Baseflow recession analysis across the Eagle Ford gas play
(Texas, USA)

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INTRODUCTION

Baseflow generation

Usually derived from hydrographs

Baseflow represents the contribution of shallow aquifers to the river streamflow

Baseflow is mainly observed during the hydrograph recession curve
INTRODUCTION

Water use for fracking

Eagle Ford play

Beginning of intensive fracking period

Nowadays

17/12/2000

18/12/2015
STUDY ZONE AND DATA

- 17 streamflow gauges inside the play (analysis watersheds)
- 23 streamflow gauges outside the play (control watersheds)
- Streamflow data from 1986 to 2015, obtained from the USGS Water of the Nation
- Wells for fracking were obtained from FracFocus data for the period 2011 to 2014
- Groundwater consumption and groundwater levels were obtained from TWDB
OBJECTIVE AND METHODS

Objective

Analyze baseflow recession time-space patterns of 40 catchments, located across the Eagle Ford shale gas play in Texas (USA).

Methods

Step 1

- How to quantify the impact of shale gas development on catchment baseflow?

1. Baseflow separation
   - Baseflow Index (BFI)
   - Baseflow volume (Vb)

2. Recession curve analysis
   - Recession parameter (a)

3. Baseflow patterns comparison
   - Moderate fracking period against pre-development period
   - Intensive fracking period against pre-development period

\[ \frac{dQ}{dt} = aQ^b \]
Analysis of changes in streamflow through the flow-duration curve (FDC)

Filter equation

\[ Q_d(t) = \alpha Q_d(t-1) + \frac{1 + \alpha}{2} (Q_t - Q_{t-1}) \]

\[ Q_b(t) = Q_t - Q_d(t) \]

Baseflow volume (Vb)

\[ V_b = \int_0^t Q_b \, dt \]

Baseflow Index (BFI)

\[ BFI = \frac{\sum_{0}^{365} Q_b}{\sum_{0}^{365} Q} = \frac{V_b}{V_t} \]
METHODS

Baseflow recession analysis

- Baseflow recession curves were extracted from the baseflow hydrograph (Fig. A).
- Recession curves for a period were analyzed with the Brutsaert and Nieber (1977) method through the log(-dQ/dt) vs log(Q) scatterplot (Fig. B).
- Recession parameter was estimated for each period (Fig B and C).

Recession parameter: As bigger recession parameter, as steeper the recession curve.
RESULTS: streamflow duration curves and anomalies

Streamflow duration curves and anomalies across the play, showing inside and outside the play areas. The graphs display time of exceedance for streamflow (m³/s) with areas shaded to indicate different consumption levels: Pre-development, Moderate period, and Intensive period.

Precipitation and water storage anomalies and GW consumption across the play show variations over time, with a clear indication of anomaly patterns and consumption trends.

Graphs illustrate the impact of municipal and irrigation consumption on water storage and streamflow.
RESULTS: baseflow patterns comparison

**Baseflow Index (BFI)**

- Eagle Ford play
- Catchments

Baseflow Index (BFI) is a measure of the long-term contribution of groundwater to river flow.

**Baseflow volume (Vb)**

- Eagle Ford play
- Catchments

Mean annual baseflow volume (Vb) is a measure of the groundwater volume discharge into streams.

**Recession parameter (a)**

- Eagle Ford play
- Catchments

Recession parameter (a) is related to the steepness of the streamflow recession curve and groundwater discharge period.

BFI changes (%):
- ▲ > 80
- ▲ 60 - 80
- ▲ 40 - 60
- ▲ 20 - 40
- ▲ 0 - 20
- ▲ 0 - 20
- ▲ 20 - 40
- ▲ 40 - 60
- ▲ 60 - 80
- ▲ > 80

Vb changes (%):
- ▲ > 80
- ▲ 60 - 80
- ▲ 40 - 60
- ▲ 20 - 40
- ▲ 0 - 20
- ▲ 0 - 20
- ▲ 20 - 40
- ▲ 40 - 60
- ▲ 60 - 80
- ▲ > 80

a changes (%):
- ▲ > 80
- ▲ 60 - 80
- ▲ 40 - 60
- ▲ 20 - 40
- ▲ 0 - 20
- ▲ 0 - 20
- ▲ 20 - 40
- ▲ 40 - 60
- ▲ 60 - 80
- ▲ > 80
Municipal (blue) and Irrigation (orange) groundwater consumption across the play

- The majority of the watersheds inside the play showed higher GW consumption for irrigation.
- The majority of the watersheds outside the play showed higher GW consumption for municipal uses.
- High water table decreases were shown during the intensive fracking period in some wells.
Higher negative changes were detected in baseflow patterns inside the play during the intensive fracking period.

Effects in watersheds inside the play were associated with an intensive fracking activity and higher irrigation rates.

However, it should be noted that the intensive fracking period is also linked to high water stress conditions generated by depletion in groundwater storage and low precipitation/recharge rates; which are associated to an exceptional drought.

Results show that the observed decline in baseflow patterns are more significant in intermittent streamflow regimes.


