

# Multistage Completions for Hydraulic Fracturing – The Past, Present, and Future

**SPE GCS**

**Permian Basin Study Group**

June 4, 2020

**Check out my video blog  
and training courses at  
[www.uog.training](http://www.uog.training)**

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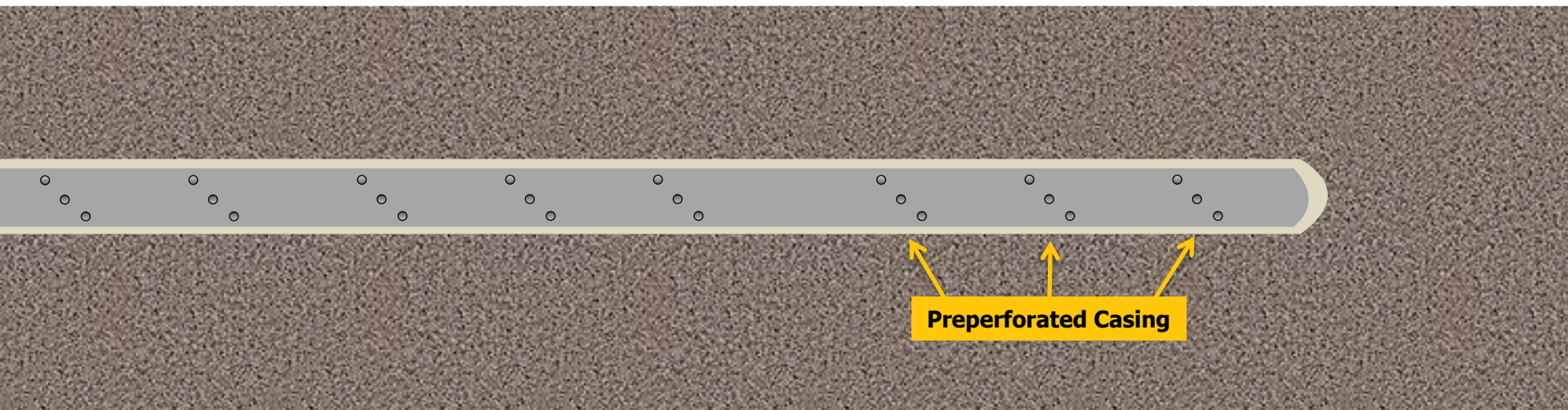


# Barefoot Completions

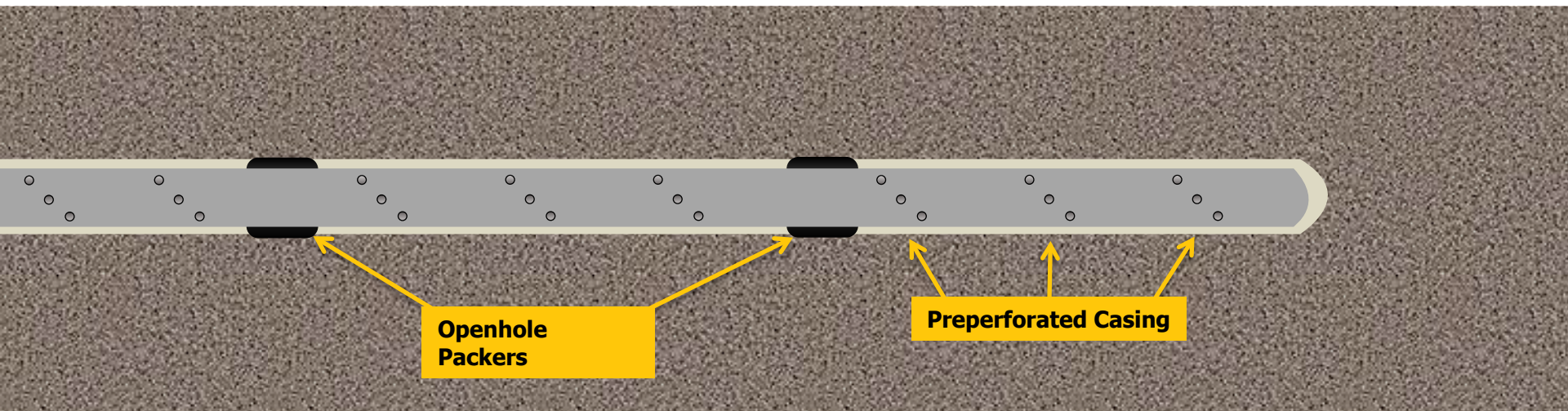
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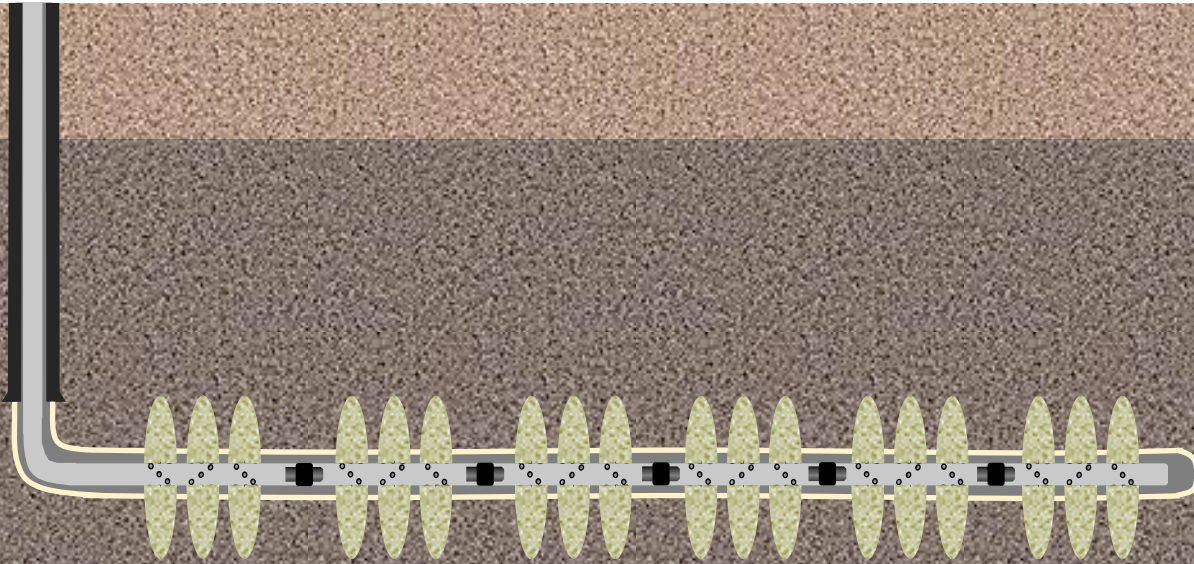
# Slotted Liner



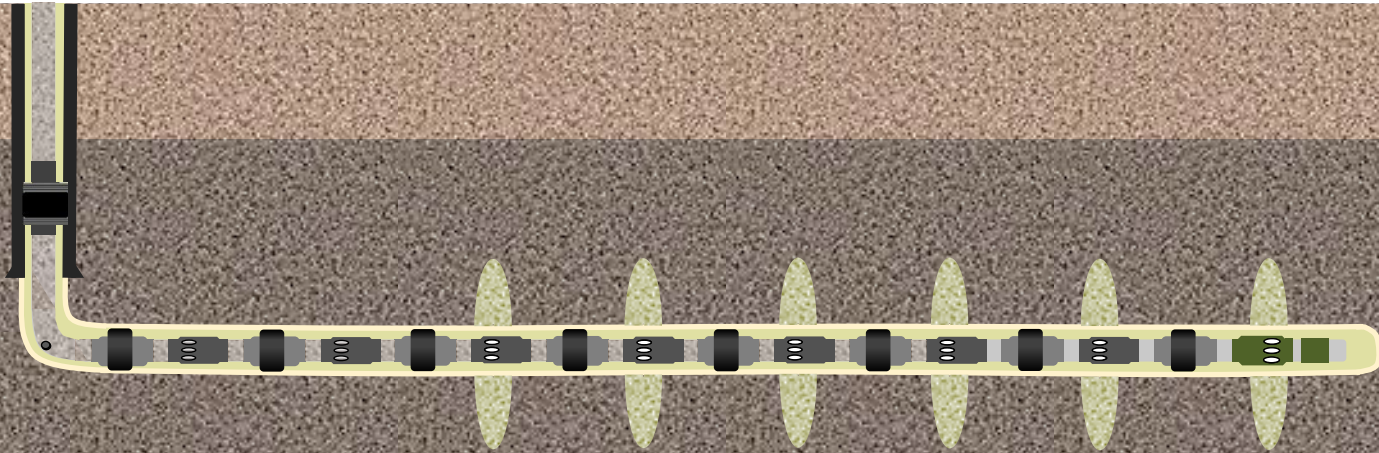
# Slotted Liner with Annular Isolation



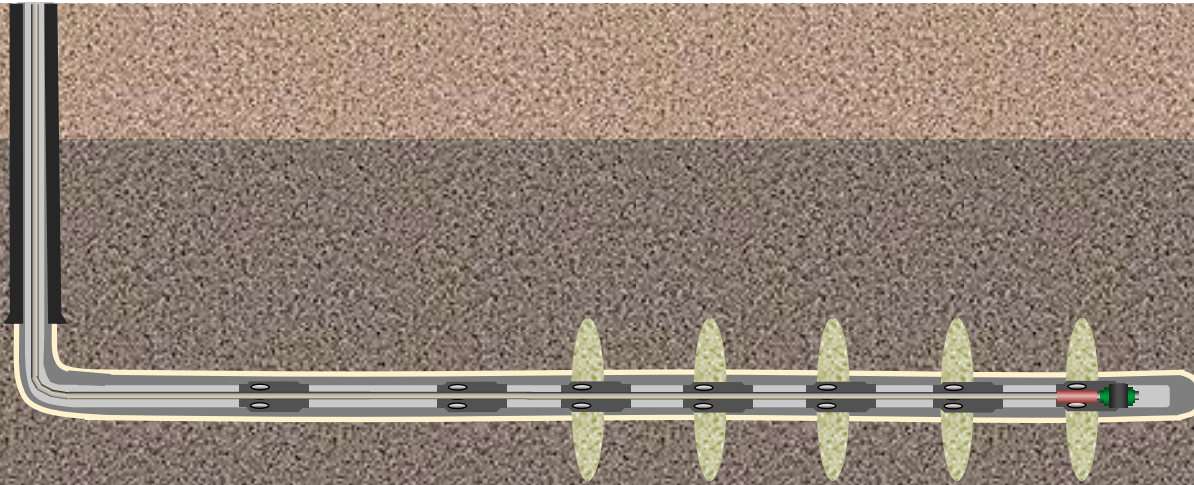
# Plug-and-Perf (PNP)



# Ball-Activated Completion Systems (BACS)



# CT-Activated Completion Systems (CTACS)



# Shifts over the last 10-12 years

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- 3 stages > 5 stages > 12 stages > 24 stages > 40+ stages
- Sand volumes
- Sand types
- Sand sizes
- Fluid types

