WaveX®

Reservoir Dimensioning

The Capillary Model

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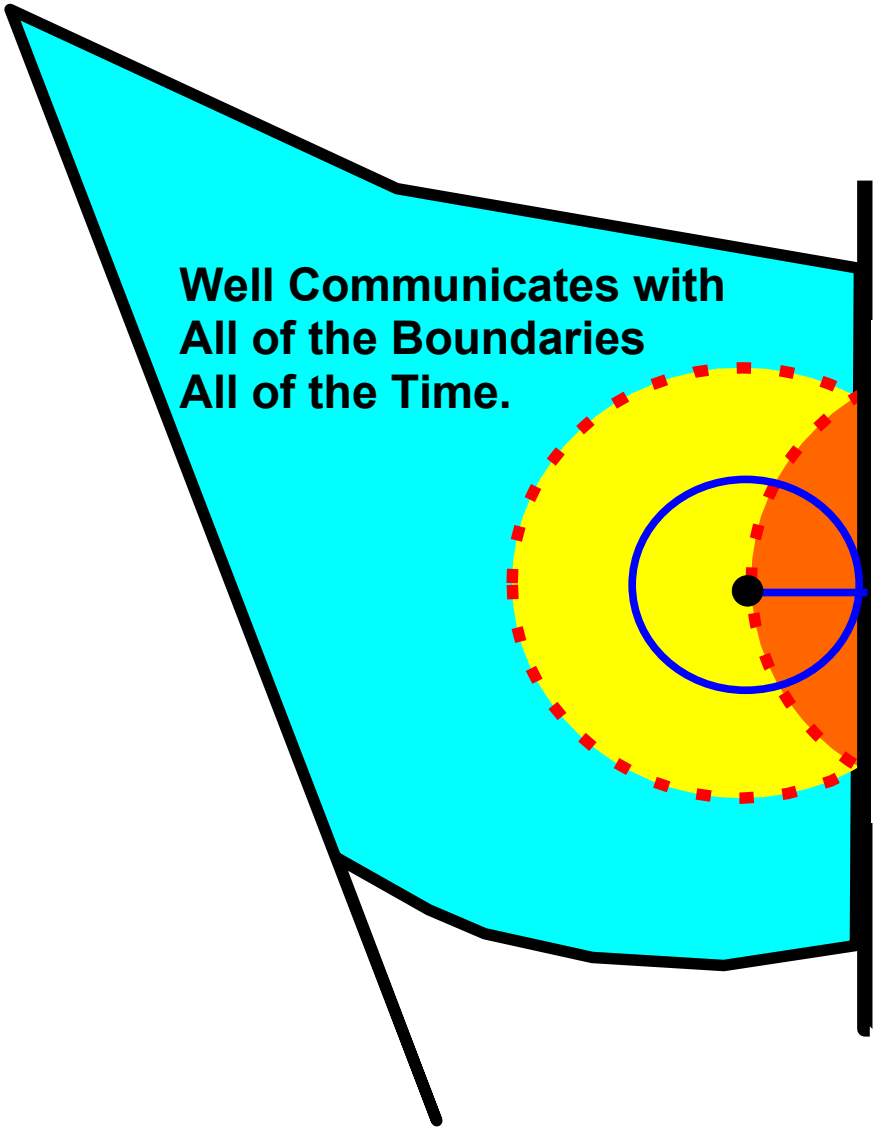
The Bounding Shockwave

- **Sitting On the Wave Riding Backwards.**
  - **The Element has Steady Conditions**
    - **Constant Pressure in Front**
    - **Darcy Flux to the Rear.**
    - **Energy Depletion Based Upon Path Length.**
- **Diffusion Wave Behavior.**

Traditional Diffusion Model



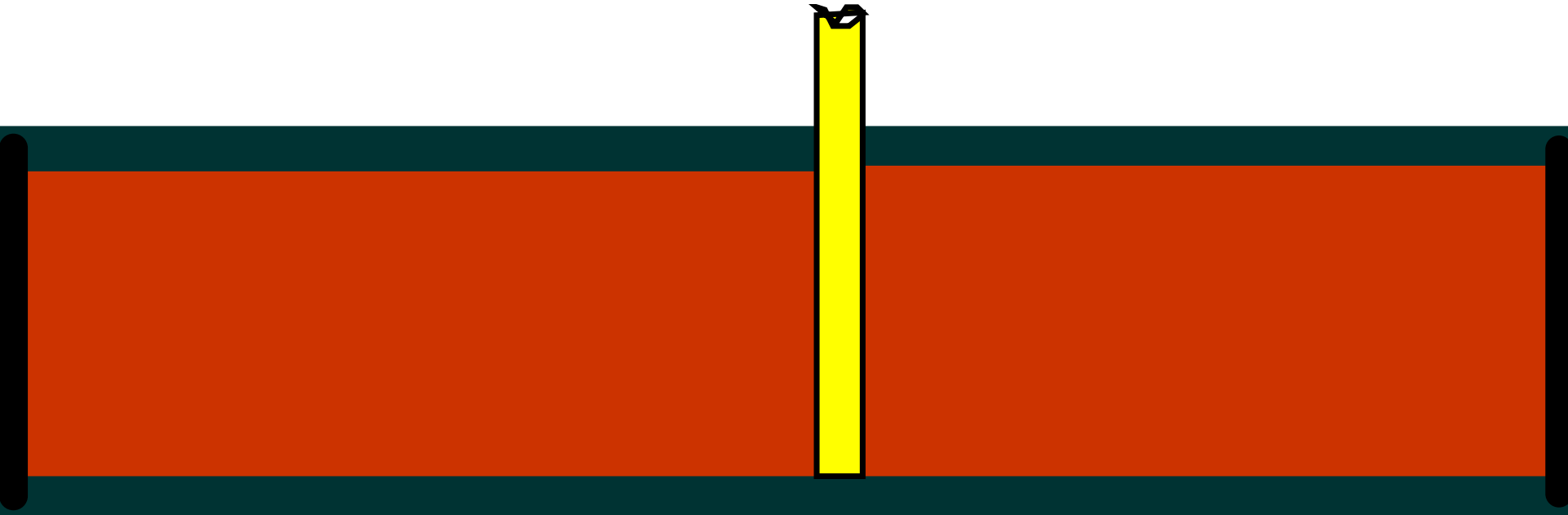
The Dashed Red Line Represents the Radius of Investigation. Rinv Is Based Upon the Hypothetical Effective Drainage Volume of the Well..

