Integrating the environmental water requirements of rivers into operational water resource management – an example from South Africa

Denis Hughes, Stephen Mallory* and Nikite Muller
Institute for Water Research
Rhodes University, Grahamstown
***Water for Africa, Pretoria**
South Africa

Environmental Flows Conference
3 – 6 September 2007
Brisbane, Australia

Environmental water requirements

- **The SA National Water Act (1998) and National Water Resources Strategy**
  - Reserve: balancing ecological protection and sustainable use
- **Components assessed in ecological Reserve determinations are those related to**
  - Supporting ecological functioning: flow, physico-chemistry, geomorphology
  - Assessing ecological functioning: invertebrates, fish, vegetation, diatoms, habitat integrity

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

- **Different methods of assessing EWRs to provide Flow Duration Curves**
  - Incorporating natural variability (low and high flows) to ensure ecological functioning
  - Varying levels of low flow with periodic high flow events reflecting natural temporal flow patterns
- **Advantage to managing flows**
  - EFR requires lowest flows during dry periods and higher flows only when surplus water available
  - Principle used in water resource yield models to generate FDC under different scenarios (present day, future requirements) to estimate whether flow requirements can be met

Issues for implementation

- **Methods for determining low flow requirements are different to those for high flow requirements**
  - Low and high flows perform different ecological functions
  - Decision rules for changing continuous low flows vs releases for short-term high flow events are different:
    - Infrastructure requirements to manage high flows frequently lacking (storage capacity or release capacity)

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Requirements for real-time operation

- **EFRs should be integrated into overall resource management**
  - EFR is treated as water “user”, similar to other demands on water resource
  - E.g. in water stressed situation, users cannot expect to have water demands satisfied all the time, and the demand will have to be limited to drought yield of system

Requirements for real-time operation

- **Methods for managing EFR during implementation phase should be same as that used during the (Reserve) assessment / determination phase**
  - EFR variations should follow natural variations
  - Operational rules and curtailments should follow natural triggers
    - Exception where storage capacity of the resource has substantially altered natural resource, and operating rules should be based on state of the storage
  - Different sectors should have different curtailment rules, as socio-economic impacts will be different for different sectors

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Developing a model for implementation: operating rules and water resource management decision making system

- **Decision making system developed <u>assumes</u>:**
  - River basin is divided into management zones
  - Each management zone has its own set of operating rules
  - EFR is specified for the downstream end of the zone
- **<u>Requirements</u>:**
  - Simulate natural flows
  - 5 matrices of operating rules
  - Quantified through calibration and optimisation of water resource systems yield model

IWR

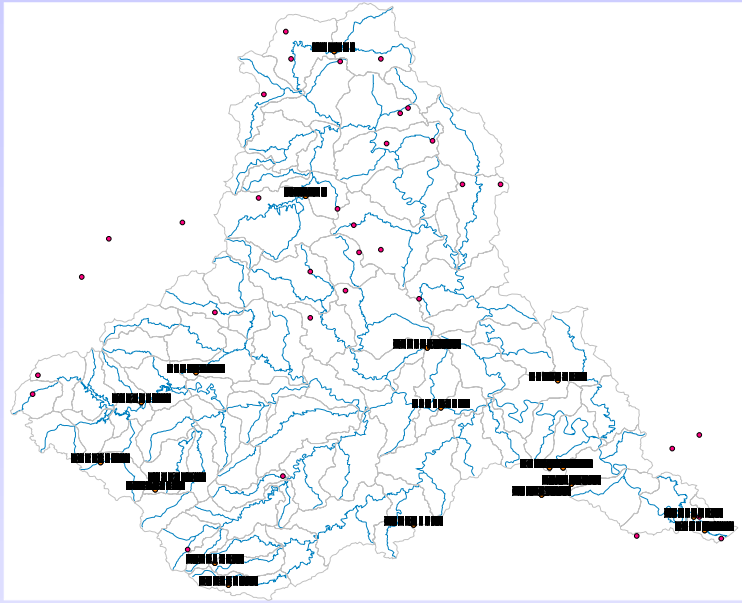
UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WRA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Matrices of operating rules

- EFR targets
- Reservoir releases for users
- Reservoir release rules
- Run-of-river curtailment rules
- Monthly curtailment factors



Application of model with Thukela catchment

- Favourably received by water resource managers
- Esp. management of low flow requirements

But several problem areas have been identified

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY

amanzi amyoli

WFA

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa

Problems encountered with model

- **Trigger information:**
  - required for effective management: hydrological monitoring networks are of great importance
  - current trends suggest that monitoring networks are declining and methods to take account of this are being developed
- **Compulsory licensing:**
  - has not yet been implemented
  - compliance (with curtailment rules) is difficult to enforce

Problems encountered with model

- **Problem of high flow releases:**
  - Component defined by peak, duration and hydrograph shape
  - Specified during certain months, but reflect natural occurrence of such events
  - Possible only where reservoirs with sufficient storage and release capabilities to meet requirements
  - Reservoir releases are subject to hydraulics of main channel (models are available)
  - Match releases from reservoirs to natural flows from tributaries
    - To ensure ecological connectivity between main channel and tributaries
    - Tributaries are unlikely to have monitoring gauges