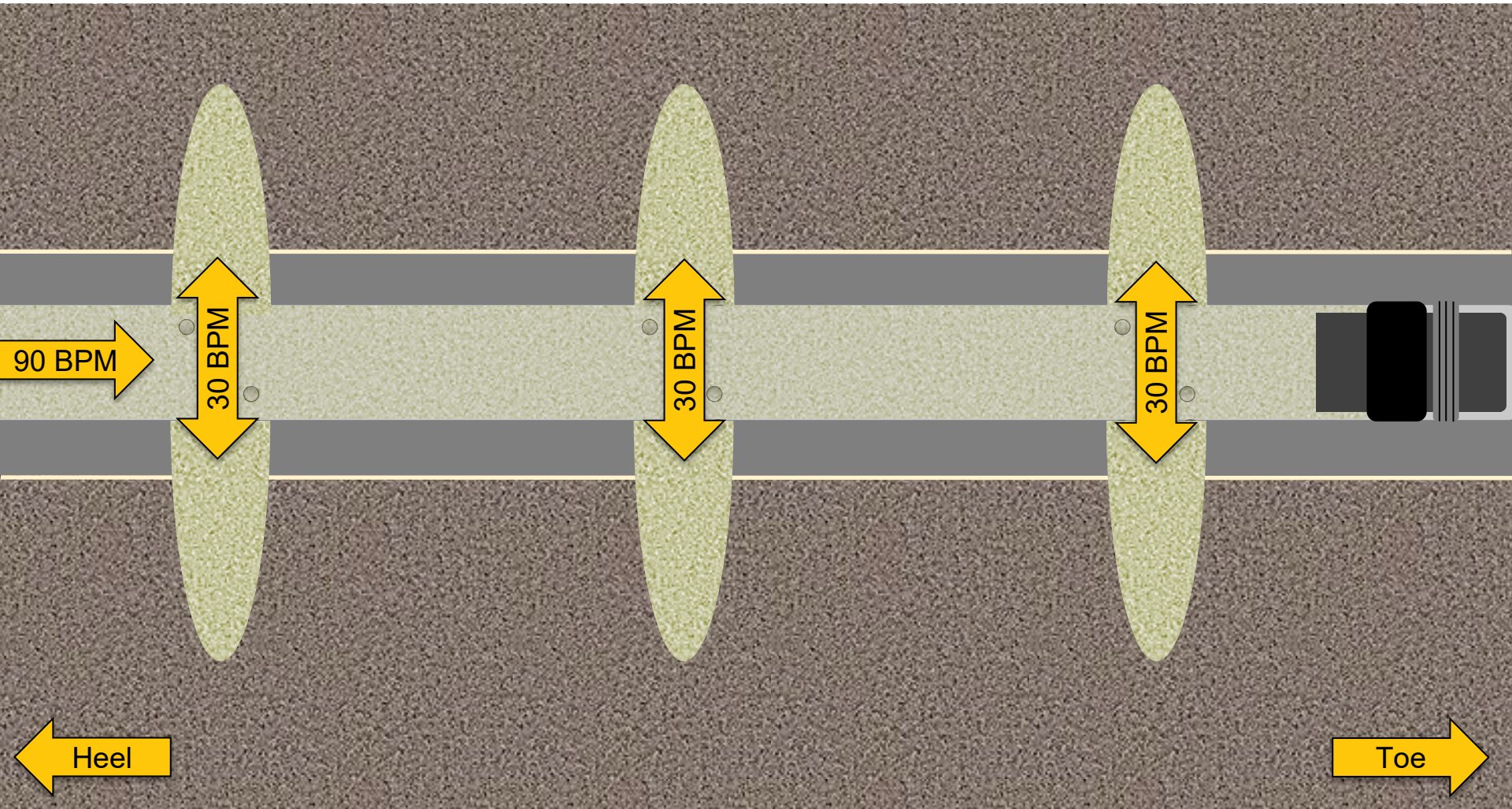


# What are We Doing Today?

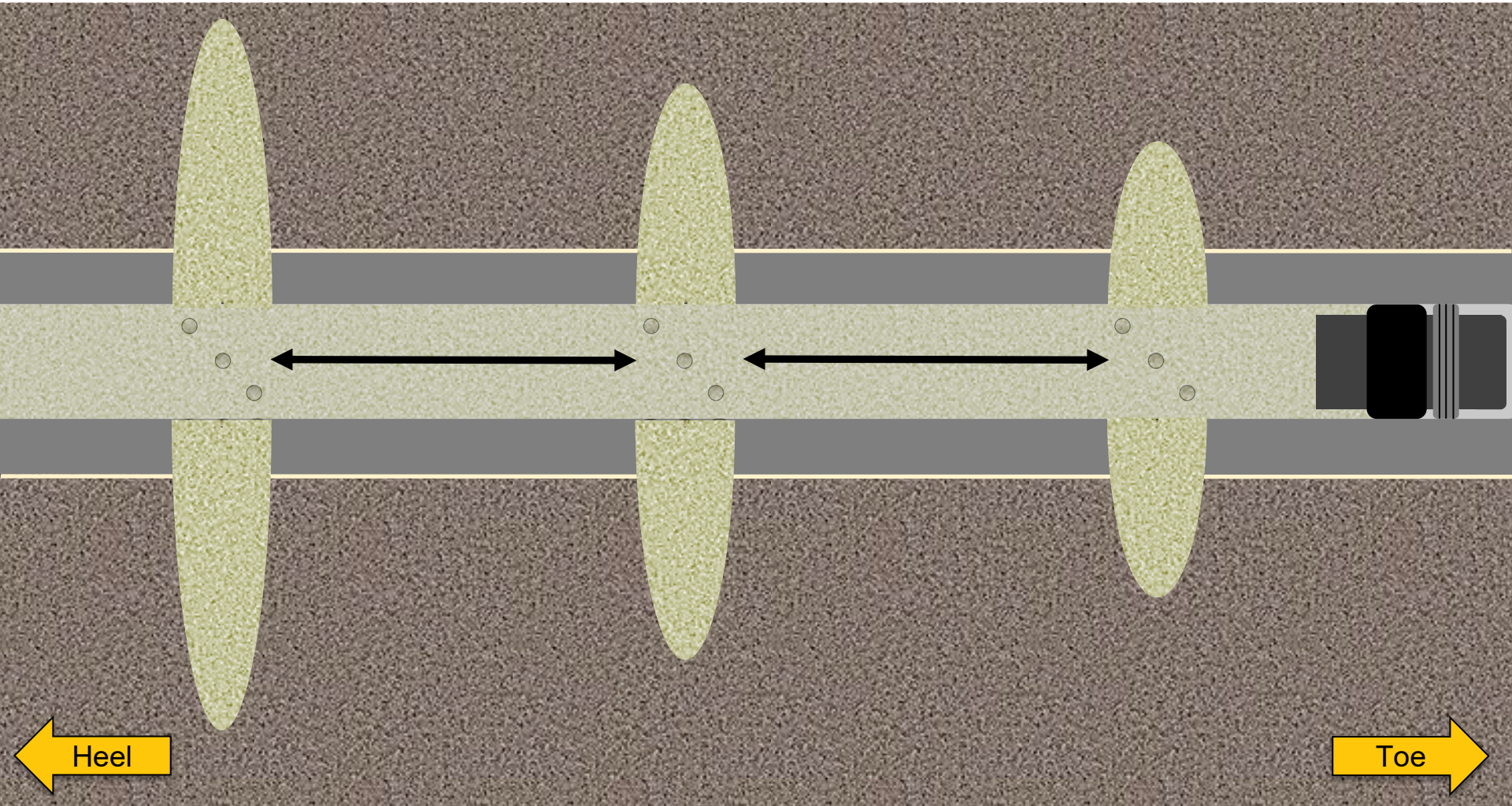
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- PNP is approximately 95% of the US market
  - More clusters per stage
  - Limited Entry Perforating
  - Diverters are being used more

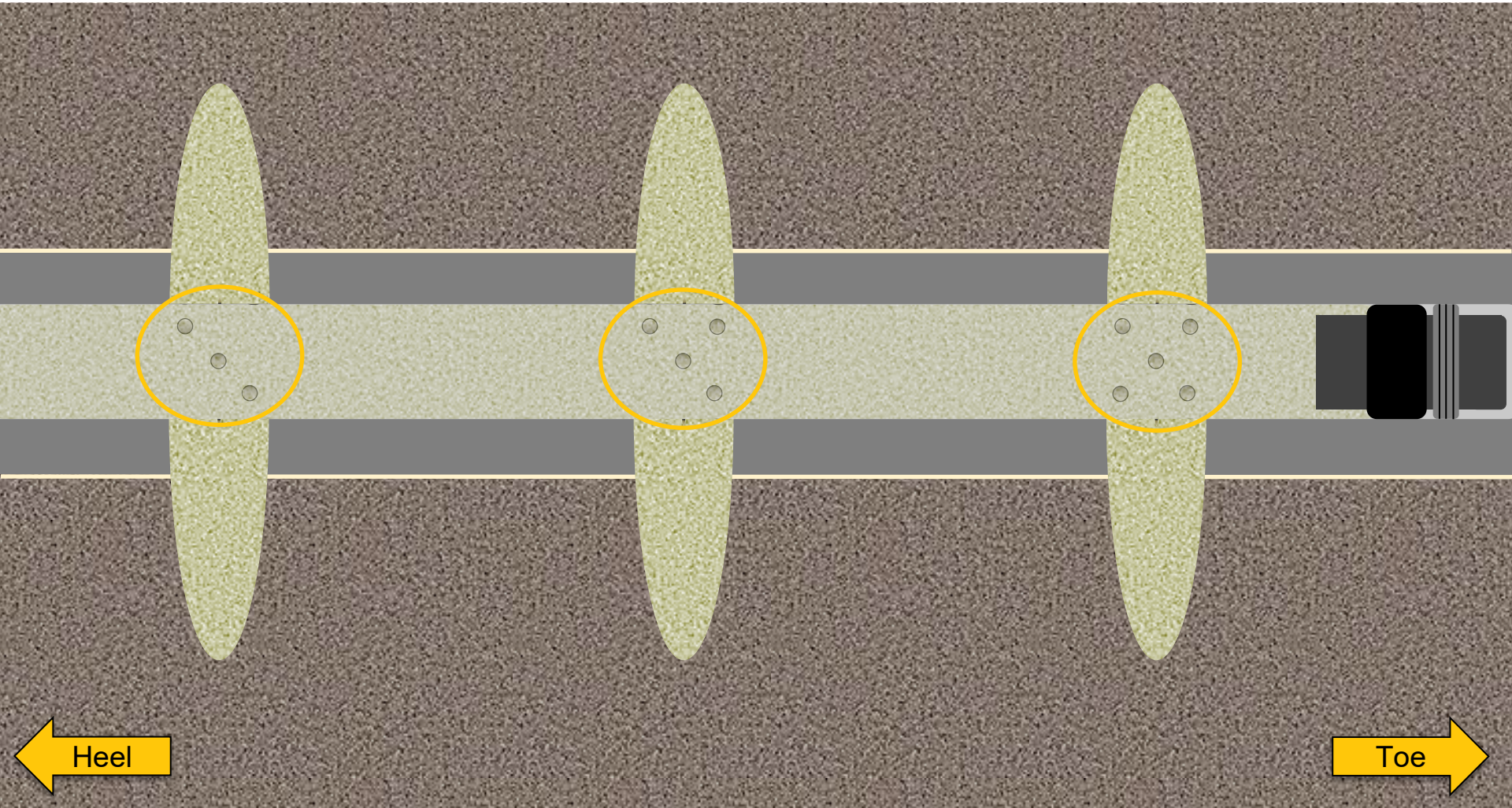
# Fluid Distribution Through Clusters



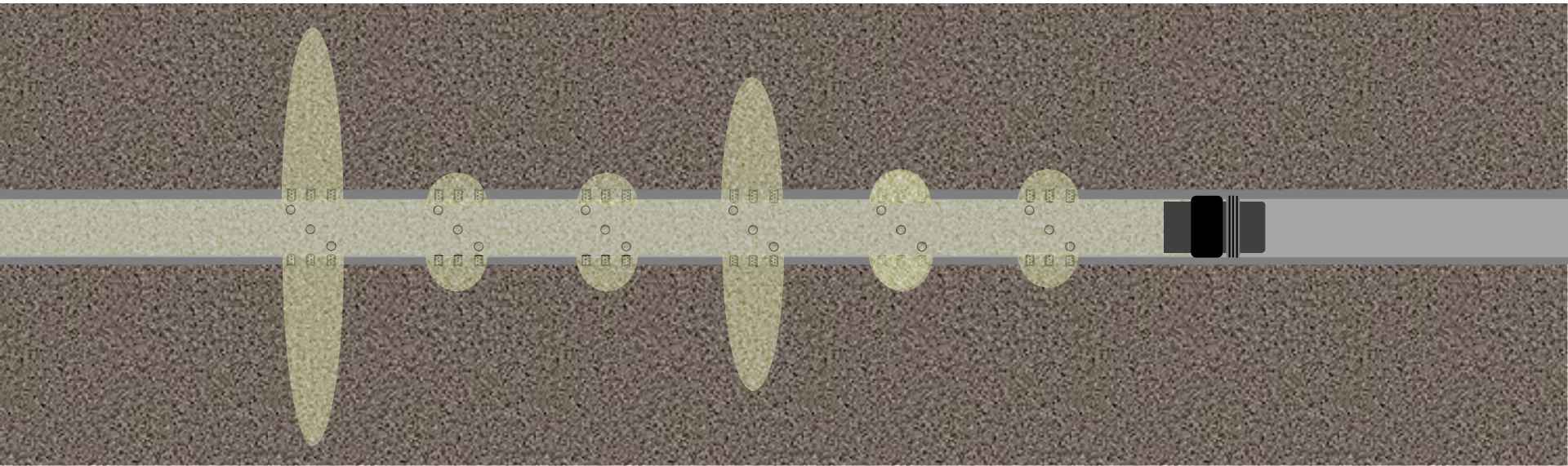
# Fluid Distribution Due to Friction Losses



