Managing sedimentation in spate irrigation schemes

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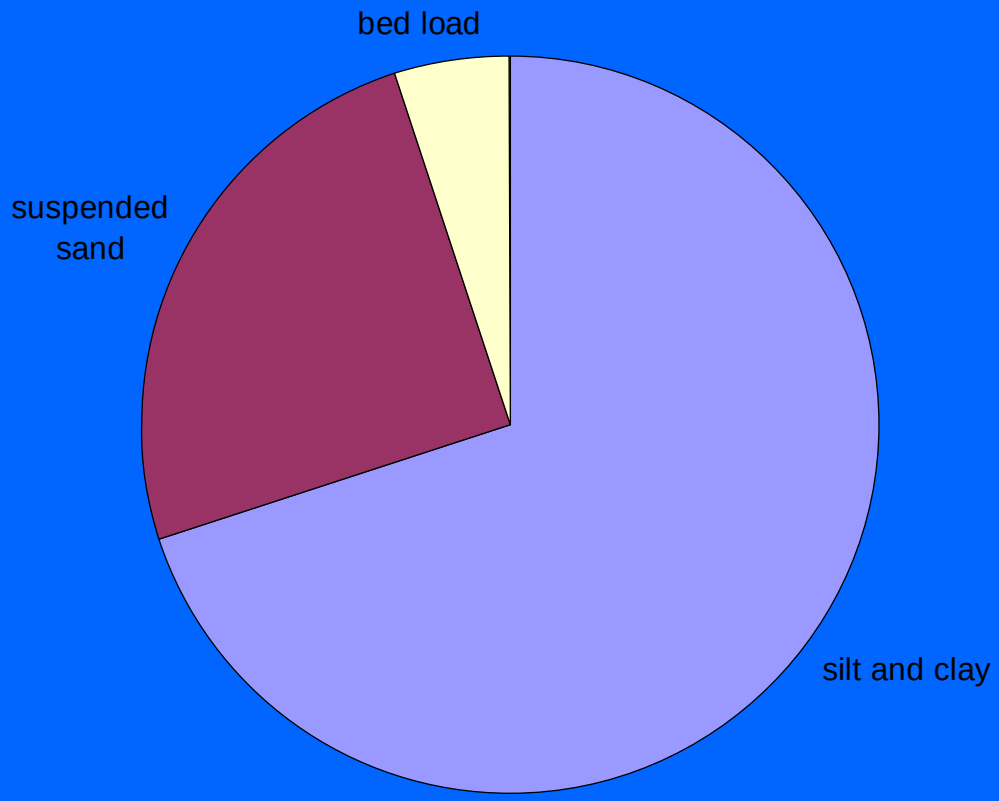
Sediment transport in wadis

- Wadi bed materials can range from boulders and cobbles to silts
- Total load sediment concentrations exceeding 10 percent by weight occur in some wadis.

Typical range of sediment sizes transported in wadis



Sediment management in traditional systems

- Intakes are washed away by large floods
- Traditional canals are steep
- Usually all the flow in a canal is diverted fields at a single point,
- When command starts to be lost intakes can easily be moved further upstream

Sediment problems in modernised systems

- Much larger discharges diverted from flood flows
- Sometimes limited sediment transporting capacity in canals = canal sedimentation
- Manual operation of sluice gates in spate flows difficult or impossible.
- Farmers may also be extremely reluctant to open sluice gates or operate flushed settling basins = no sediment exclusion = large de-silting requirements
- Rising command levels = weir crests and the sill levels of water control structures need to be raised in expensive rehabilitation projects