Diffusion Model

- Fixed Boundary
- Point to Point Potential Gradient Flow
- Relaxation of Field to Changes in Flow

Diffusion Model

All Reservoir Volume Is Active All Boundaries Influence Model All of the Time



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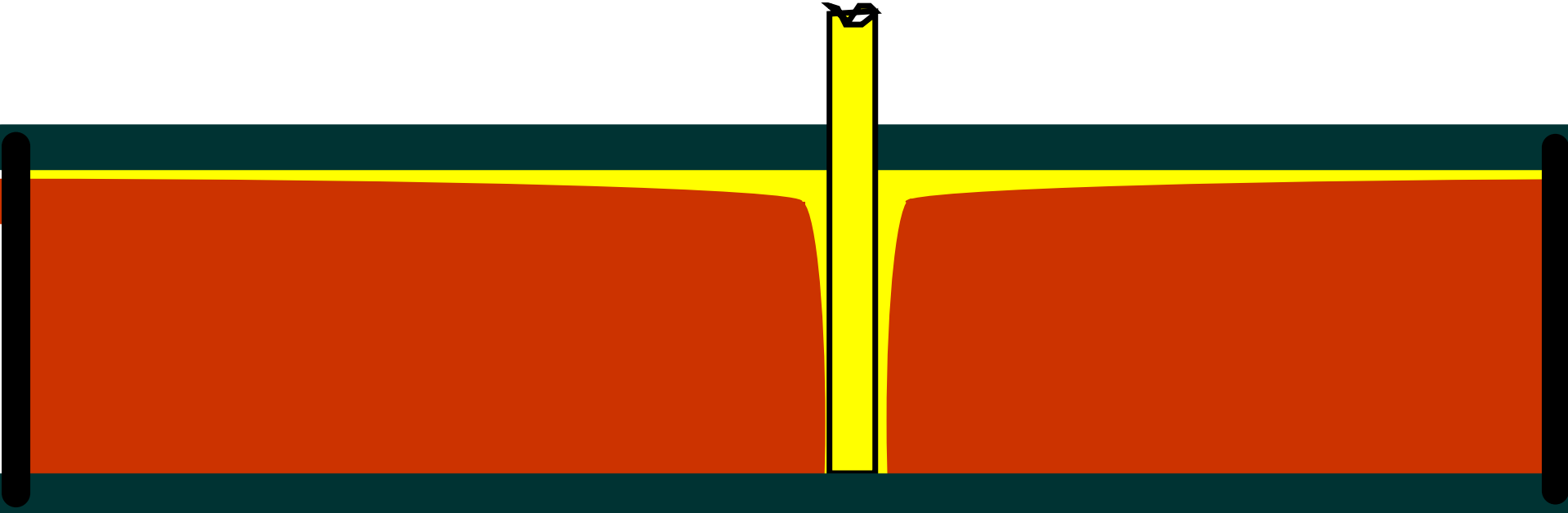

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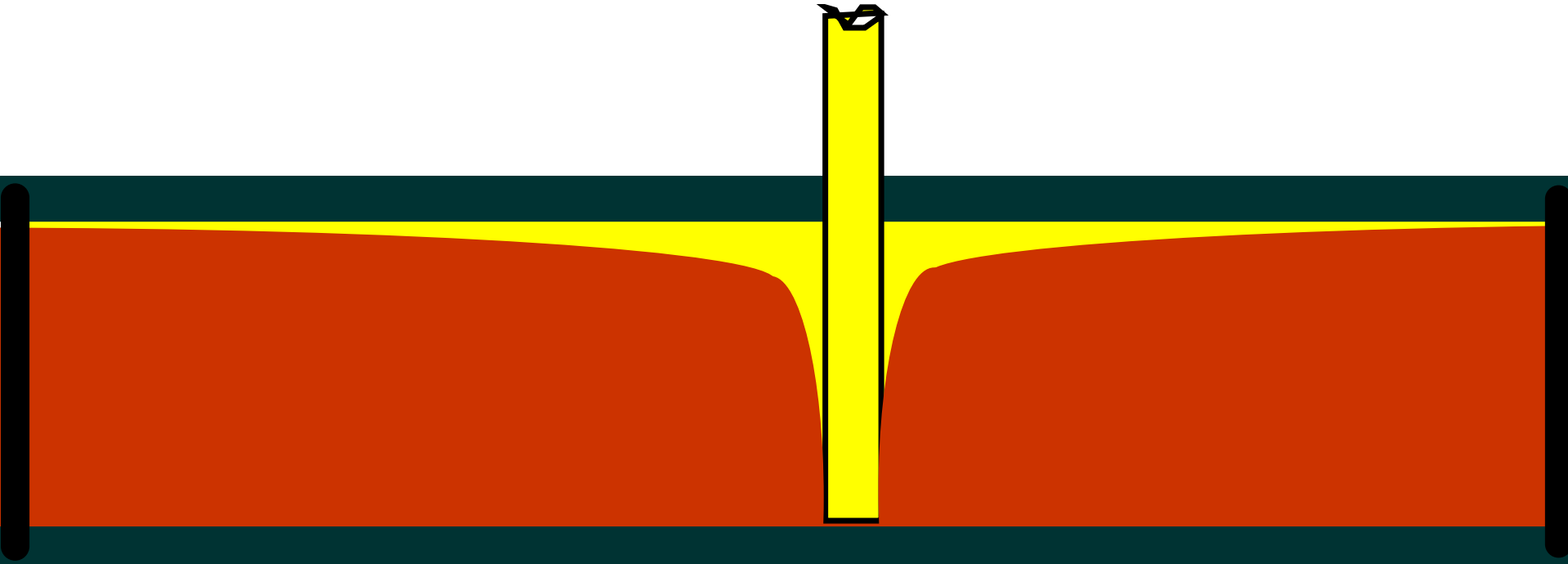

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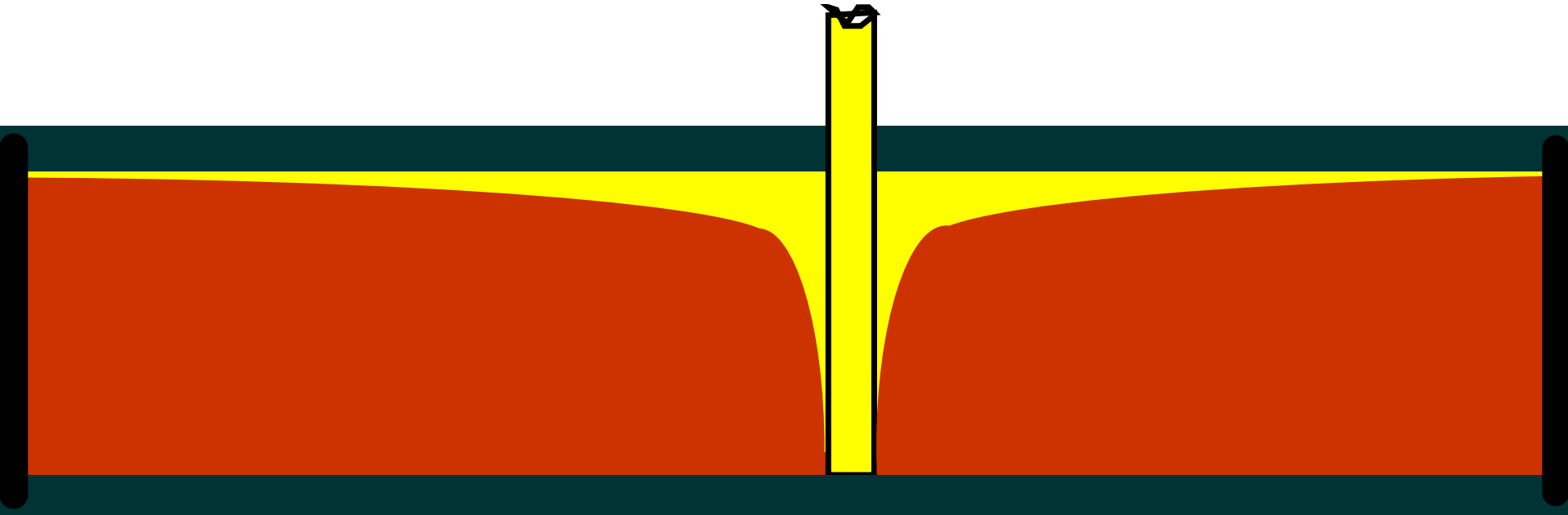