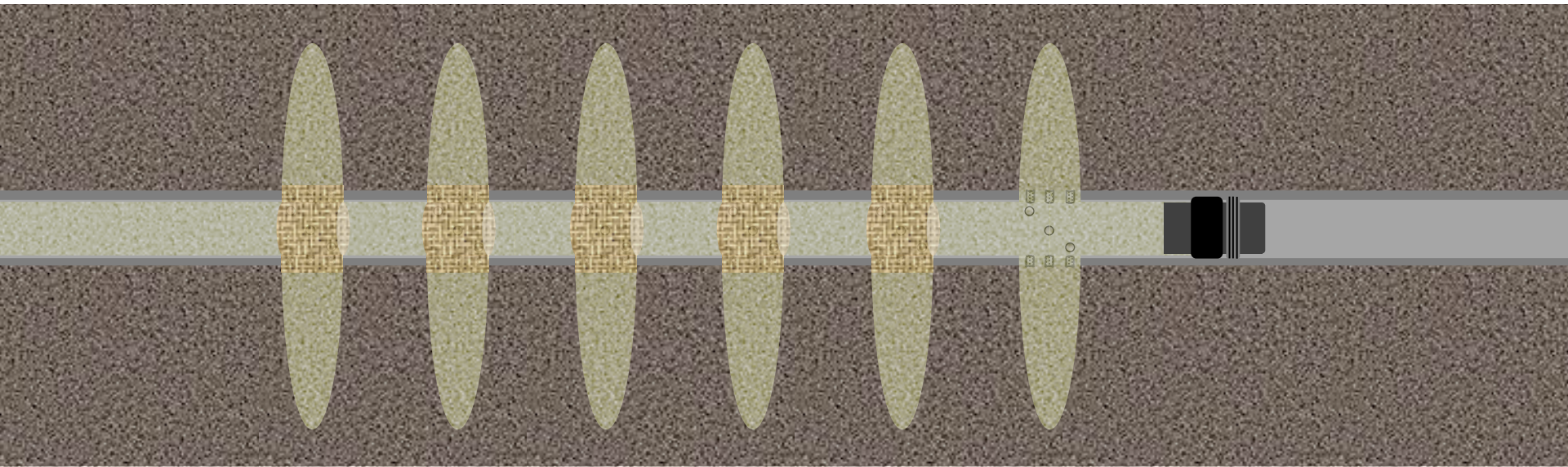
# Limited-Entry Perforating



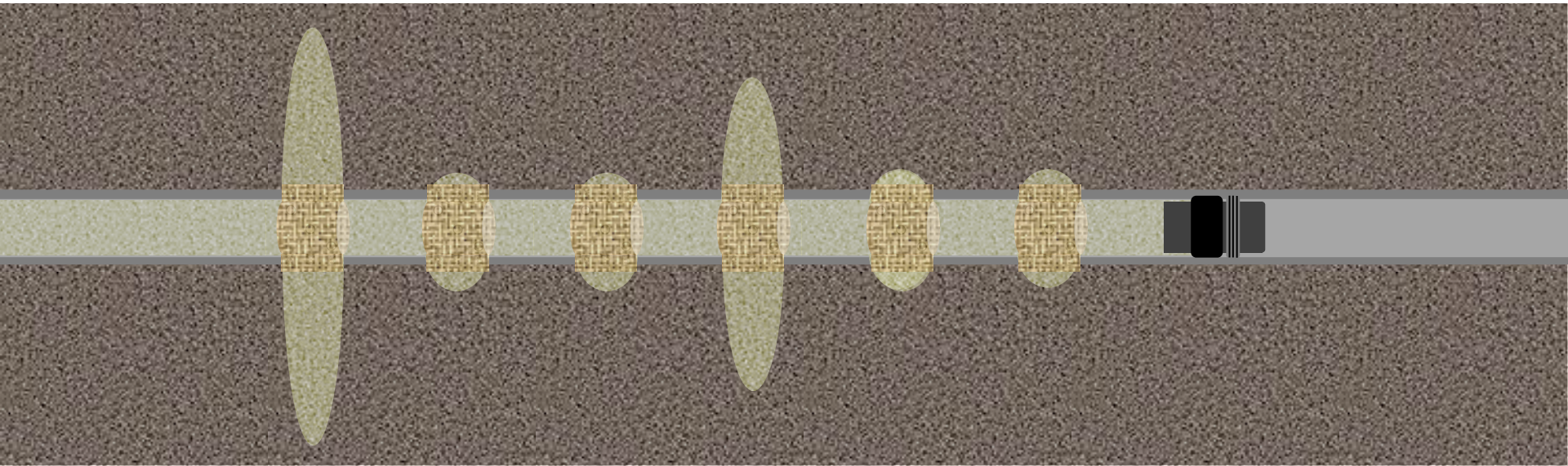
# More Clusters per Stage, More Variability



# Diverters



# Diverter Strategy



JPT Article on Diverters: *Getting More from Fracturing with Diversion*  
<https://www.spe.org/en/jpt/jpt-article-detail/?art=2979>

# What are We Doing Today?

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How did we get here?



# Completion Optimization

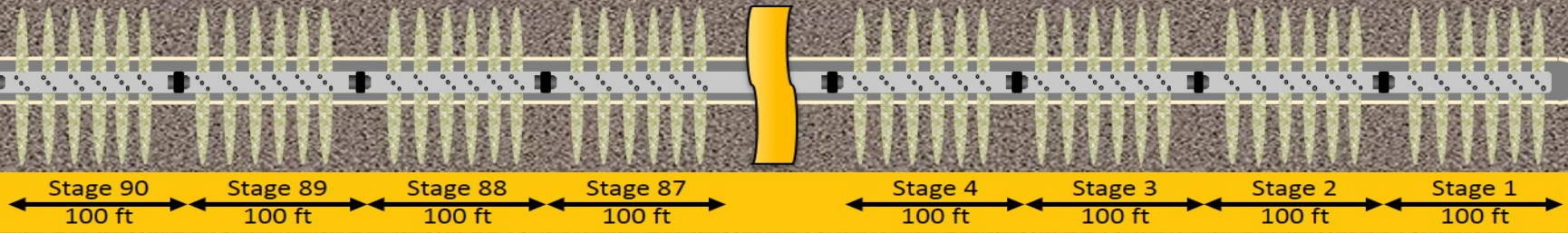
## Q1 2016 Operator Presentation

9000-ft lateral  
100-ft per stage  
15-ft cluster spacing



90 stages  
6 clusters\stage  
540 injection points

Assume 2 hours of downtime between stages  
90 stages = 180 hours or 7.5 days (24-hr crew)  
540 stages = 1080 hours or 45 days (24-hr crew)

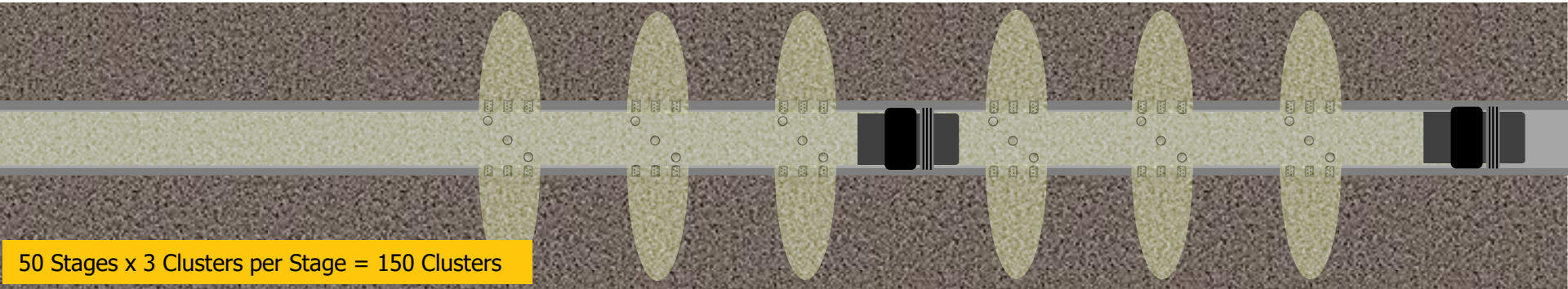


# Completion Optimization

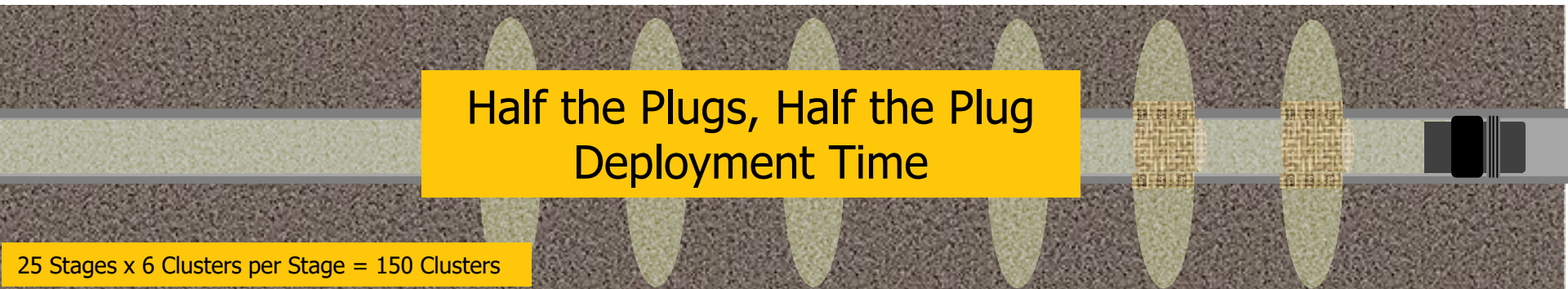
	Stages/Clusters for 540 injection points	Total Wireline Time*
180 plugs		
90 plugs		
45 plugs		

\* Assuming 2 hours between stages

# Fewer Stages, Same Number of Clusters



50 Stages x 3 Clusters per Stage = 150 Clusters

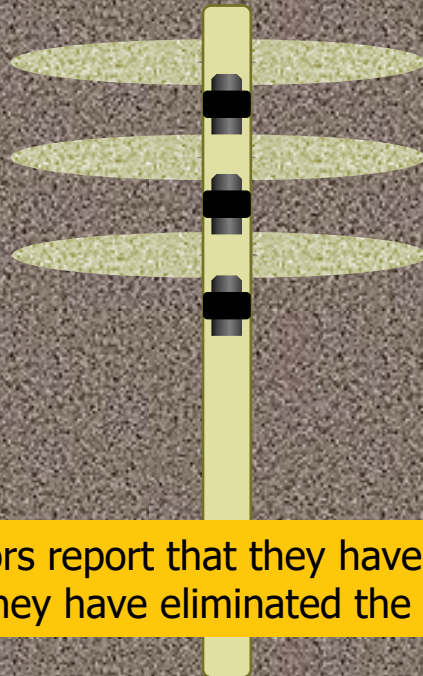


Half the Plugs, Half the Plug  
Deployment Time

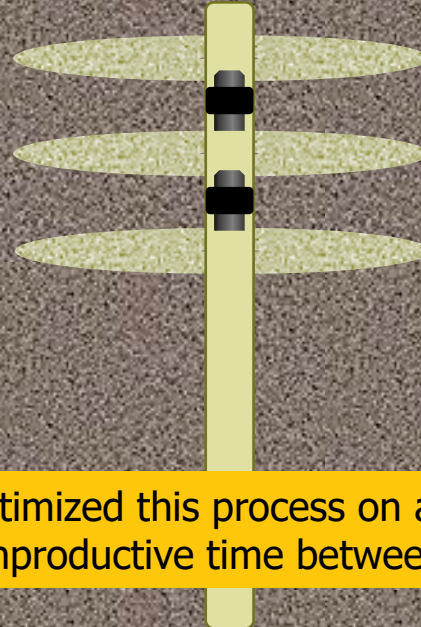
25 Stages x 6 Clusters per Stage = 150 Clusters