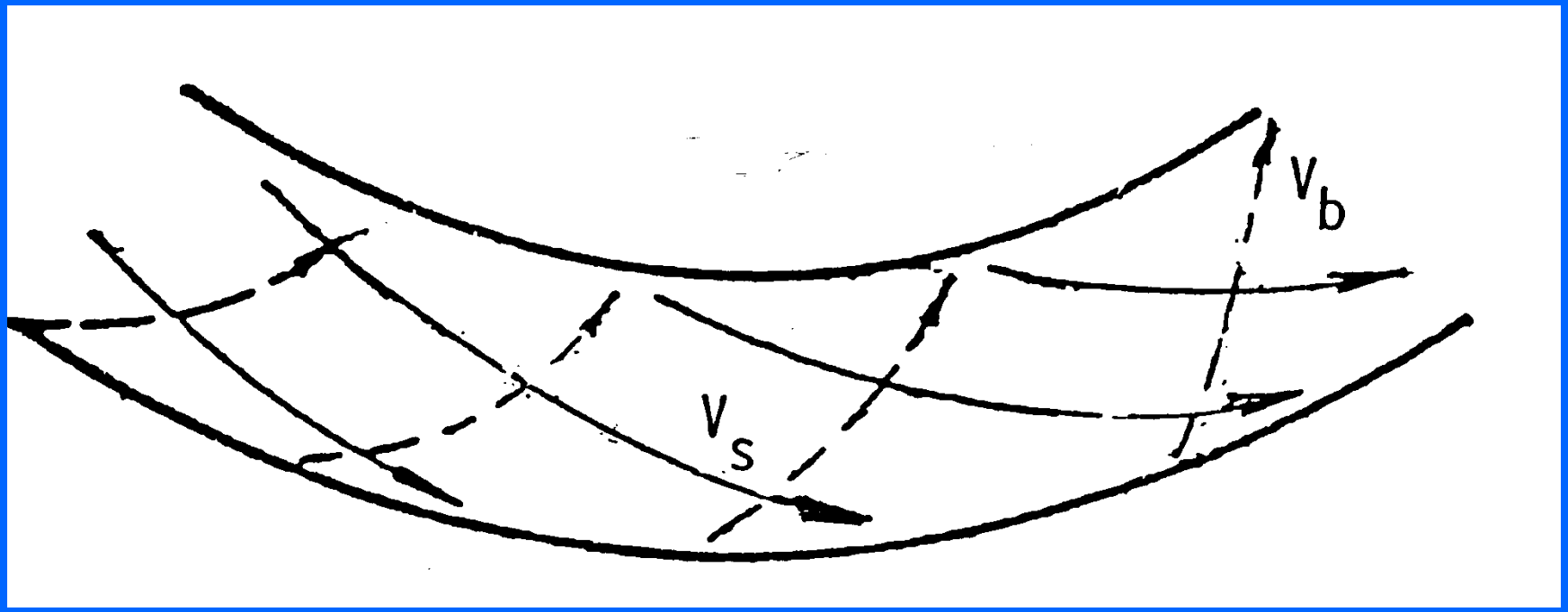
A Sediment management strategy

- Limit the diversion of coarser sediments
- Transport fine sediments through canals to the fields
- Make provision for the inevitable rise in command levels
- Accept the need for canal de-silting and plan for it