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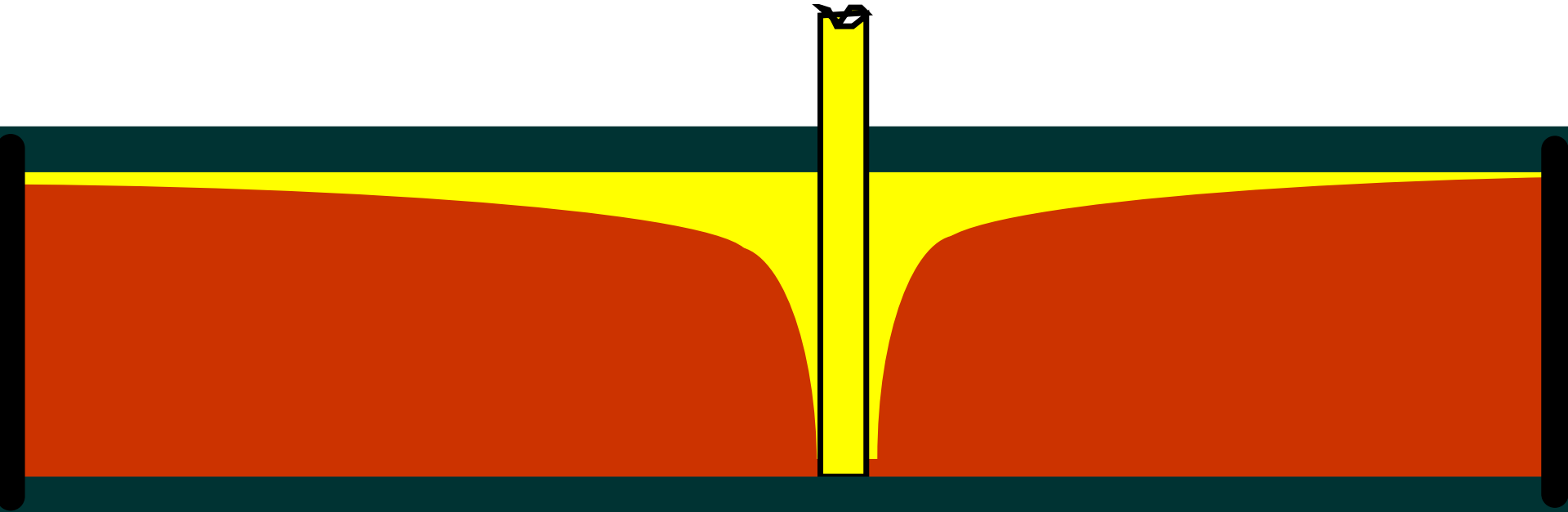

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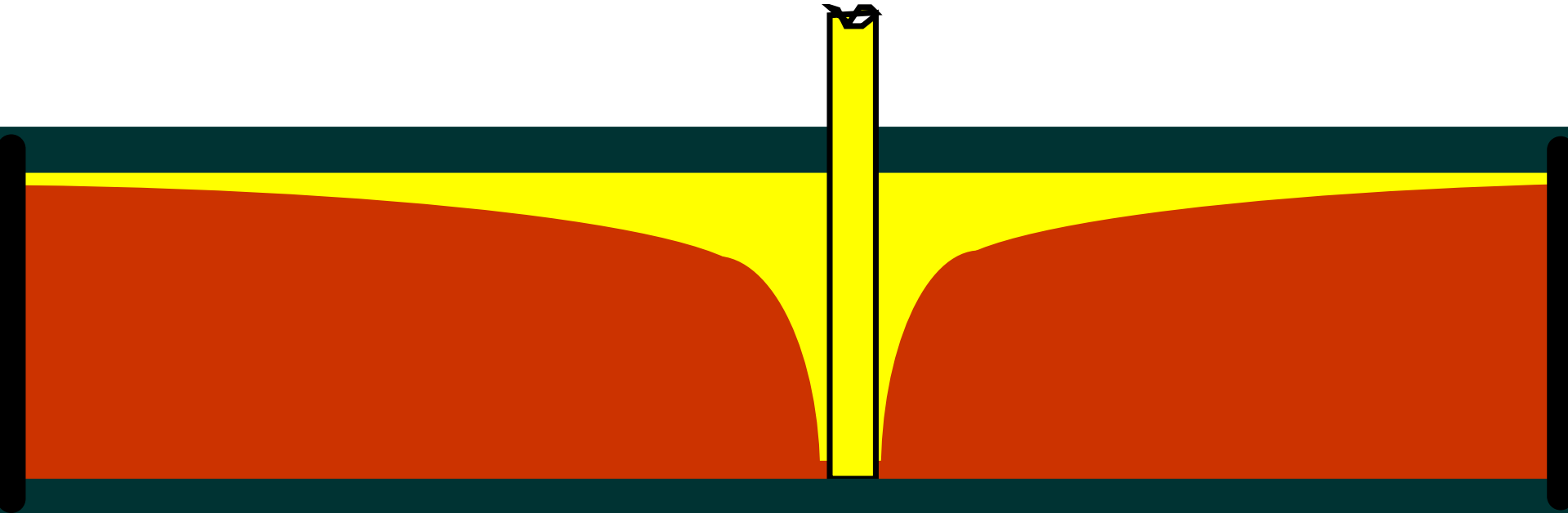