# Simultaneous Fracturing Operations

Well A

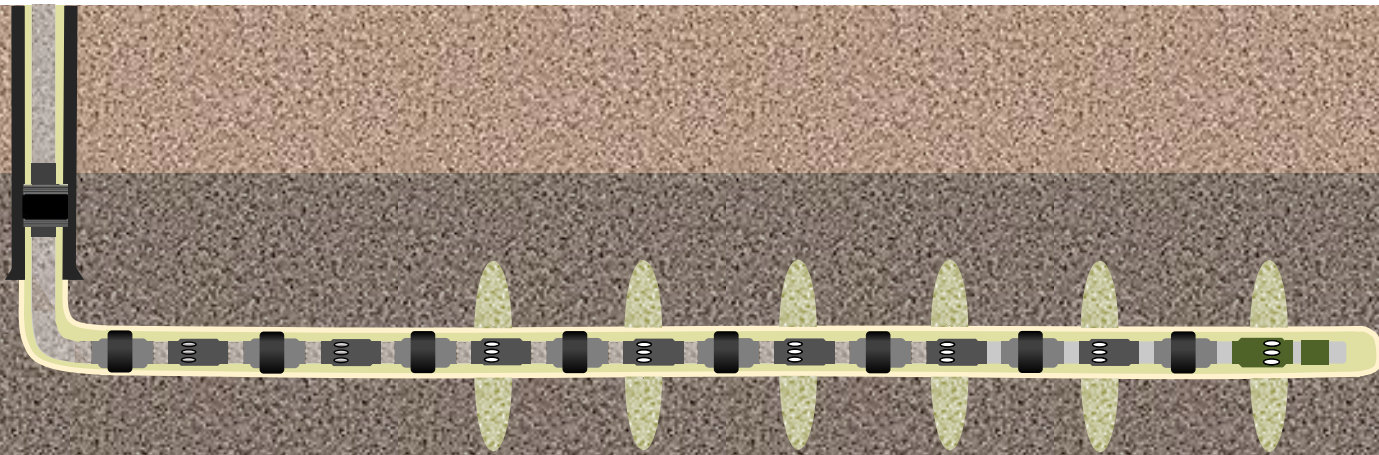


Well B



Some operators report that they have optimized this process on a large scale to the point they have eliminated the nonproductive time between stages.

# Decline of the BACS



## Exceeded Tech Limits of Traditional BACS

- Finite number of ball and ball seat combos
- Diameter restrictions
- Simultaneous fracturing ops for PNP

# Downturn Economics in the US

Consider the effect of the downturn on completion decisions

## Typical US Operator Structure

Drilling AFE – Everything done with the drilling rig

Completions AFE – Everything done between drilling rig and production

Production AFE – Everything done after completion

# The Downturn and the Impact on Completions

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US Bakken Example



If an operator's strategy is drill but not complete, PNP is the clear choice

# Other Downturn Effects

- Cash is king – the primary objective is breakeven on the well
- Services are cheap and readily available
- Less tolerance for failure – afraid they'll lose their job
  - A certain level of failure is tolerated with traditional completions

Not necessarily a bad thing

- Record initial production

Keep in mind

- Record amounts of fluids and sand have been pumped
  - Completion strategies today are very different
- “Core” acreage is being developed



# What are We Doing Today?

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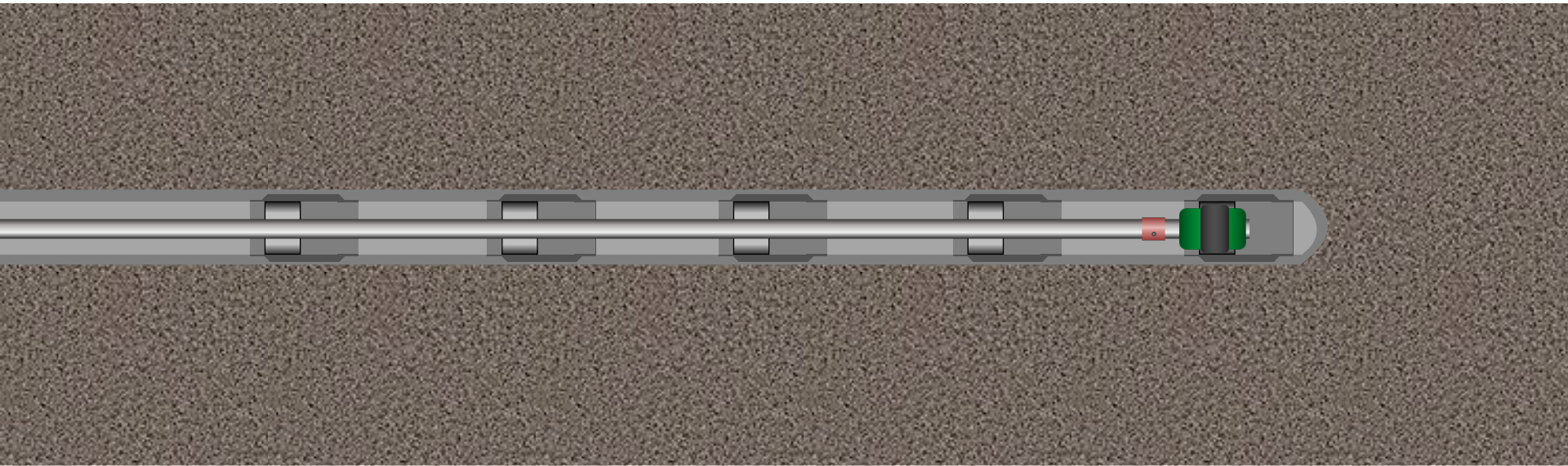
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**Do we have it figured out?**

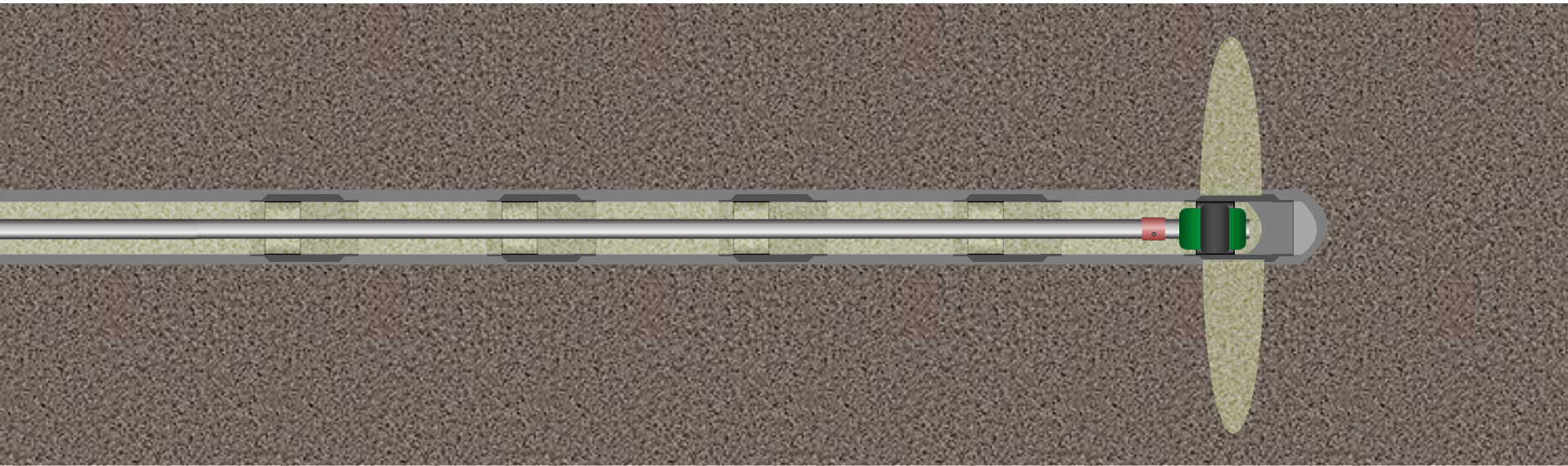
# Interesting Trials/Technologies to Watch

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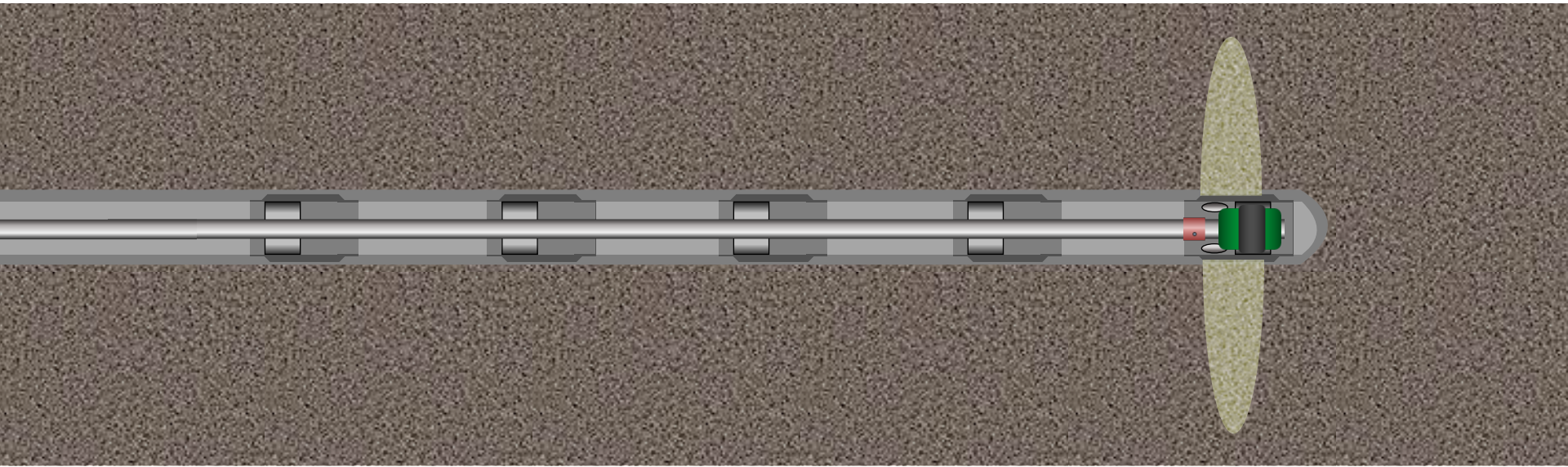
# Watchlist – Out-of-Order Fracturing