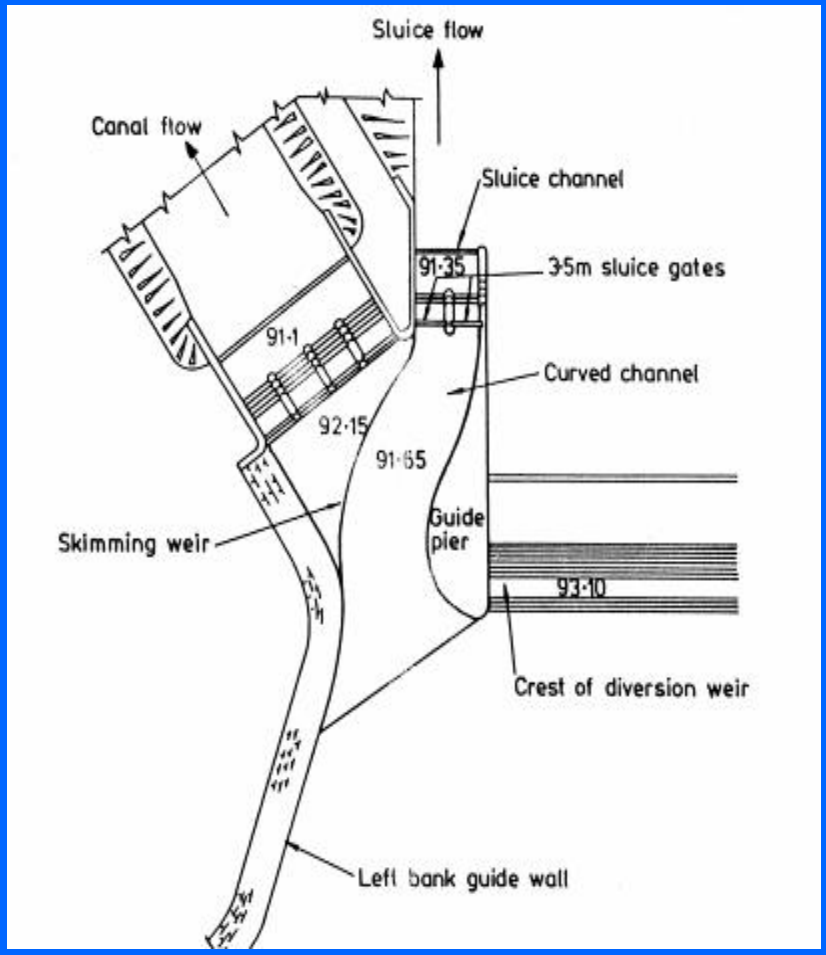
Limit diversion of coarse sediments

- Locate intakes at outside of bends
- Limit diversion when wadi flows high –throttling structures or close gates