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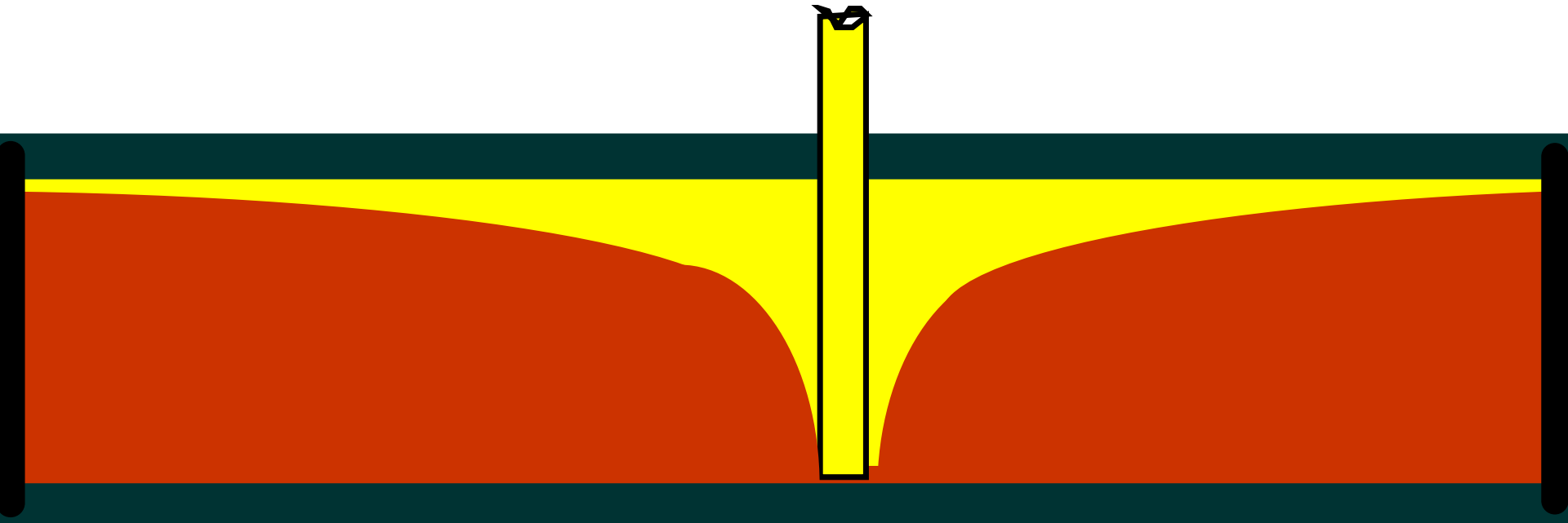

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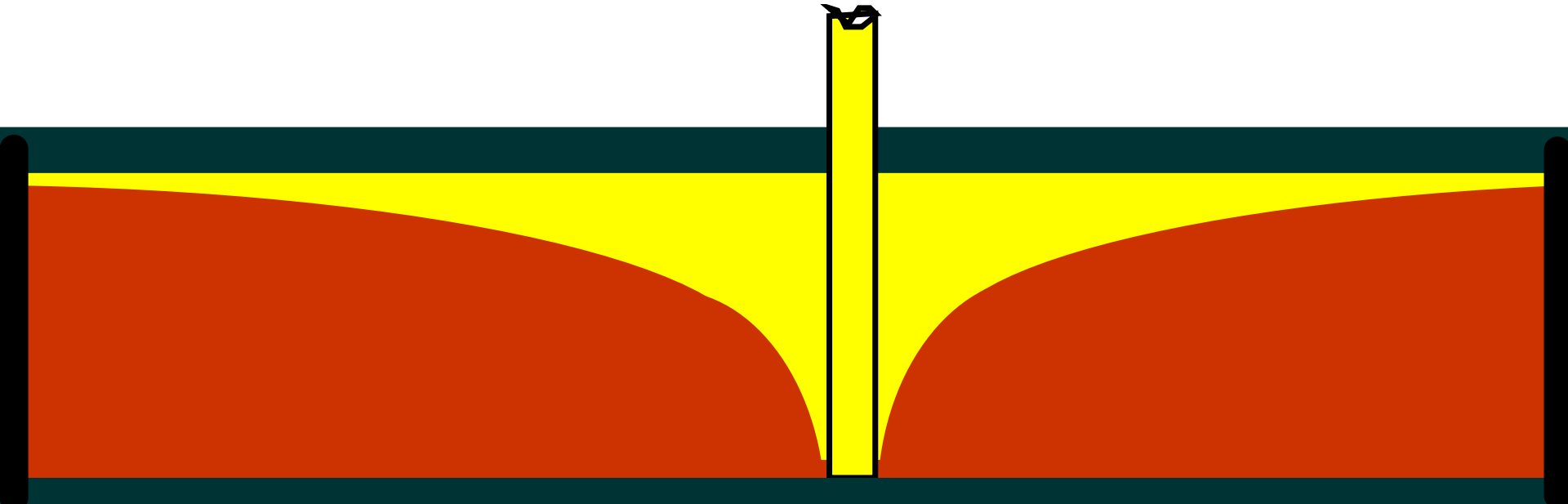

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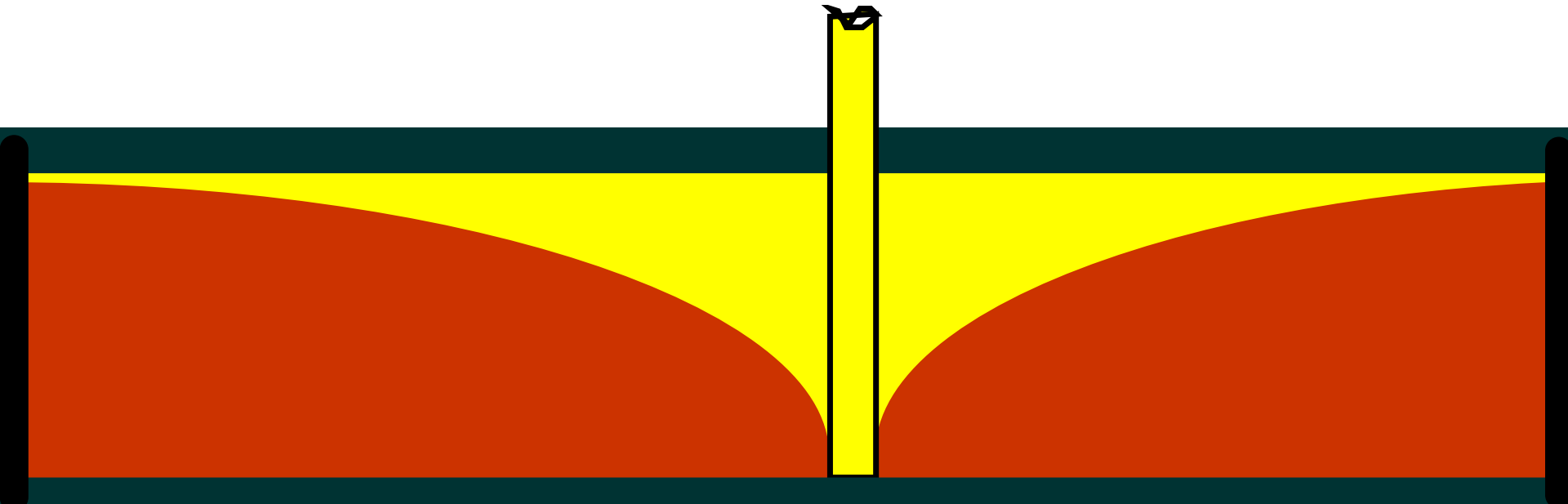