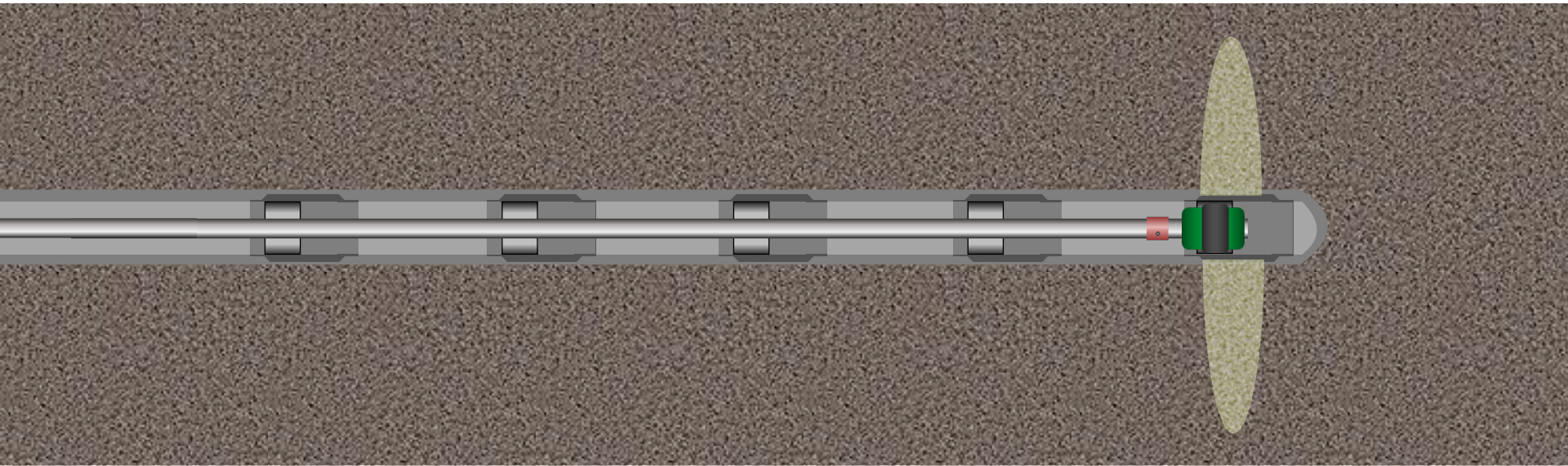
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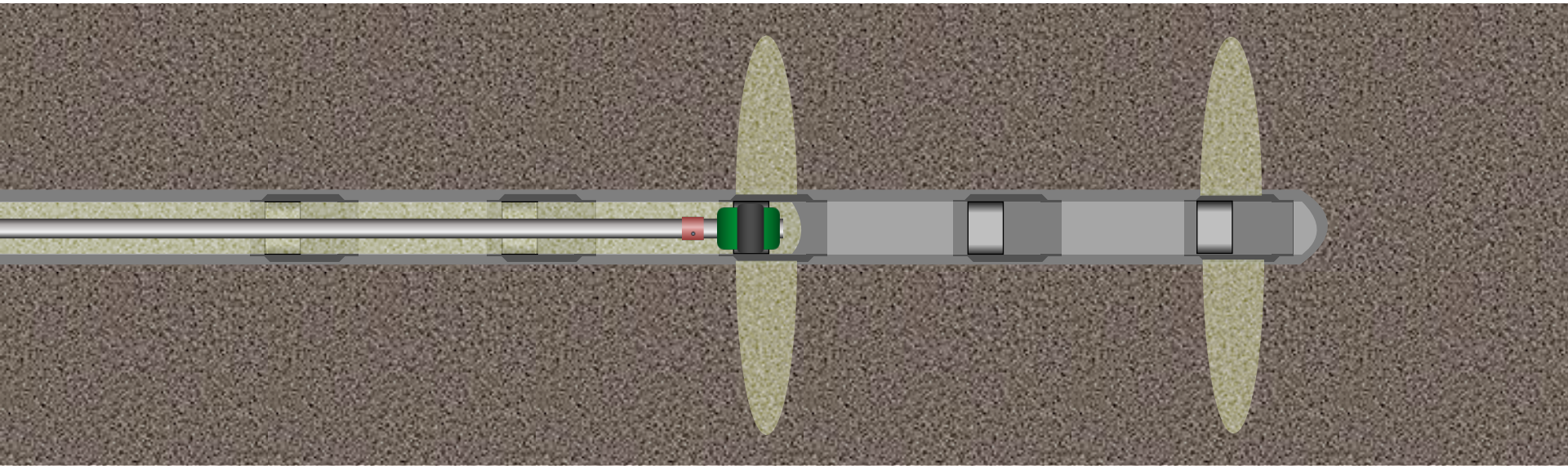
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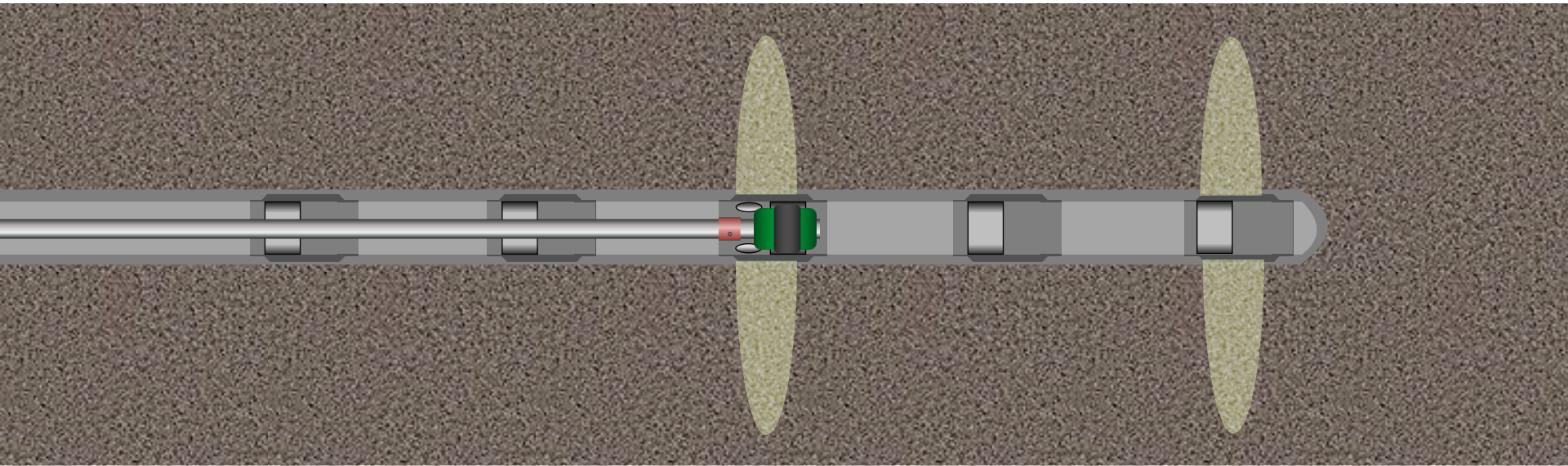
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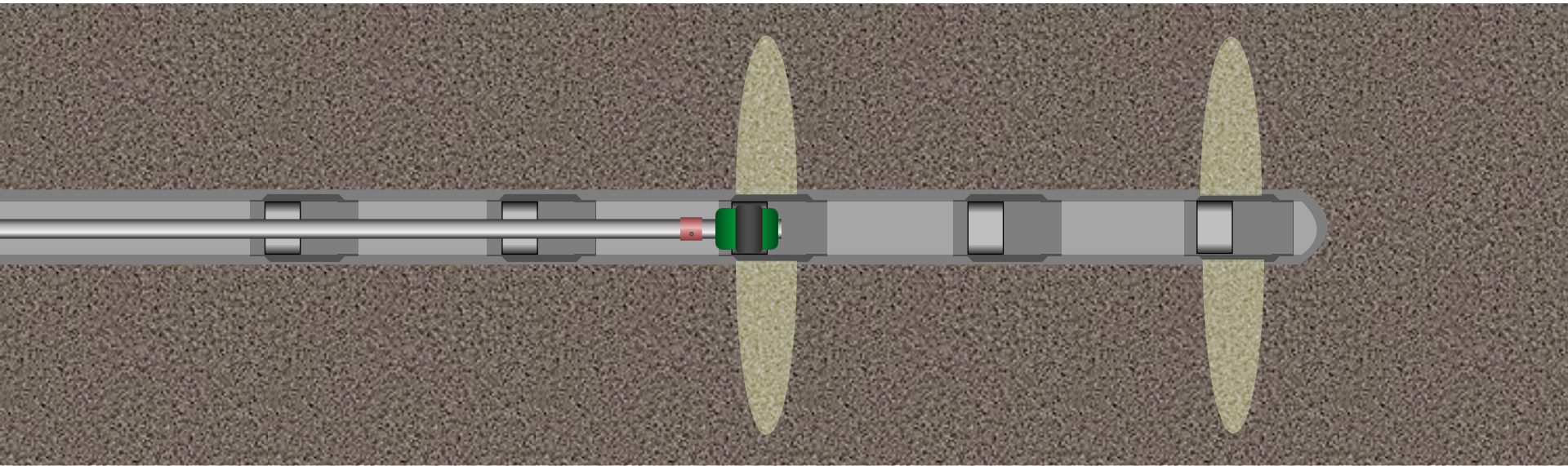


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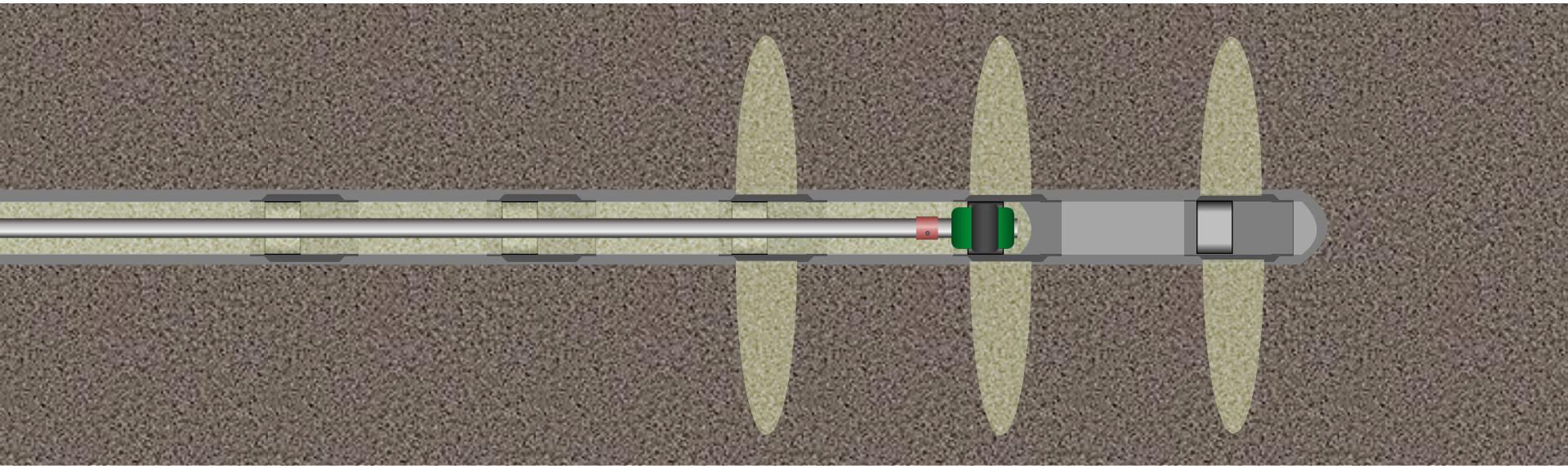




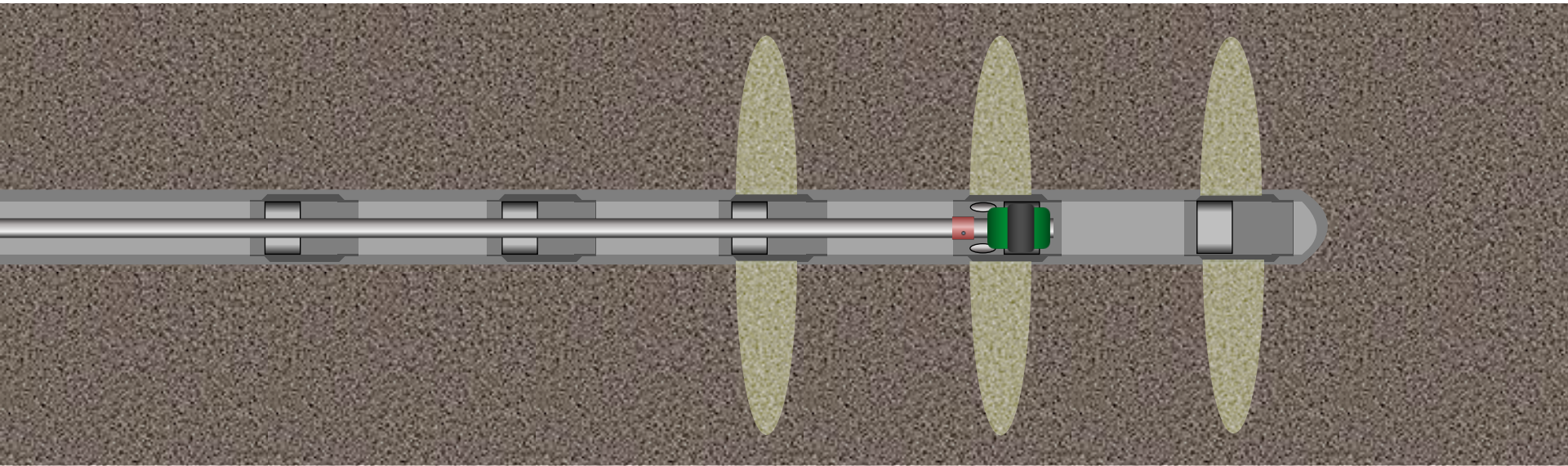
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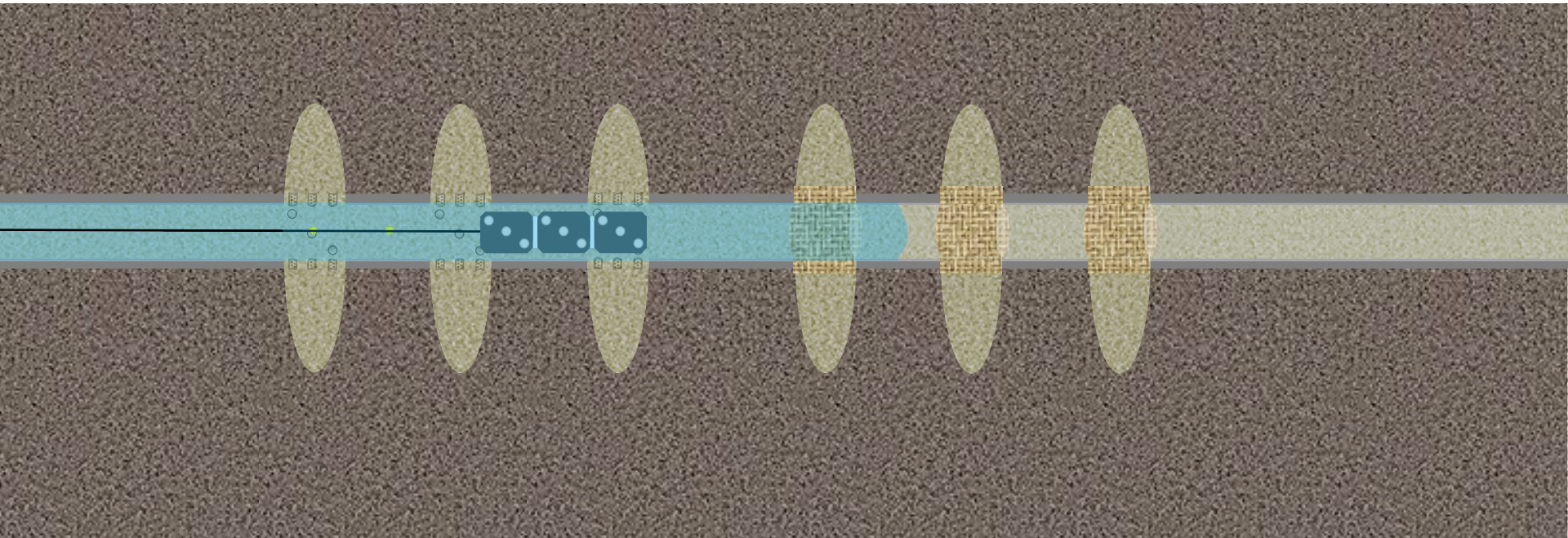
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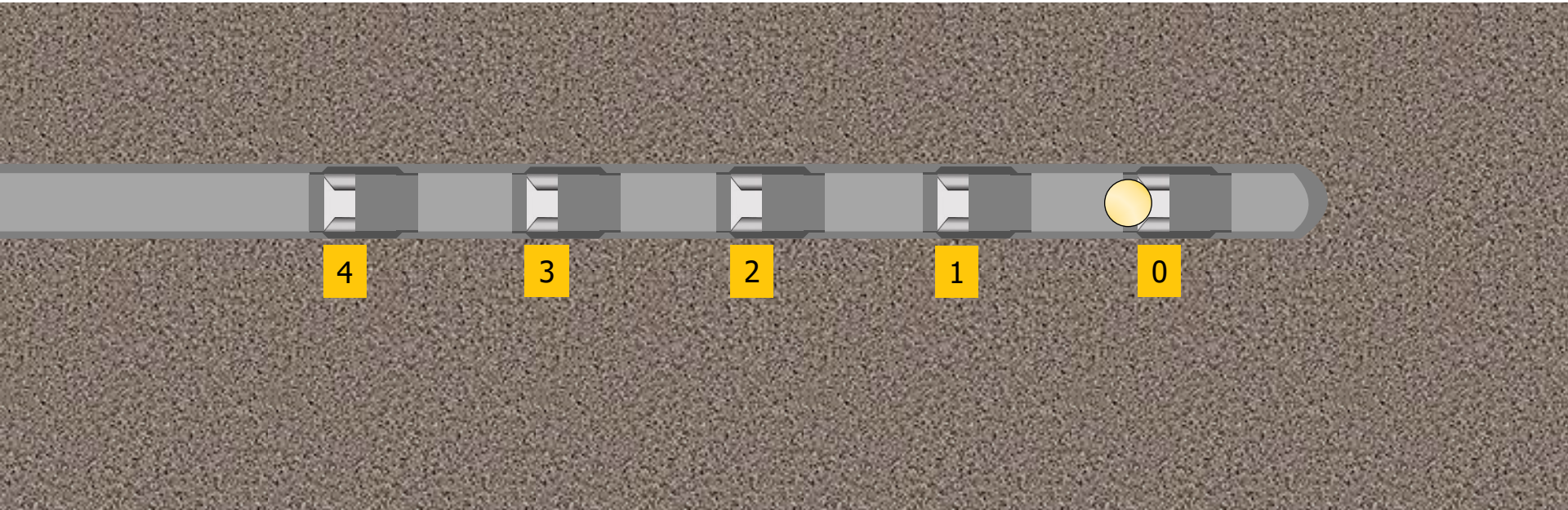
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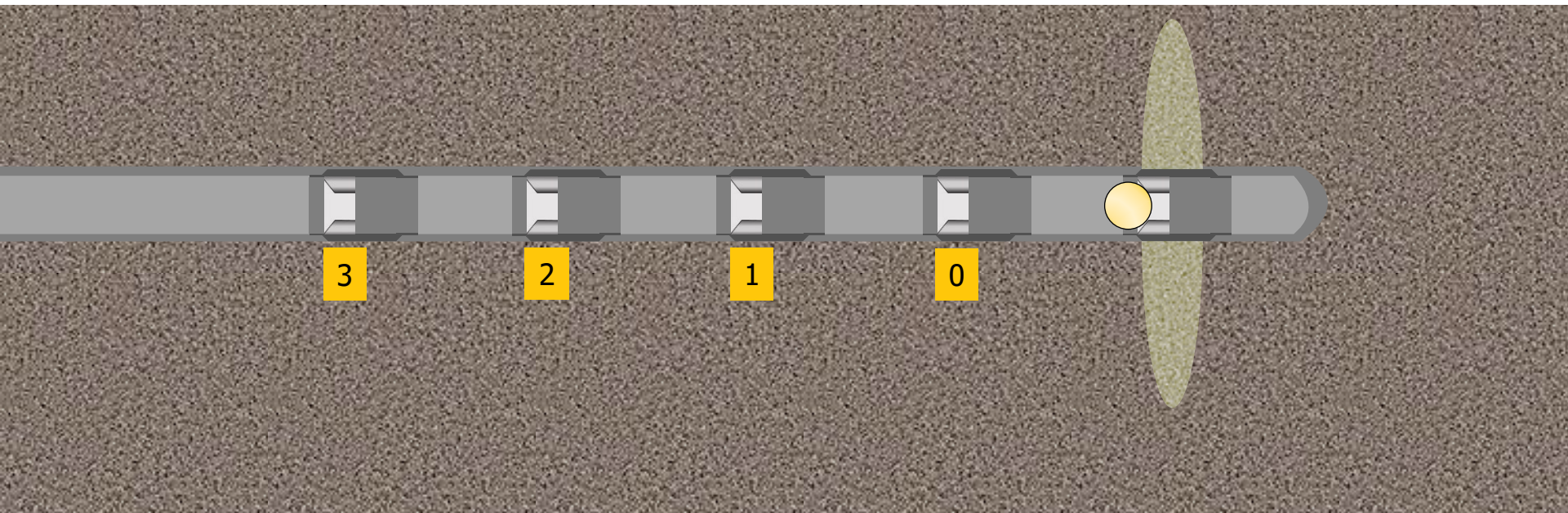
# Watchlist – Diverters Eliminating Frac Plugs?



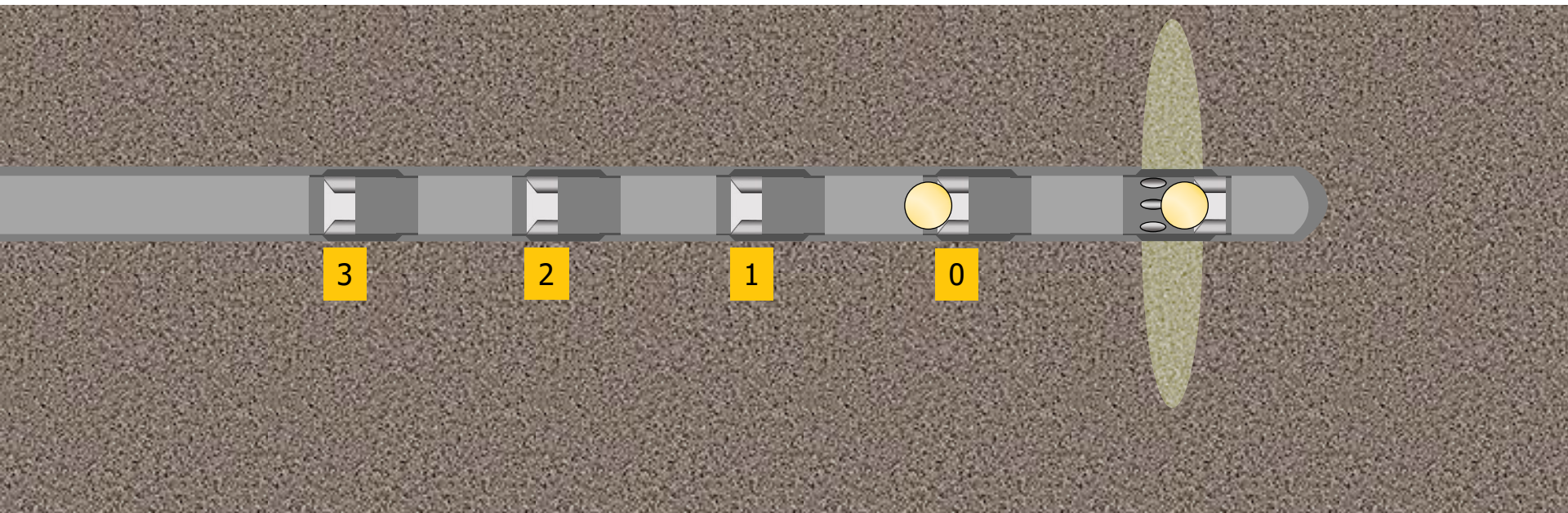
# Watchlist – Counting Frac Sleeves



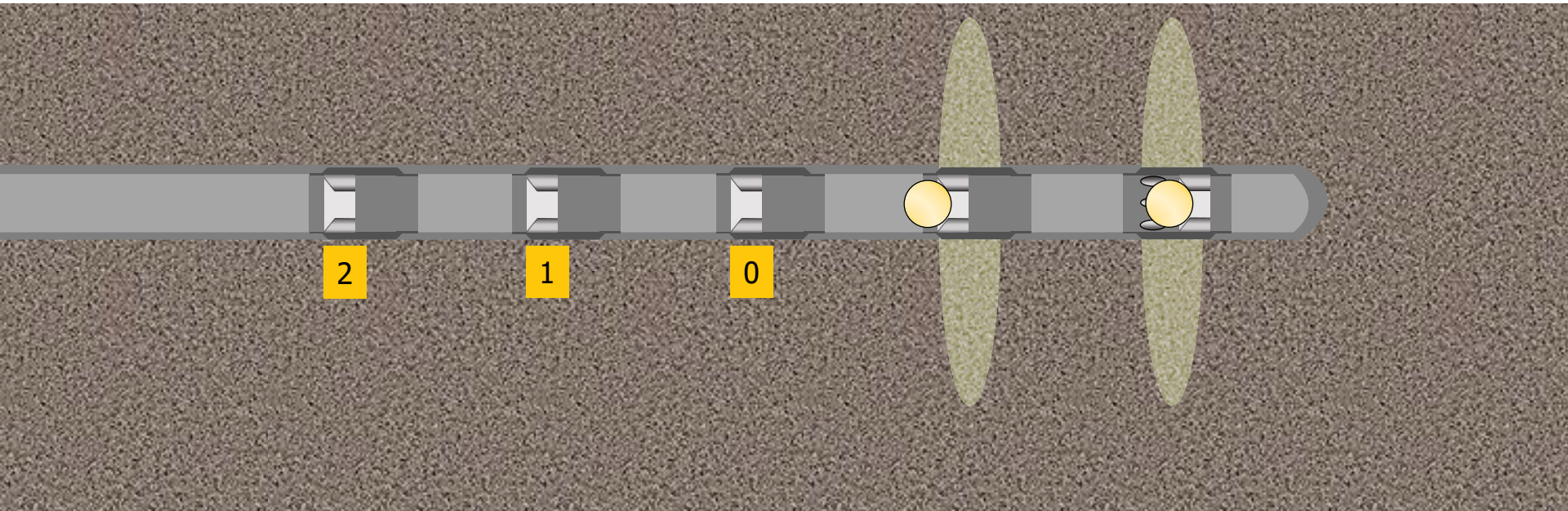
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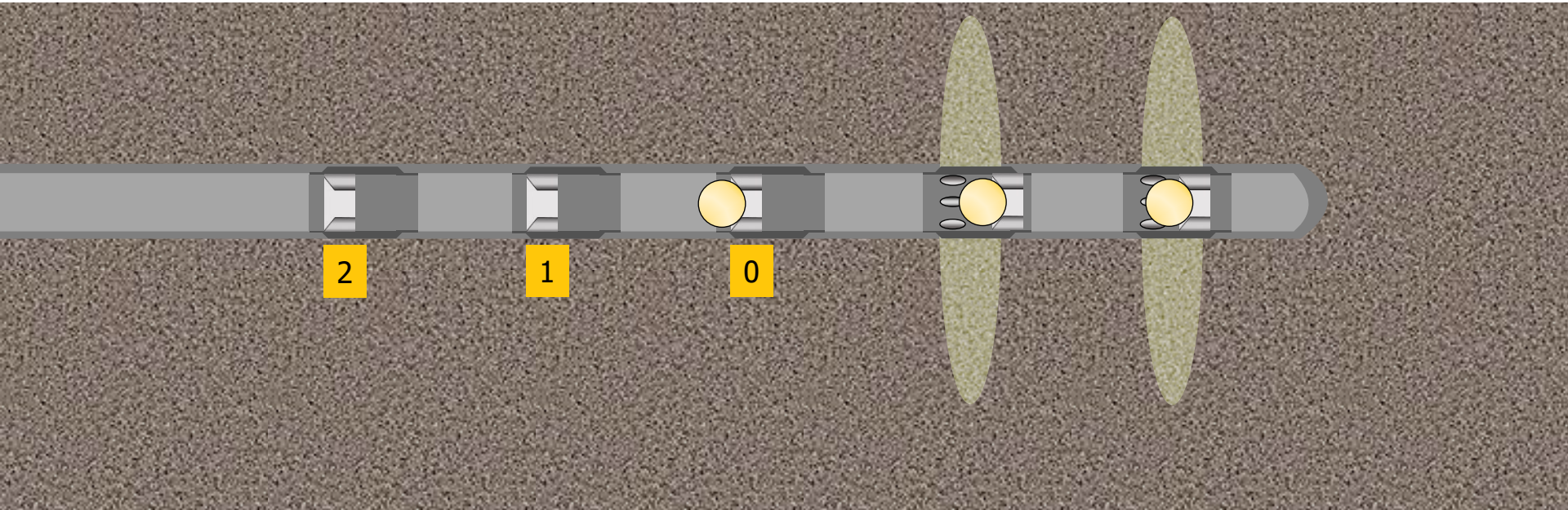


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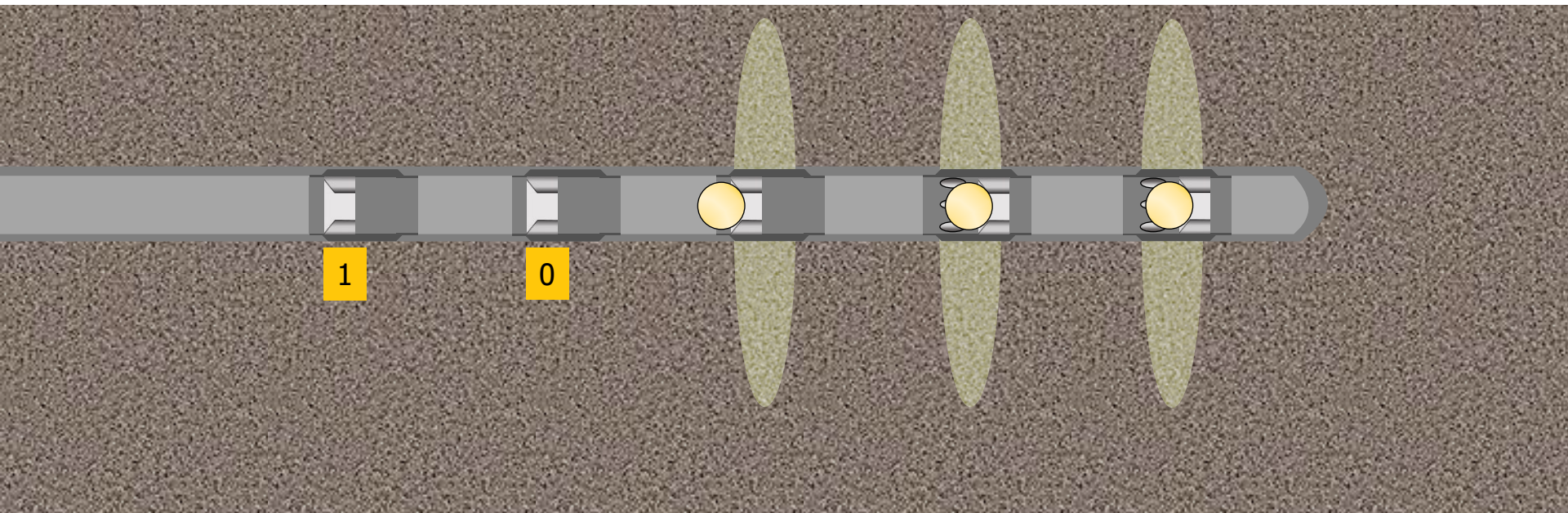




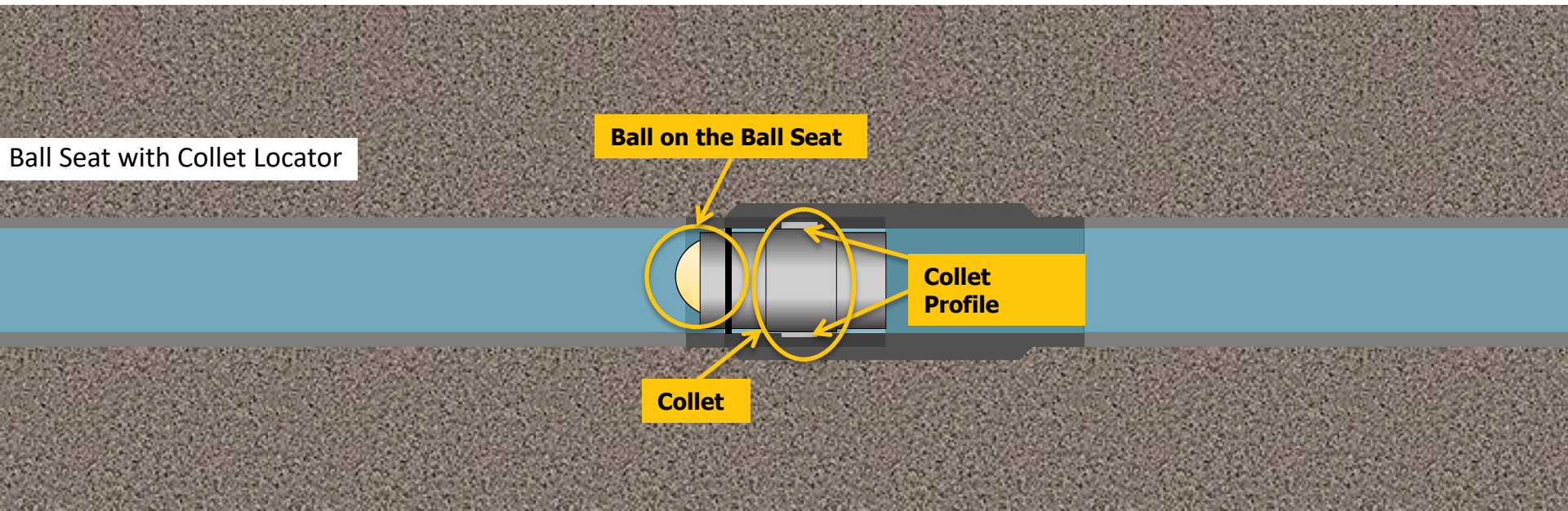
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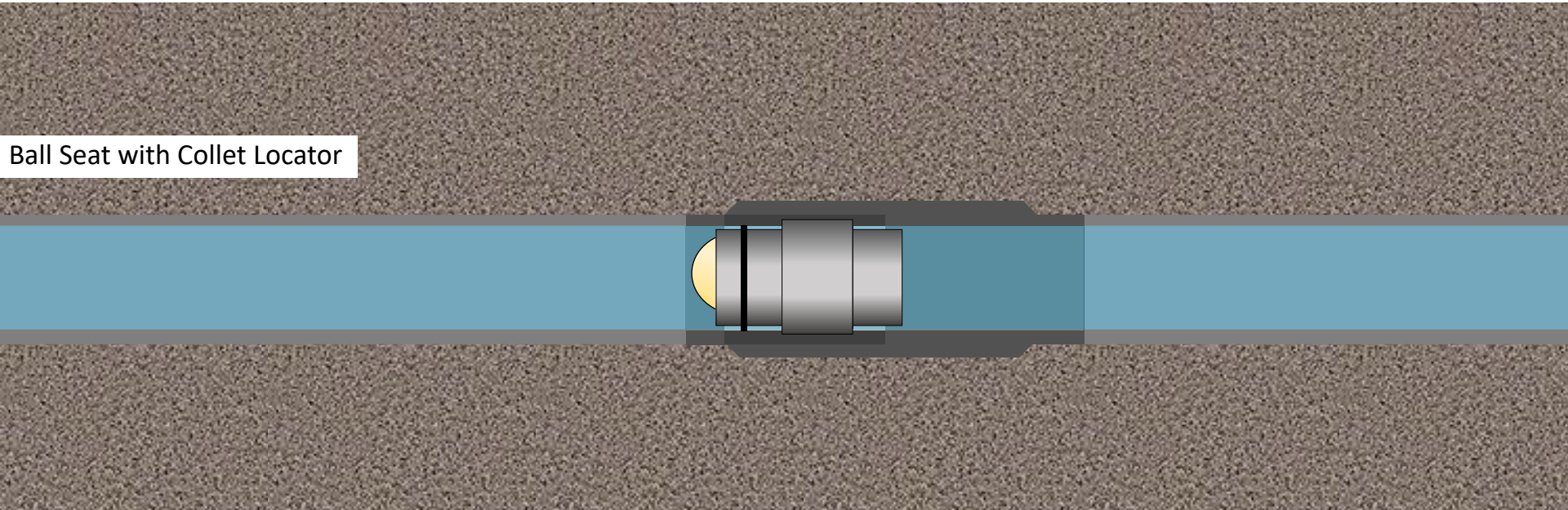


# Watchlist – Frac Sleeves w/ Collet Profiles



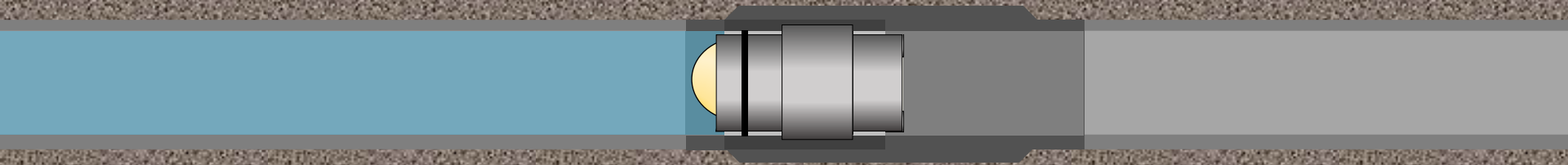
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Ball Seat with Collet Locator



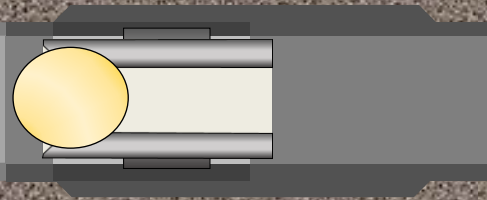
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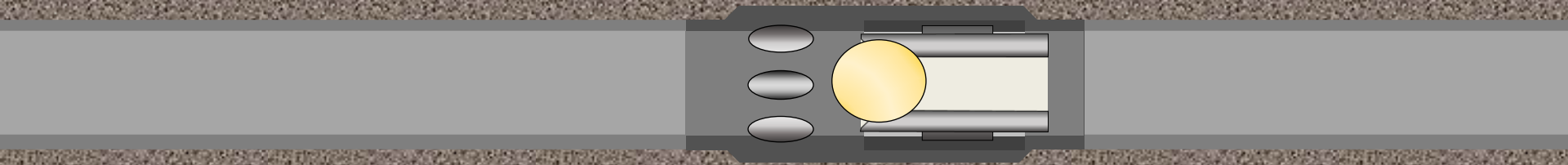
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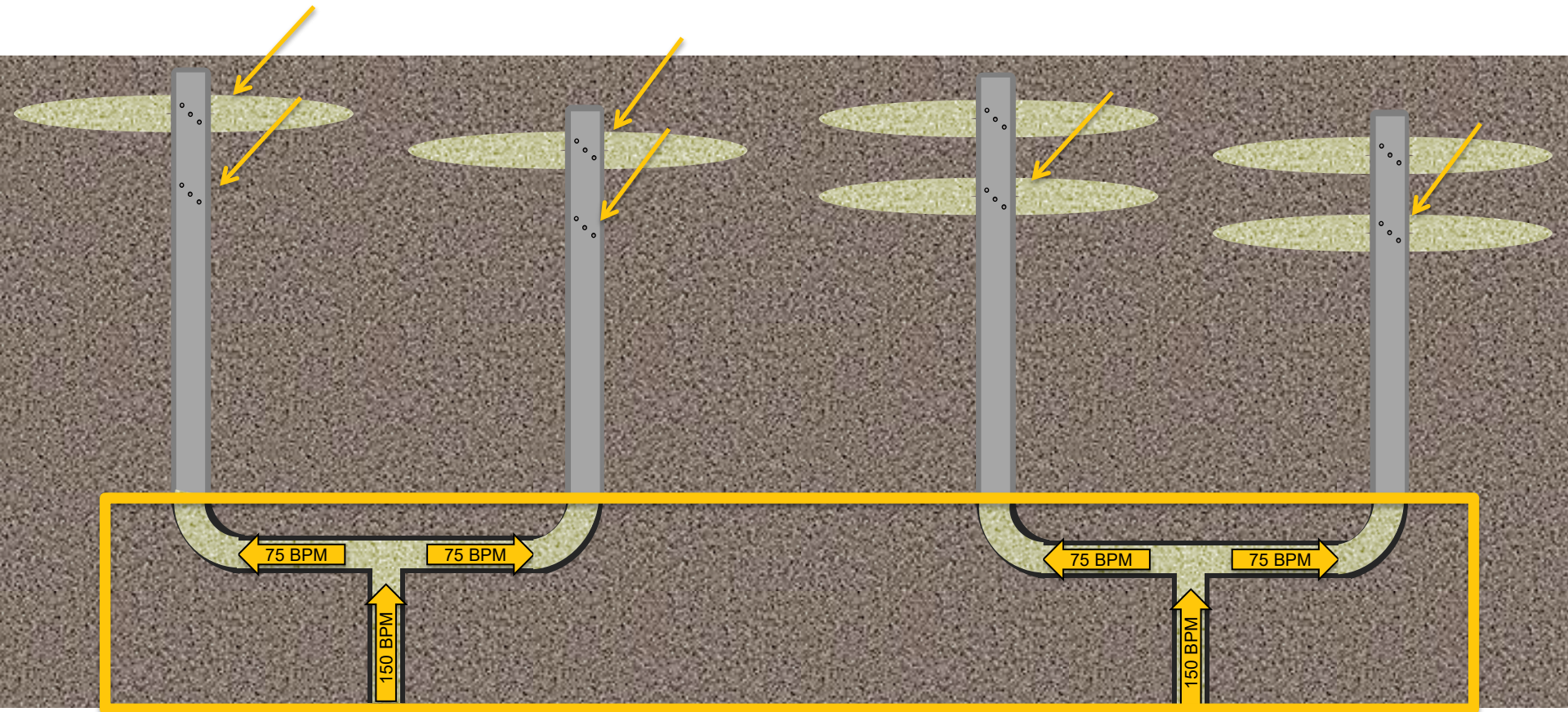
# Interesting Trials/Technologies to Watch

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- Other markets - Canada
- Kicking Horse, STEP Energy Services, and NCS Multistage 228-stage completion in Montney
  - Dec 2018 press release
- Stage Completions 142-stage completion in Permian
  - May 2019 press release

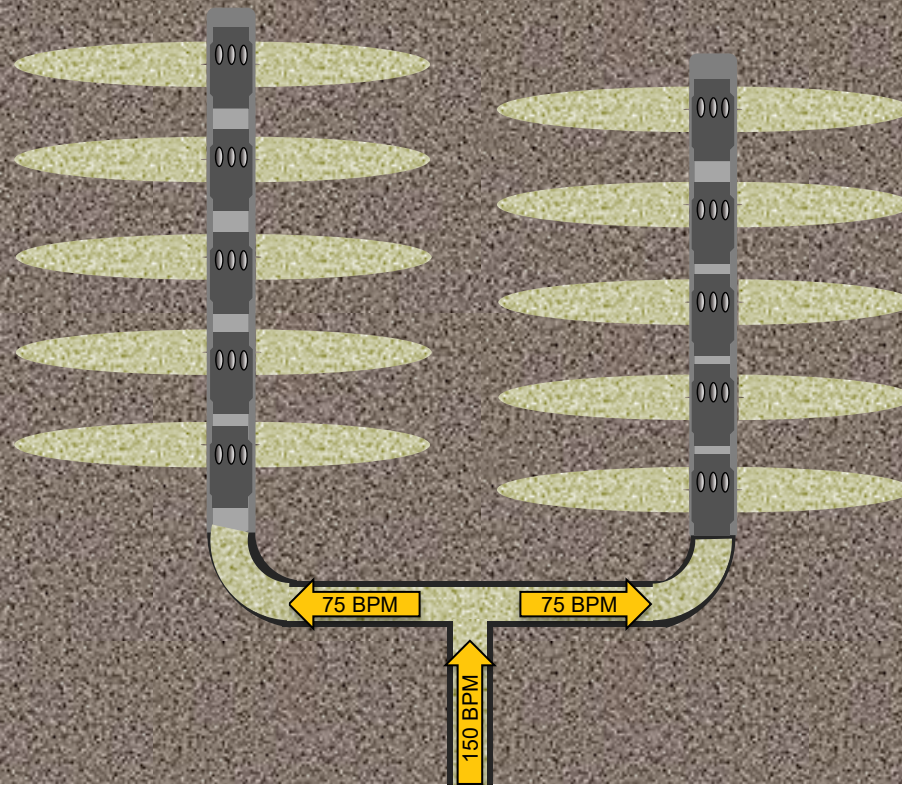


# Watchlist – Split Fracturing Fluid Flow



At surface

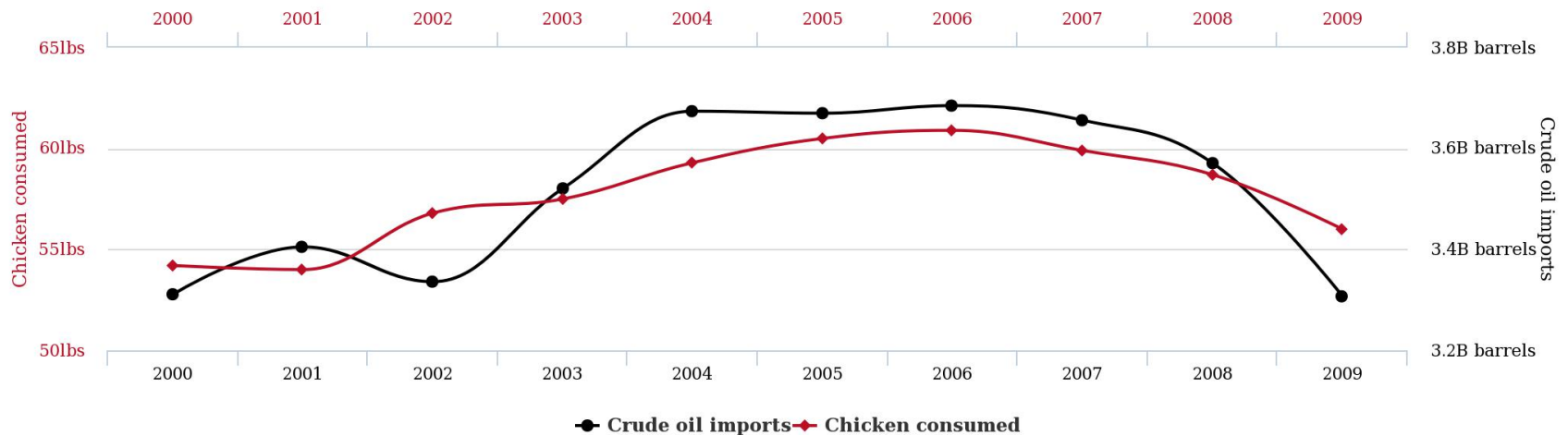
# Watchlist – Split Fracturing Fluid Flow



# Advanced Data Analytics

- Garbage in = garbage out
  - Public data
- Correlation is not causation

## Per capita consumption of chicken correlates with Total US crude oil imports



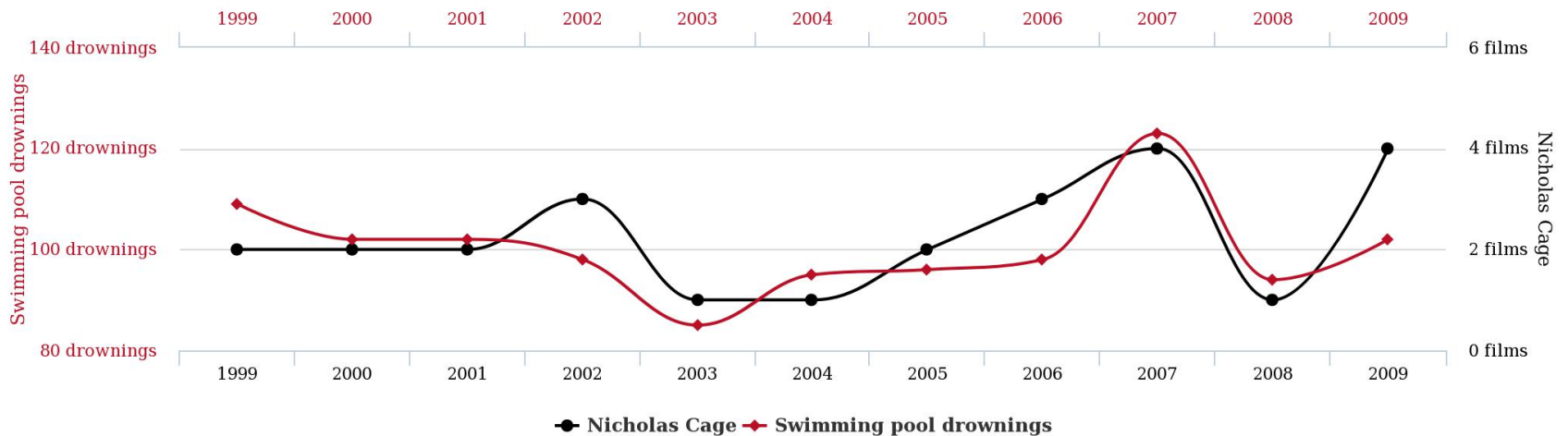
tylervigen.com

Source: <http://tylervigen.com/spurious-correlations>

# Advanced Data Analytics

- Garbage in = garbage out
  - Public data
- Correlation is not causation

**Number of people who drowned by falling into a pool**  
correlates with  
**Films Nicolas Cage appeared in**



tylervigen.com

Source: <http://tylervigen.com/spurious-correlations>

# Advanced Data Capture

- Fracs are not always executed as designed

Frac Schedule
2.0 PPG
2.5 PPG
3.0 PPG
3.5 PPG
4.0 PPG

Drilling	Completions	Production
Out of zone	Executed as designed	Choke management
Toe up or down	Completion design	Artificial lift

# Crazy Prediction – Rise of Shorter Laterals

Could We See a Shift Toward Shorter Laterals With More Concentrated Stages?

Most plays target 10,000' laterals

- Better overall well production
  - What about individual stage production?

Throughout the evolution, there have been 5,000' laterals that outperform 10,000'

There are questions on how effective a frac treatment is in the toe of long laterals

Benefits

- Half the completion cost
- Savings on the drilling side
- Easier to stay in zone

Potential Benefits

- Better frac job
  - Better decline curve
  - Better production per stage
- Better artificial lift strategies

# Thank You!

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Check out my video blog on multistage completions for hydraulic fracturing:

<http://www.unconventionaloilandgastraining.com/blog>