- Sediment excluding intakes
- Secondary sediment control

Bed load sweep at a channel bend



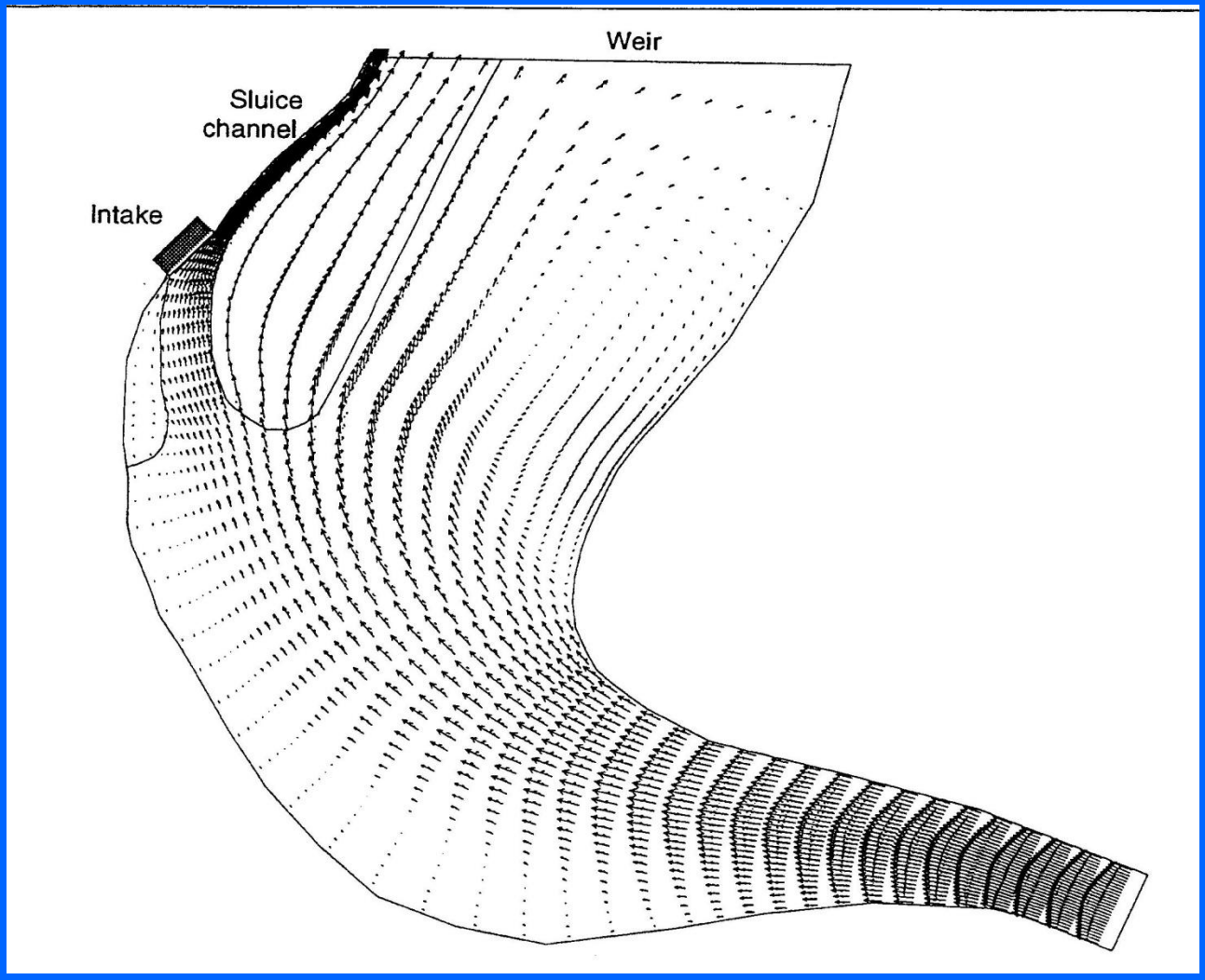
Examples of “sediment excluding” intakes



