National Water Commission
Raising National Water Standards Program
Groundwater Surface Water Interaction Tool (GSWIT) Project

Incorporating Groundwater-Surface Water Interactions in River Models

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Groundwater use in the MDB

The 2008 Murray-Darling Basin Sustainable Yield project found that:

• Current groundwater use is 16% of total water use

• Under current groundwater sharing arrangements, groundwater use could double by 2030

• One-quarter of all groundwater use will eventually be directly sourced via induced stream flow leakage. This impacts on:
  - Riverine ecology (particularly through reduced base flows)
  - Downstream surface water supplies (overall reductions in flow)
  - Water allocation (so-called ‘Double Allocation’ problem)
Impacts of groundwater pumping on rivers

Figure 3 ~ Effect of groundwater pumping on a gaining stream. (Note: induced stream leakage after 1,000 days is labelled as ‘induced recharge’)

GW-SW interaction modelling issues

- Groundwater-surface water (GW-SW) interaction processes are poorly handled in existing river models
  - Typically lump groundwater fluxes into the unaccounted loss/gain component of the water balance – and this is derived through calibration

- Model choice is restricted by data availability
  - At the whole-of-river scale, the general groundwater data scarcity in Australia means that generally only low fidelity modelling is possible (i.e. parsimony)
  - While fully coupled GW-SW models are in principle better, they are data intensive, complicated to use, and have poor river management capabilities
    - Unlikely to be widely adopted in water management agencies

- Temporal scale issues need to be addressed because surface water and groundwater processes operate at significantly different timescales – all about determining the time lags
The eWater CRC is building the next generation of tools to support the Australian and international water management industry. Groundwater Surface Water Interaction Tools (GSWIT) have been developed for two of the river planning and management tools:

- **Source Catchments** – for predicting water yield and constituents from upland un-regulated catchments.
- **River Manager** – for assessing long term impacts of water resource policy on system storages, flows and water shares in regulated rivers.
PERFECT-GWlag model

- **Catchment-scale** model that provides output of daily flows and salt loads at a gauging station of interest
  - Applicable to upland un-regulated catchments
  - Utilises groundwater flow and salt transport concepts encapsulated in the 2CSalt model developed in CRC for Catchment Hydrology
- Provides GW-SW interaction functionality in **Source Catchments**
  - Predicts the timing of groundwater discharge to upland streams
  - Accounts for both lateral flow (quick) and groundwater discharge (slow)
  - Handles both gaining and losing streams
  - Improves low flow (i.e. base flow) prediction
- **Source Catchments** provides the un-regulated surface water inflows (including base flow) to River Manager
PERFECT-GWlag conceptual model

1-D Water Balance (PERFECT)

Rain

Deep Drainage

Runoff

Daily Stream Flow

P (scaling)

fixed-delay

Runoff

Lateral Flow

Discharge

Recharge

α ts

β

GWlag

D (regional GW)

L (stream losses)

GW Pumping

GWModelRunner (testing software)
PERFECT-GWlag model application

Sub-Catchments

Soils

Legend

Legend

Legend

Land Use

Groundwater Parameters

Legend

Legend

Legend

Soils

Land Use

Climate

Sub-Catchments

Soils

Land Use

Climate

Functional Units

Groundwater Parameters

Legend

Legend
Groundwater-Surface Water Link Model

- **Reach-scale** model that determines the exchange flux of water between a river and the underlying aquifer
  - Applicable to regulated river systems
  - Handles both gaining and losing (saturated and unsaturated) connections
- Provides GW-SW interaction functionality in **River Manager**
- Dynamically models groundwater pumping, diffuse, irrigation and flood recharge, bank storage exchange, and evapotranspiration
- Allows fluxes or heads from external groundwater models (such as MODFLOW) to be passed to/from **River Manager**
  - Groundwater models that have been calibrated for GW-SW exchange should always be the first preference
Conceptualisation of GW-SW Link Model in River Manager

- Estimates the GW-SW exchange fluxes due to individual processes (using analytical and empirical equations)
- Then uses superposition to evaluate the overall exchange flux at every time step for an entire river reach
Groundwater table

Saturated connection

Gaining river

Losing river

Groundwater table

Overbank event

Infiltration, recharge, and discharge

Bank storage

Groundwater pumping

GW/SW exchange flux

 Processes depend on type of connection

Unsaturated connection

Losing river

Groundwater pumping

Recharge driven by difference in head between river and groundwater

Cumulative Interaction

Node 1 (upstream)

Node 2 (Downstream)

Link length L
Representing GW-SW fluxes explicitly improves calibration of river models

IQQM residual flows before and after inclusion of groundwater exchange fluxes from MODFLOW. Boggabri to Narrabri, Namoi River, 01/01/92 to 31/12/95
GW-SW Link Model input data

Diffuse recharge

Rates, areas, and their centroids were located
GW-SW Link Model input data

Pumping in unconfined aquifer

Pumping schedules, pump locations from river and boundaries were identified

Similar pumps were grouped into 13 pump clusters according to their “Hydrological response time” to minimise data handling and run time
GW-SW Link Model versus MODFLOW

Date

29/12/95  16/7/96  1/2/97  20/8/97  8/3/98  24/9/98  12/4/99  29/10/99  16/5/00

-60
-50
-40
-30
-20
-10
0
10
20
30
40

SW/GW exchange flux (ML/day)

+ve = Gaining, -ve = Losing
The influence of GW-SW exchange can now be explicitly accounted for in the new generation catchment and river models – should assist in a paradigm shift whereby river and groundwater modellers work together

This new functionality enables:

- improvement in catchment-scale prediction of base flow and how it can be impacted by climate change, land use change and groundwater development
- removal of the GW-SW exchange fluxes out of the unaccounted loss/gain parameters in river models, thus improving their calibration
- explicit accounting of the time lags associated with groundwater processes, thus enhancing the forecasting capability of river models

It is important to note that these tools do not replace groundwater models (i.e. MODFLOW) that have been calibrated for GW-SW exchange – these should always be the first preference