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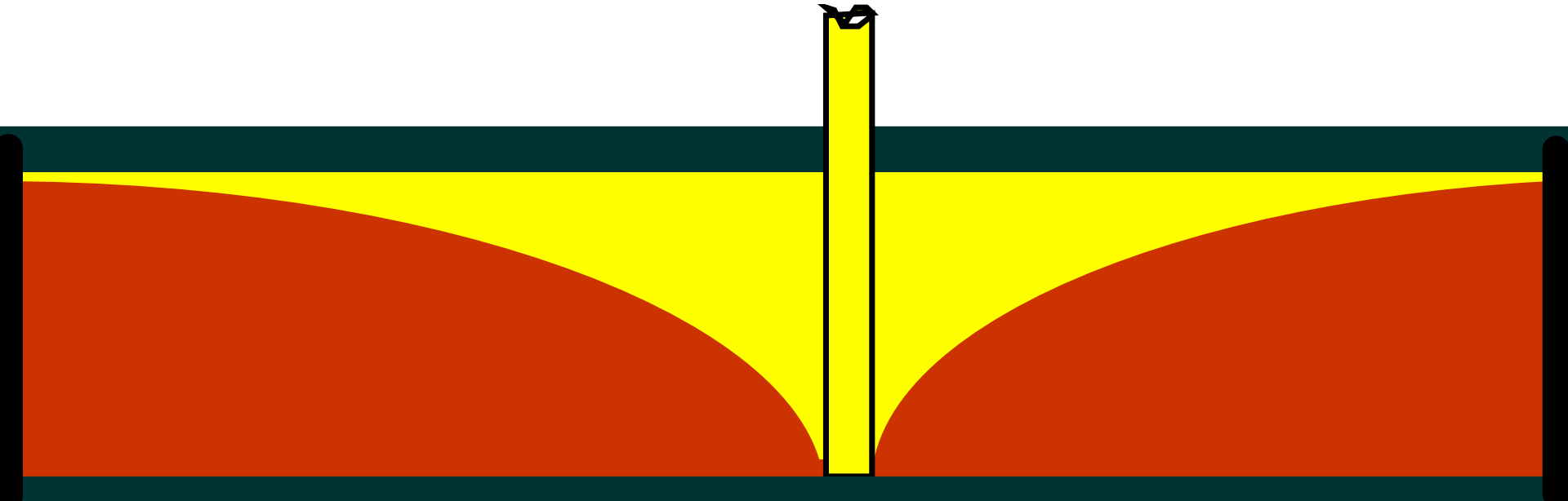

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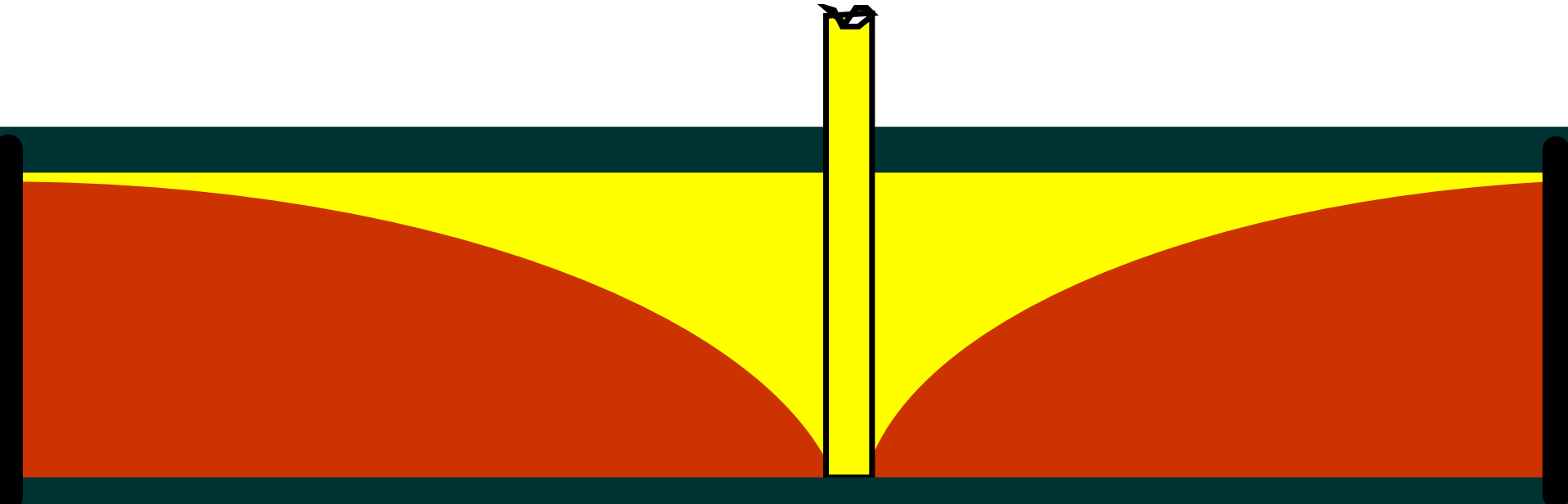