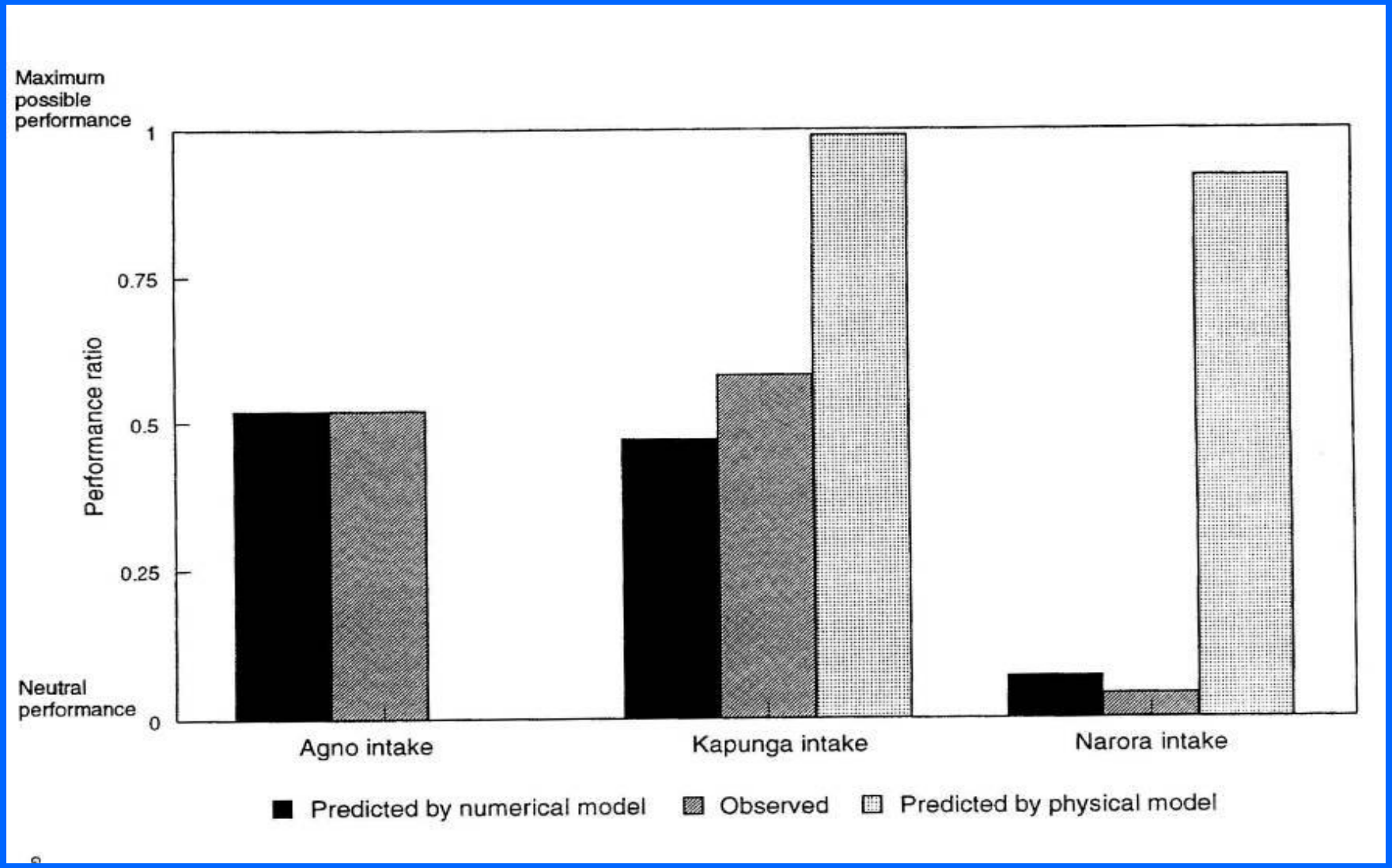
Sediment excluding intakes – application of physical and numerical models

