Production Effects from Frac-Driven Interactions in the SE Midland Basin, Reagan Co., TX

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Introduction
Introduction

• As operators transition from field delineation to field development, frac-driven interactions (AKA frac hits) are becoming more common and more severe in most unconventional shale plays
  • Miller et al. (2016), King et al. (2017), Pankaj (2018)

• DNR had observed FDIs company acreage but had not evaluated them systematically
  • Decided to quantify the effects within an area of active development
What Are Frac-Driven Interactions?

• Frac-driven interactions (FDIs) formalized by Daneshy & King (2019)

• Variety of interactions:
  • Child-Parent pressure/fluid hits
  • Child-Child pressure/fluid hits
Goals

1. Document FDIs in active area of development
2. Quantify FDI frequency, intensity
3. Create rules-of-thumb for shut-in procedures
Methods
Workflow

1. Identify FDIs from offset frac jobs
2. Categorize parent-child spatial relationship
3. Measure inter-well distance
4. Plot FDI category vs. inter-well distance
   • Filter by different criteria
Study Area/Wells

- **Study area**
  - Midland basin, Reagan Co., TX

- **Study wells**
  - 47 horizontal wells
  - 16 vertical wells
  - 17 multi-well frac jobs
FDI Interpretations

• Based on changes in oil rate, WOR, and GOR after an offset frac job
  • Must distinguish between flush production vs. FDIs

• Parent wells were reviewed if they were either…
  • Within one mile directly east or west of a frac job OR
  • Within a 500-ft radius of the heel or toe of a frac job
FDI Interpretations

1. No FDI
2. Oil banking
3. Small water hit
4. Moderate water hit
5. Large water hit
## Parent-Child Spatial Relationships

<table>
<thead>
<tr>
<th>Wellbore Geometry</th>
<th>Offset direction</th>
<th>Hz “buffer” well?</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>Direct</td>
<td>False</td>
<td>A</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td>True</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>In–line</td>
<td>—</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Stacked</td>
<td>—</td>
<td>F</td>
</tr>
<tr>
<td>Vertical</td>
<td>Direct</td>
<td>False</td>
<td>G</td>
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<tr>
<td></td>
<td></td>
<td>True</td>
<td>H</td>
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<tr>
<td></td>
<td>Indirect</td>
<td>False</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>True</td>
<td>J</td>
</tr>
</tbody>
</table>
Direct Offsets (Vertical wells)

Direct Offsets (Horizontal wells)
Indirect Offsets (Vertical wells)

Indirect Offsets (Horizontal wells)
**In-line Offsets**

**Stacked Offsets**

**Only applicable for horizontal wells**
Horizontal "Buffer" Well
All Configurations

Color by:
- No FDI
- Oil banking
- Small water hit
- Moderate water hit
- Large water hit

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<td>20%</td>
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<tr>
<td>2,000 &lt; x ≤ 3,000</td>
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<td>19%</td>
<td>14%</td>
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<td>5,000 &lt; x</td>
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Vertical vs. Horizontal Parent Wells

All Vertical Well Configurations (G - J)

- Color by:
  - No FDI
  - Small water hit
  - Moderate water hit
  - Large water hit

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<td>2,000 &lt; x ≤ 3,000</td>
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</table>

All Horizontal Well Configurations (A - F)

- Color by:
  - No FDI
  - Oil banking
  - Small water hit
  - Moderate water hit
  - Large water hit

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<td>14%</td>
<td>18%</td>
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<td>14%</td>
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<tr>
<td>1,000 &lt; x ≤ 2,000</td>
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<td>17%</td>
<td>13%</td>
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<td>2,000 &lt; x ≤ 3,000</td>
<td>27%</td>
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<td>20%</td>
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<td>0%</td>
<td>0%</td>
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</tr>
</tbody>
</table>
Direct vs. Indirect Offsets

**Limited to parent wells with no “buffer” well**
In-line vs. Stacked Offsets

Well Configuration E

Well Configuration F
Indirect Offsets Without vs. With “Buffer” Well

Well Configuration C

Well Configuration D

Inter-well Distance [ft]

Inter-well Distance [ft]

% FDI Types (normalized)

% FDI Types (normalized)

Color by:
- No FDI
- Oil banking
- Small water hit
- Moderate water hit

Color by:
- No FDI
- Small water hit
Major Takeaways (1/2)

• Horizontal wells receive FDIs more frequently, and with greater intensity, than vertical wells

• Stacked or direct offset parent wells receive FDIs more frequency and greater intensity

• FDI frequency and intensity is strongly correlated with inter-well distance
  • More strongly correlated for vertical wells
Major Takeaways (2/2)

• “Buffer” wells significantly reduce FDI frequency and intensity
  • Albeit at the expense of the “buffer” well itself

• Oil banking is occasionally encountered in horizontal wells but not observed in vertical wells
  • EDIT: Oil banking has been observed in vertical wells in other areas

• Most parent wells received either (a) small/moderate water hits or (b) no FDI at all
Discussion
Discussion (1/2)

• End-member results not surprising
  • Horizontal vs. vertical wells
  • Direct vs. Indirect vs. In-line vs. Stacked offsets
  • “Buffer” well present vs. absent

• However, the cumulative effect of each layer was more marked than anticipated
Discussion (2/2)

• The efficacy of “buffer” wells was not foreseen but aligns with field experience

• Positive FDIs were not recognized previously despite its occurrence in other unconventional plays
  • See Miller et al. (2016), Pankaj (2018)

• FDIs are a nuisance but do not appear to pose a major risk
Conclusions
Conclusions (1/2)

• FDI frequency/intensity are a strong function of:

  1. Wellbore geometry
  2. Offset direction between the parent/child well
  3. Presence/absence of a “buffer” well
  4. Distance
Conclusions (2/2)

• FDIs are not a significant risk to oil production in parent wells in SE Midland basin

• Production effects are:
  • Usually limited to increased water production and lower GORs
  • Usually temporary (weeks to months)
Questions?
References
References