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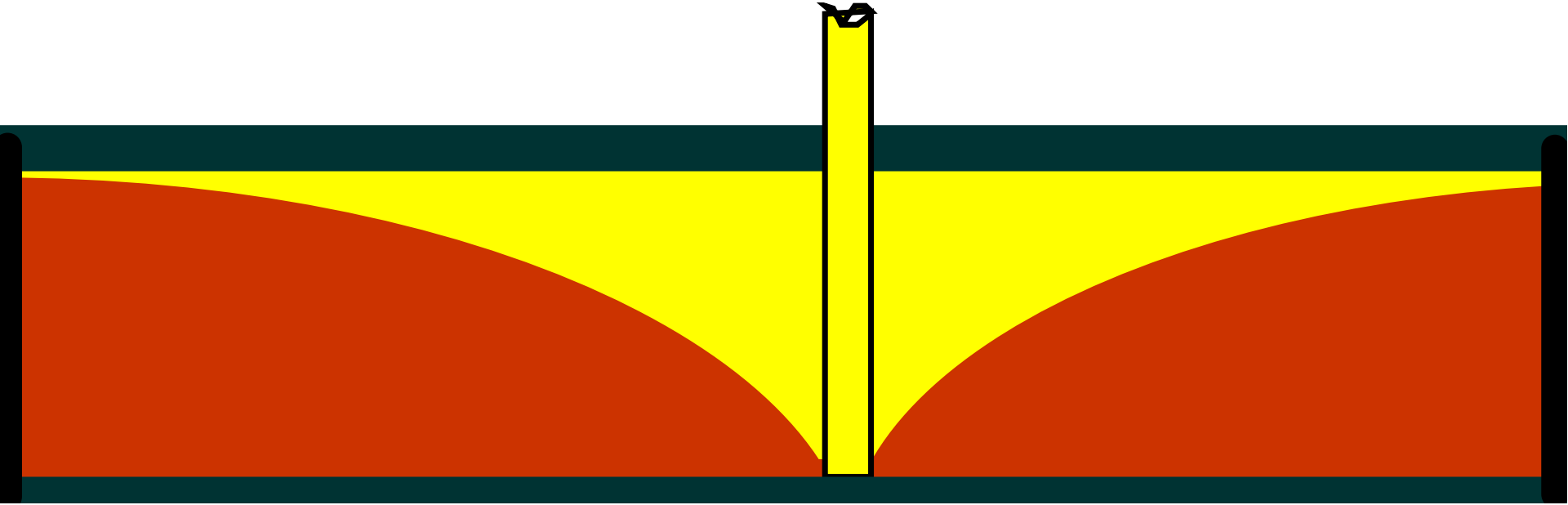
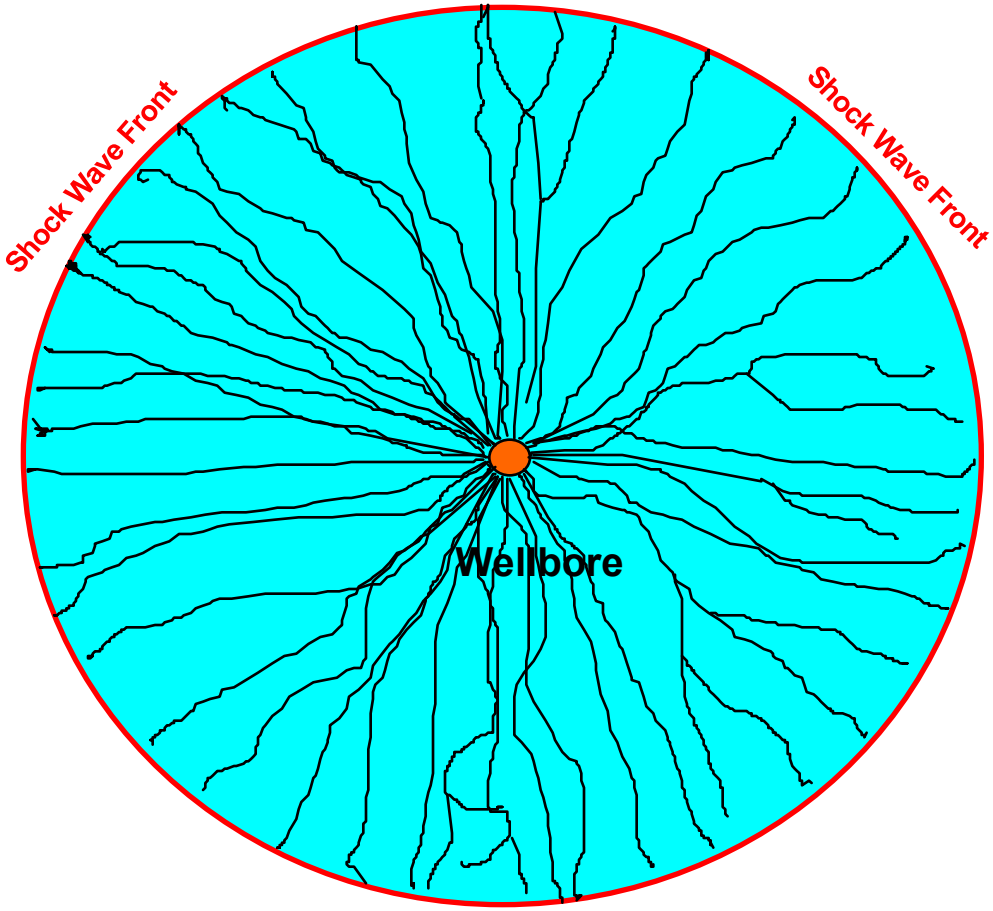


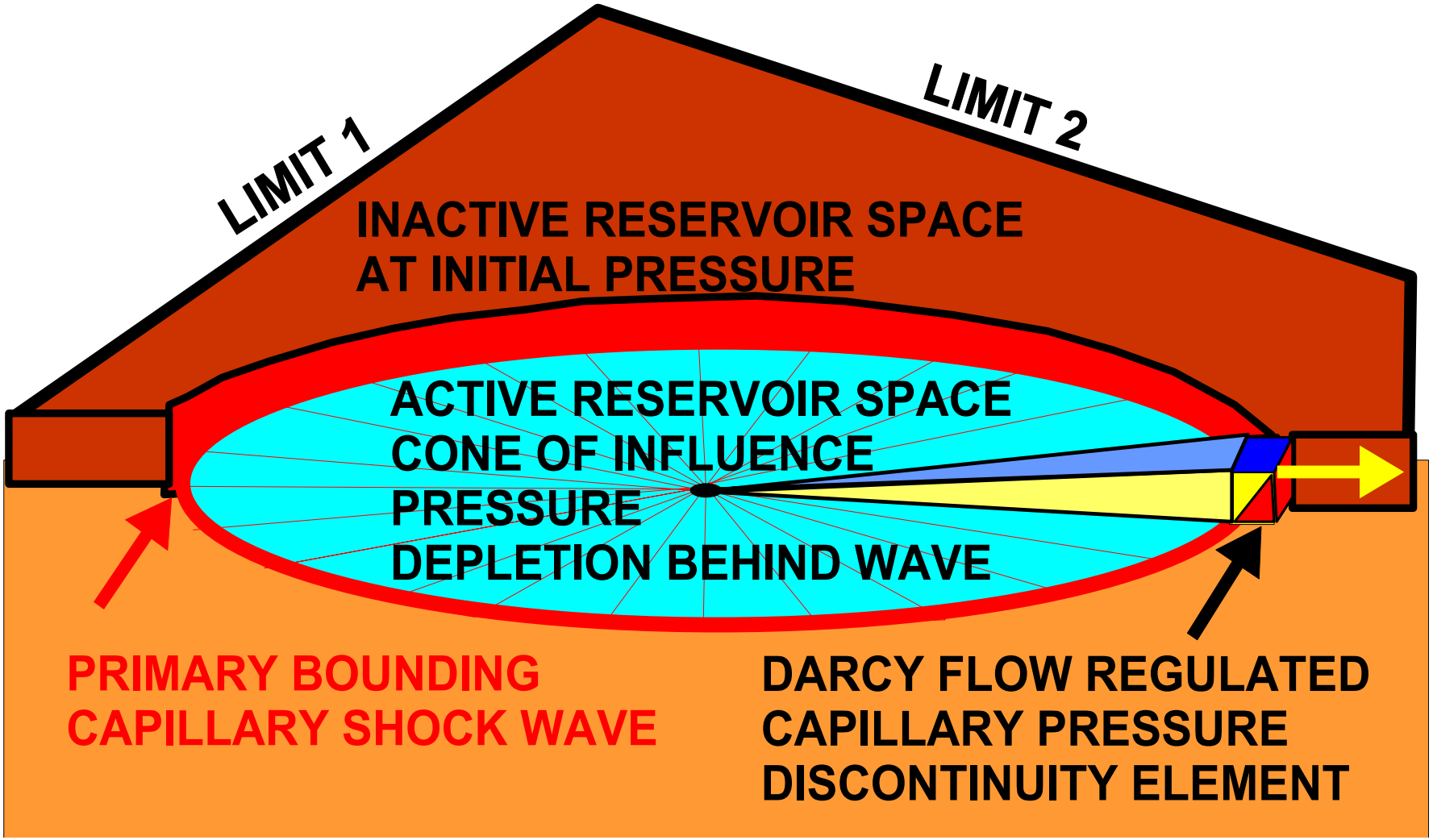
The WAVEX^{SM} Capillary Model

Is Based Upon a Growing Capillary Cluster Radiating From the Producing Well.