- Physical models of practical scale overestimate sediment excluding performance - only represent coarsest sediment fractions
- Numerical modelling overcome problems in simulating a wide range of sediment grain sizes. Models and software available – suitable for predicting performance of basic intakes, sediment extractors, settling basins and canals. BUT need some data!

3 D numerical Model to predict sediment exclusion



Sediment exclusion



Secondary sediment control

- Extractors abstract water continuously from the bed of a canal, can provide control over the size range of the extracted sediment but not usually used in spate schemes

- Settling basins (gravel traps) – trap coarse sediments at the head of the Main canal

Wadi Mawr settling basins

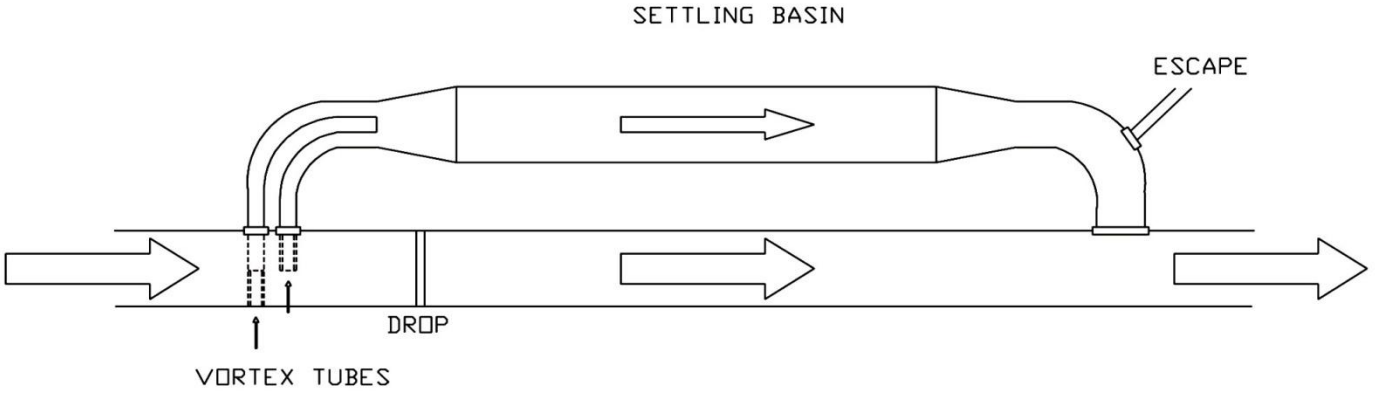
Settling basins in spate schemes

- Advantage of a gravel trap is that some sedimentation can occur without limiting flows, important where the available head is limited. If an excavator is used then de-silting is mostly focussed at the basin. Disadvantages include :
- Availability of flows for flushing
- Operation of flushing gates in rapidly varying spate flows
- Large variation in sizes of sediment trapped with operating discharge-silts trapped at through.
- Mechanical excavation can be difficult

Minimising trapping fine sediments

- Basins should be relatively narrow, with sediment storage obtained by increasing the length, rather than the width or depth of the basin.
- If it is considered necessary substantial reductions in the trap efficiency for fine sediments can be made if the tail water level in the basin is lowered for very low basin discharges. One possibility is to provide a notched weir at the basin exit, so that tail water levels are substantially lowered when the basin discharge is very low.

Hybrid extractor/flushed basin for large schemes



Transport fine sediments through canals to the fields

Transport fine sediments through canals to the fields

- Design steep canals
- Minimise flow division – ideally maintain full canal discharge from intake to field outlet, (except for flow division to reduce flows to those that farmers can handle)
- Avoid water control structures that slow down/pond canal flows (except at the diversion to field outlet)

Spate canal design methods

- no scouring – no silting” criteria – not for spate
- “Regime” design methods - Simons and Albertson include equations for canals with sand beds and cohesive banks carrying “heavy” sediment loads – have been used in spate systems
- Rational methods provide the most logical method of designing canals to achieve a specified sediment transporting capacity. Chang, 1985 method provides predictions of slopes and bed widths that are similar to that observed in many spate systems.