Problem of integrating water quality

- Methods for assessing water quality requirements well developed (although not peer reviewed)
- Incorporated in EWR process through the ecostatus model, providing qualitative links to flow
- Simplified flow-quality model developed, and used in some Reserve studies, but a fully integrated model remains elusive

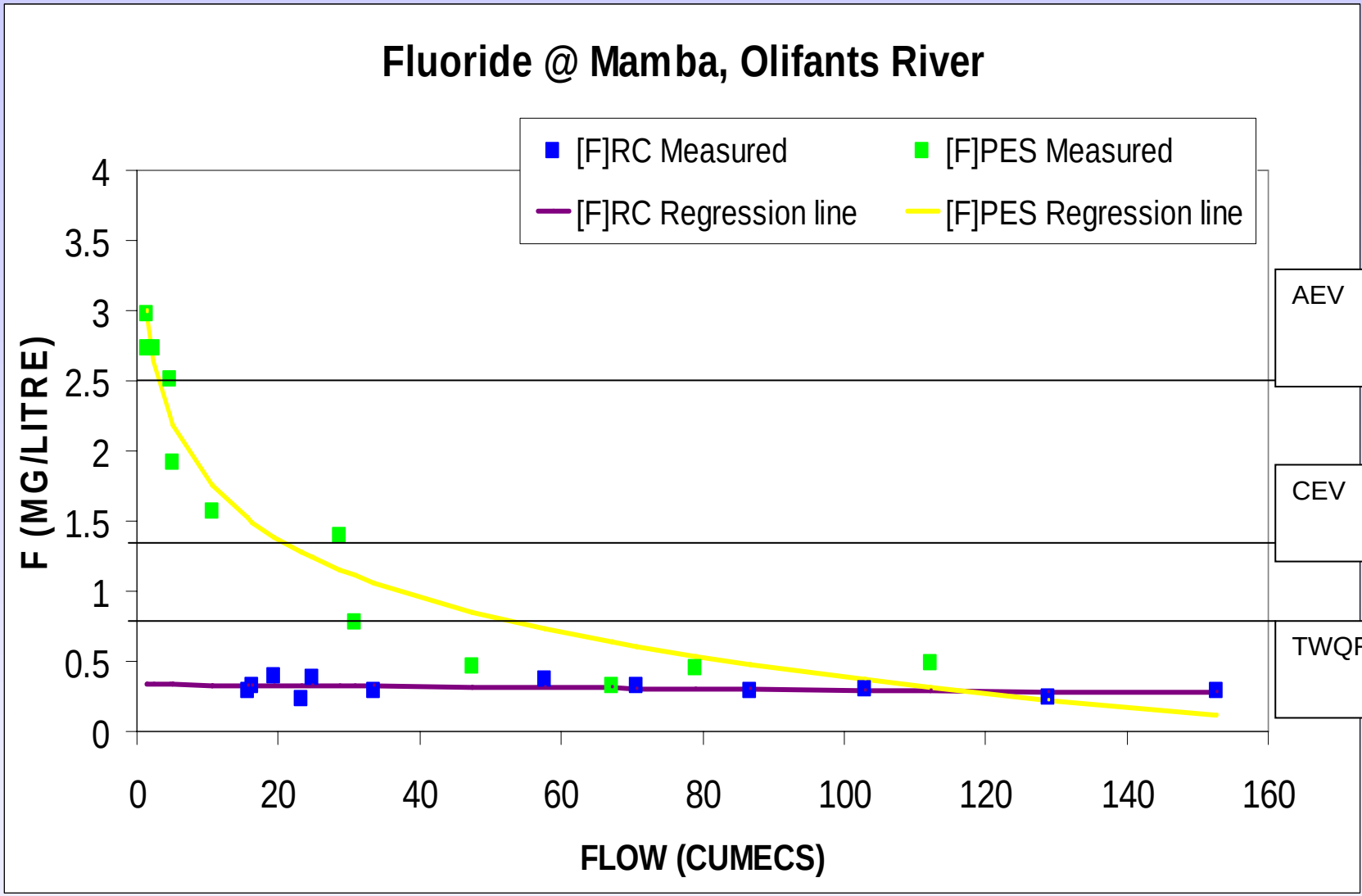
IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Problem of integrating water quality



IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY

amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Problem of integrating water quality

- **Identified several short-comings**
  - Discrepancy between quality and flow monitoring points, and allocation of resource units
  - Data issues: few water quality parameters monitored, frequency of monitoring
  - Difficult to establish quantity-quality relationships
  - Durations of exposure to changes in water quality are not considered
  - Distinguishing between flow related and non-flow related water quality issues (resource *vs* source issues)
  - Site-specific water quality trigger values for management intervention

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Discussion and Conclusion

- Low flow management system can be established
  - Practical to operate and achieve defined ecological objectives
- Flexible for different management situations
- EFR releases can be achieved through reservoir releases or curtailment of abstractions
- Limitation: ability of authority to enforce compliance (more so with run-of-river abstractions)
- Incorporation of managing high flow releases
- Incorporation of managing water quality

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

WFA

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Acknowledgements

- Water Research Commission
- Department of Water Affairs and Forestry
- Unilever
- Rhodes University
- IWR and UCEWQ staff and students
- EFR specialist consultants

Thank you!

IWR

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY

amanzi amyoli

WFA

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa