

- A more rigorous modelling tool with calculation of afflux based on hydraulic theory, which is intended for use by more experienced hydraulic engineers in conjunction with modelling software.
- The Afflux Estimator System (AES) will be available in open source code for incorporation in commercial software. It will be linked with the Conveyance Estimation System.

Linkage Diagram



Timescale for Afflux Project

- September 2004 – Trial of Afflux Advisor by User Group
- January 2005 – ‘Alpha’ version of AES to trial incorporation with CES
- April to July 2005 – Potential users trial software (Beta testing)
- August 2005 – Final output



Fluvial Model Benchmarking

- Models are needed to implement the theory of conveyance, afflux and other principles to derive potential flood levels
- Currently most day-to-day work is with 1D models
- This project updated earlier work initiated by the NRA in 1995

Key Players

- Bullens
 - Richard Crowder – now Halcrow
- EdenVale Modelling Services
 - Chris Whitlow
- University of Nottingham
 - Nigel Wright
- University of Bradford
 - Andrew Sleigh

Packages Benchmarked

- Project limited to the three 1D fluvial hydraulic modelling packages currently supported by the Environment Agency's CIS, i.e.:
 - ISIS
 - HEC-RAS
 - MIKE 11

The Basis of the Tests

- Tests categorised into:
 - **Numerical Accuracy** – used where an analytical solution was available
 - **Capability** – used to test the ability of a package to model specific scenarios
 - **Reproducibility** – used to compare model outputs with real (mainly physical model) results

Numerical Accuracy Tests

- Test A - Subcritical and Supercritical Flows
- Test B – Triangular Channel
- Test E – Ippen Wave (tidal wave propagation)
- Test F – Monoclinical Wave (unsteady, uniformly progressive flow)

Capability Tests

- Test B – Looped System
- Test D – Weirs
- Test H – Rules (pumps and gates)
- Test I – Side Spill (embankment)
- Test K – Culverts
- Test O - Outfalls

Reproducibility Tests

- Test J – Bridges (arch and beam)
- Test L – Contractions and Expansions
- *Three other reproducibility tests had been envisaged, but were omitted due to the need for further refinement and development*

Specifications & Datasets

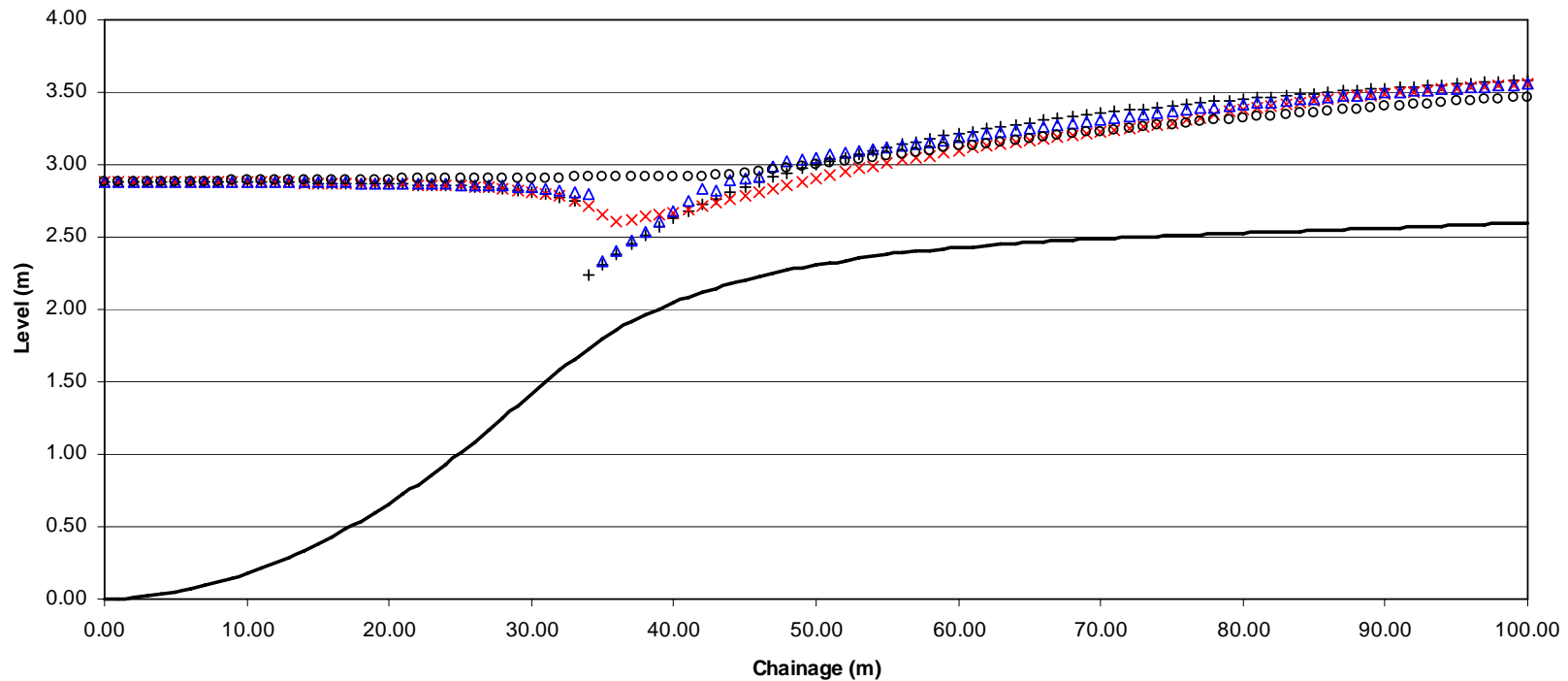
- Specifications have been written for each test, and datasets for each package made available, for use by:
 - Novice modellers as a training exercise
 - Vendors with updates of the packages tested
 - Other software houses to test their products against those already tested

Test Results

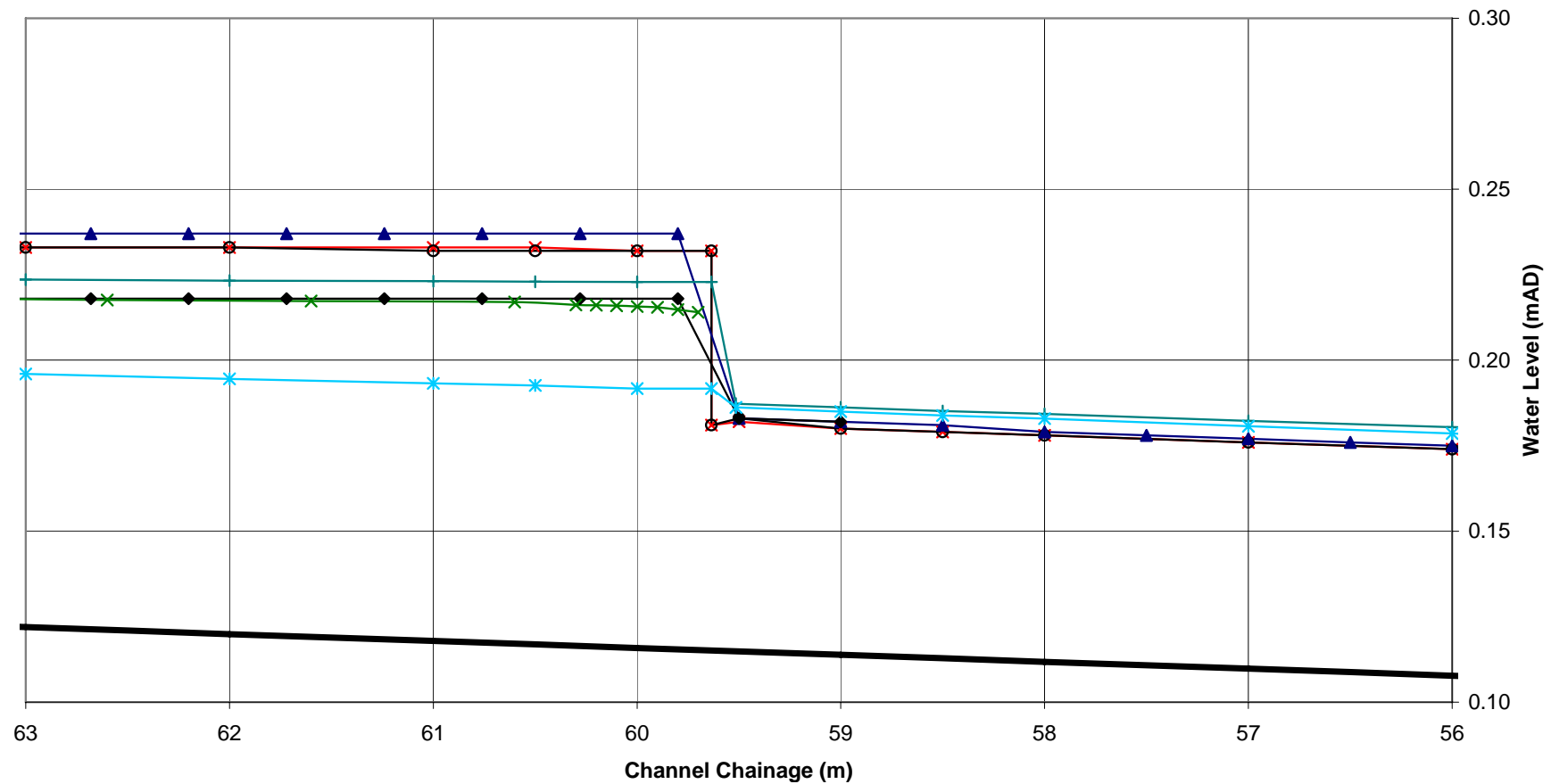
- All test results now written up, for imminent publication on Agency's website.
- All models had strengths and weaknesses.
- Vendors have had a chance to comment, and test reports identify upgrades notified by vendors.

Hydraulic Jump Results

Graph 13 - Test A Part 4 (Steady State): Subcritical to Supercritical to Subcritical Flow
Water Levels
Comparison of ISIS, HEC-RAS and MIKE 11



Bridge Test Results



Way Forward - Now

- Vendors are already rectifying shortcomings identified by the project
- If tests for upgraded or new packages are carried out and independently verified, then the Agency will consider placing those results on its website

Way Forward - Future

- The specifications could be enhanced and expanded for more complex hydraulic issues and real-life modelling problems, such as:
 - Hydraulic issues associated with planform (e.g. confluences, split flows and bends)
 - Use of hybrid 1D/2D, quasi-2D or 2D models for enhanced floodplain modelling
 - Logical Rules (i.e. structure operation)