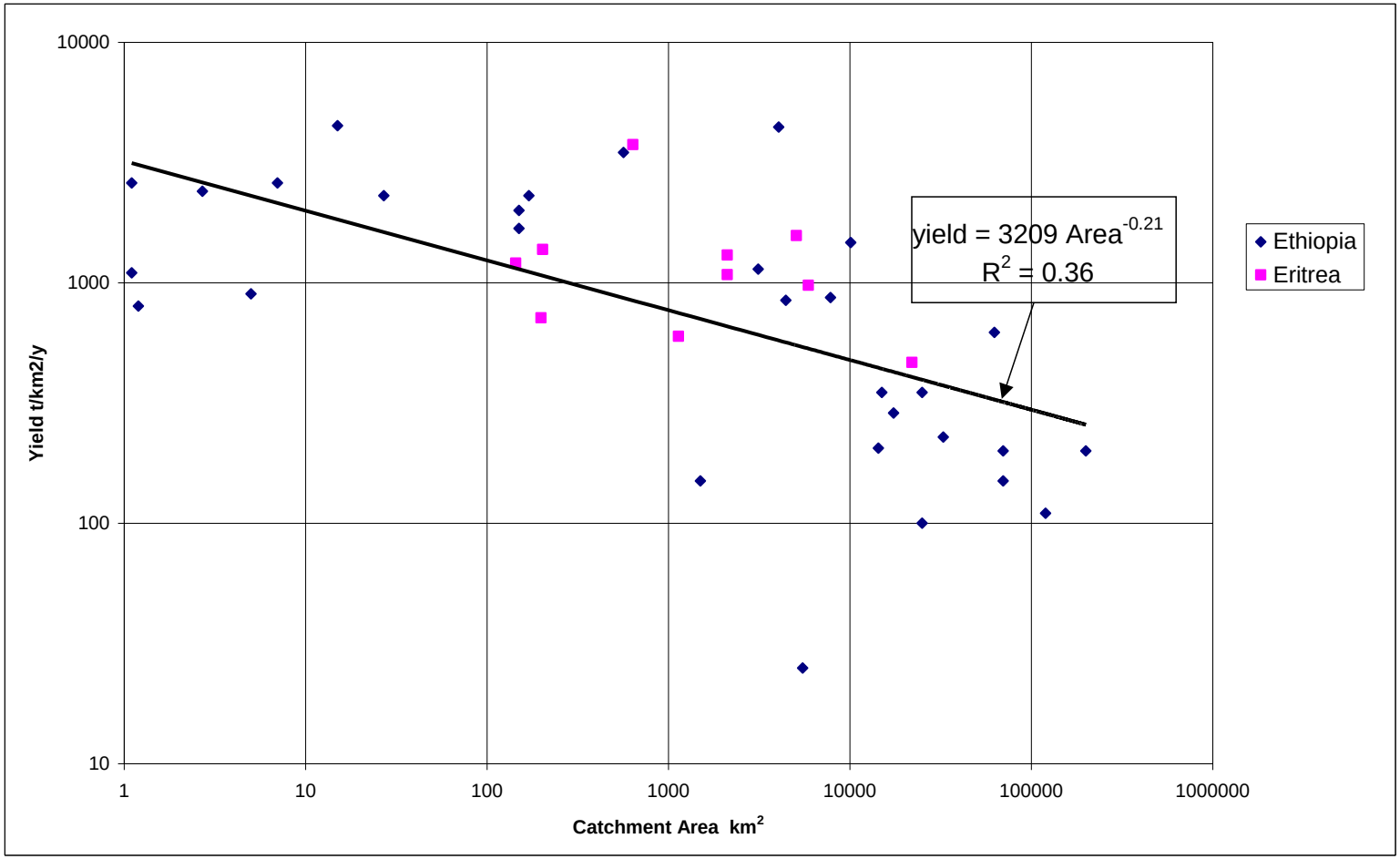
Use surveys to aid design of canals in modernised schemes

- Canal designs in modernised schemes are best based on the slopes and cross sections of (stable) existing canals. Design of enlarged, extended or new canals can then be derived using the Chang equation, with a judicious choice of input parameters to provide a good match with the slopes and cross sections observed in existing canals.

Predicting future command levels

- Rise rates 5 mm to more than 50 mm year
- Existing schemes from historical rates of rise of field and command levels, and the extent of upstream movement of traditional diversion structures.
- In new schemes, where there are no existing spate systems in the vicinity, use available sediment yield information.

Typical regional sediment yield data



Summary of sediment management options

Basic intake without a weir

- Limit flows entering canal with flow throttling structure
- If provided close gates during periods of very high wadi flows
- Design steep canals
- Consider arrangements for and sustainability of canal de-silting

Basic (small ?) intake with a low weir

- Provide simple sediment sluice
- Align canal intake to minimise diversion angle
- Limit flows entering canal, close gates during periods of very high wadi flows
- Consider if mechanically excavated gravel trap is appropriate.
- Make provision for rising command levels
- Consider arrangements for and sustainability of canal de-silting

“ Higher cost” intakes

- Incorporate sediment sluice, consider curved channel sediment excluder if bed sediments are coarse
- Align canal intake to minimise diversion angle
- Limit flows entering canal, close gates during periods of very high wadi flows
- Consider if mechanically excavated gravel trap is appropriate, or whether flushed settling basin might be feasible.
- Where high investments costs might be justified by reduced de-silting, consider hybrid extractor /settling basin system located in the canal head reach
- Make provision for rising command levels
- Consider arrangements for and sustainability of canal de-silting