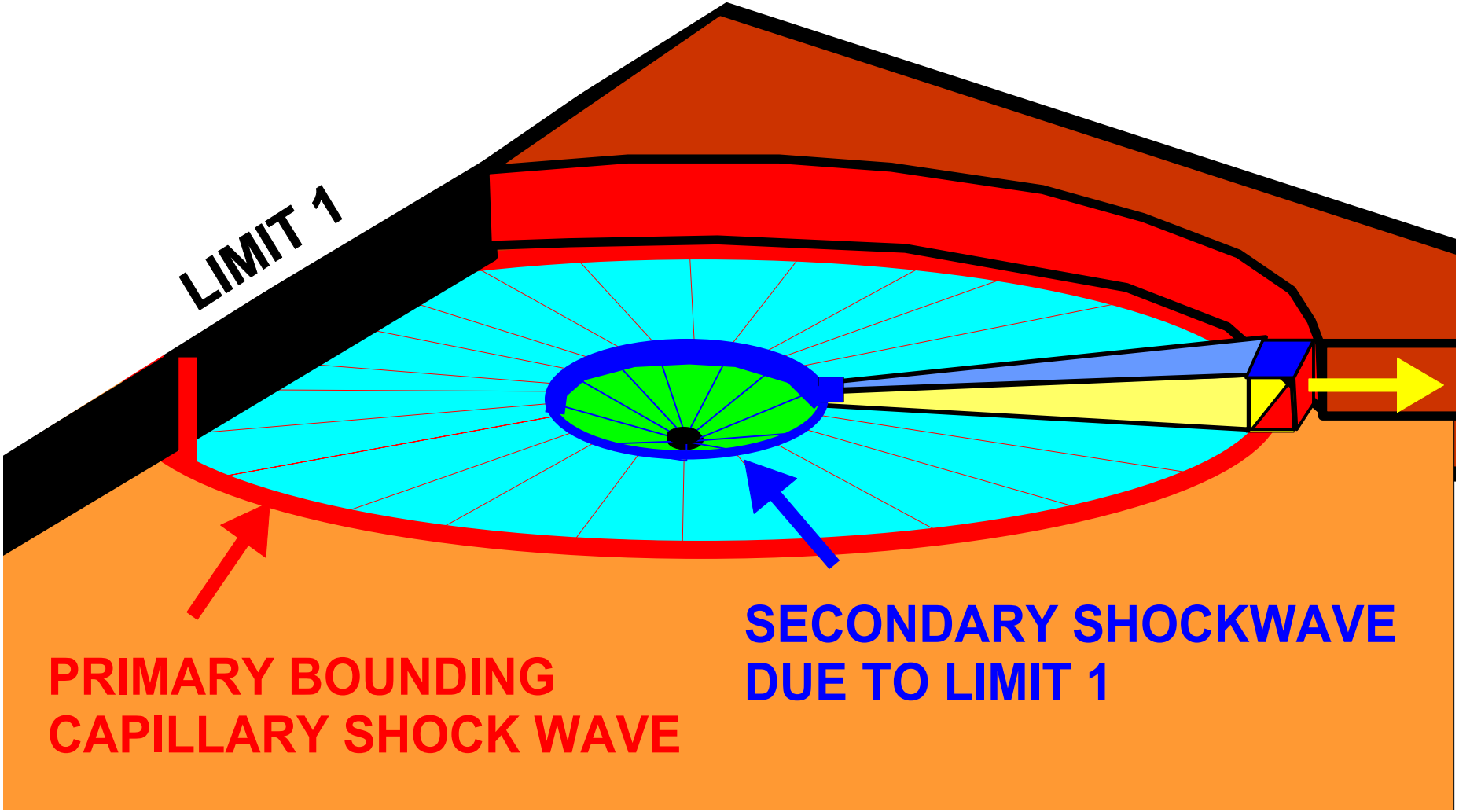
Clusters of Growing Capillaries



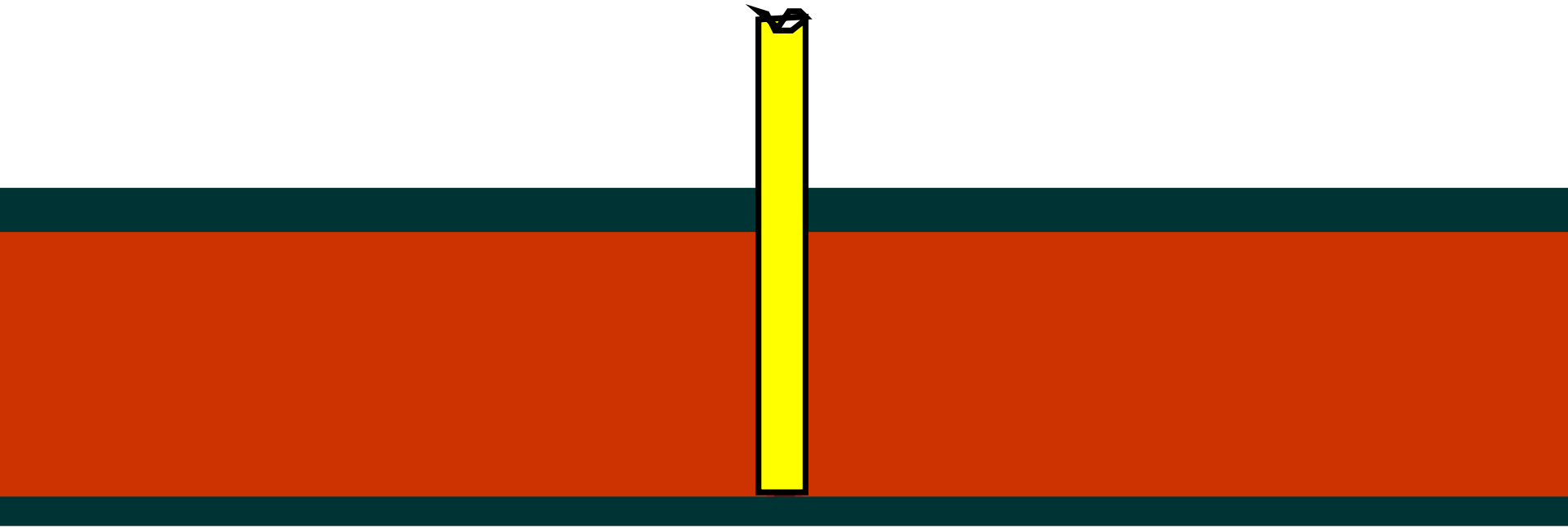
Moving Capillary Shockwave Boundary



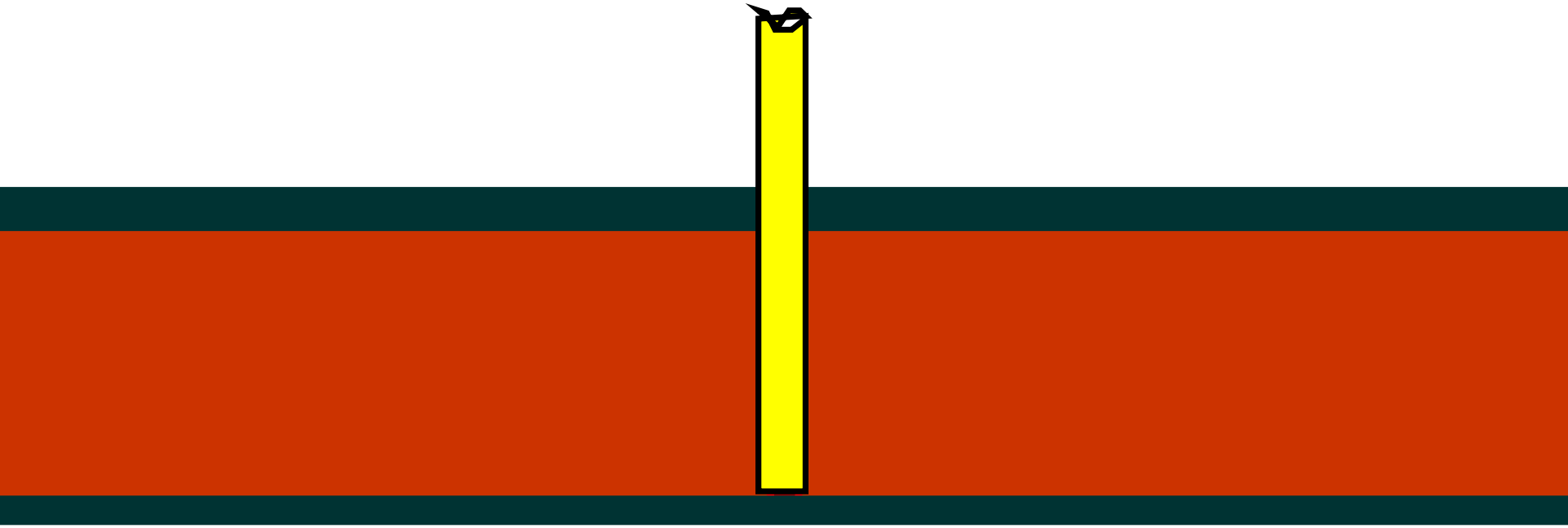
Secondary Cone Inside Primary Cone of Influence



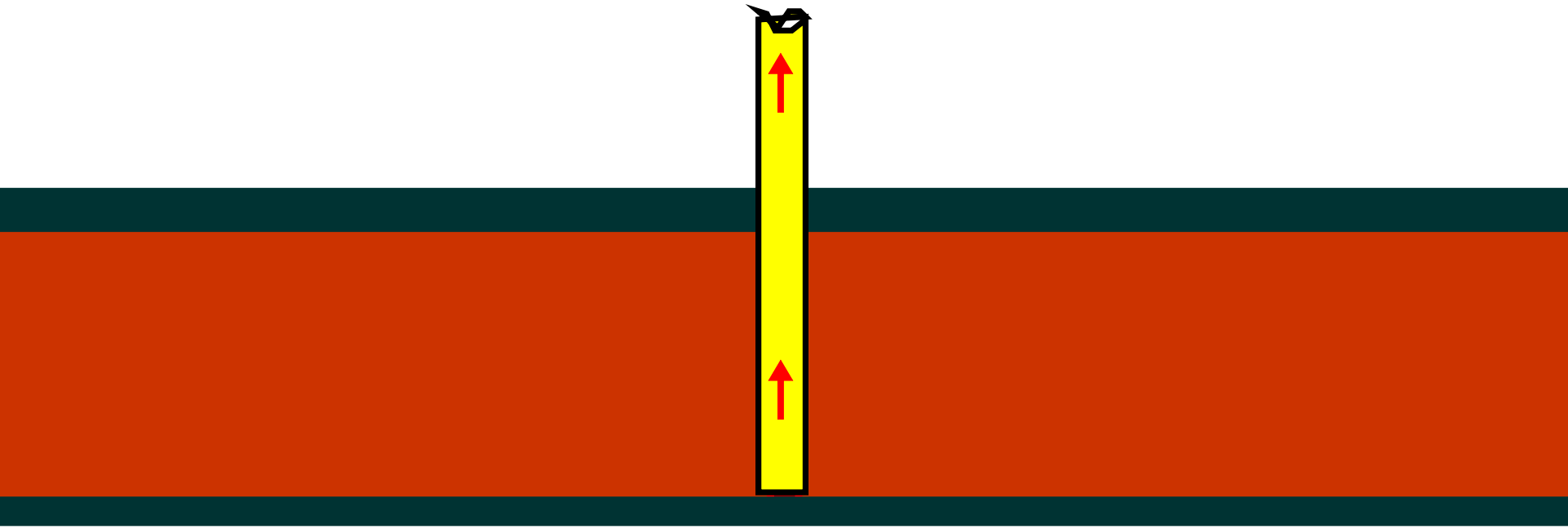
Radial Pressure Influence in Active Reservoir Volume



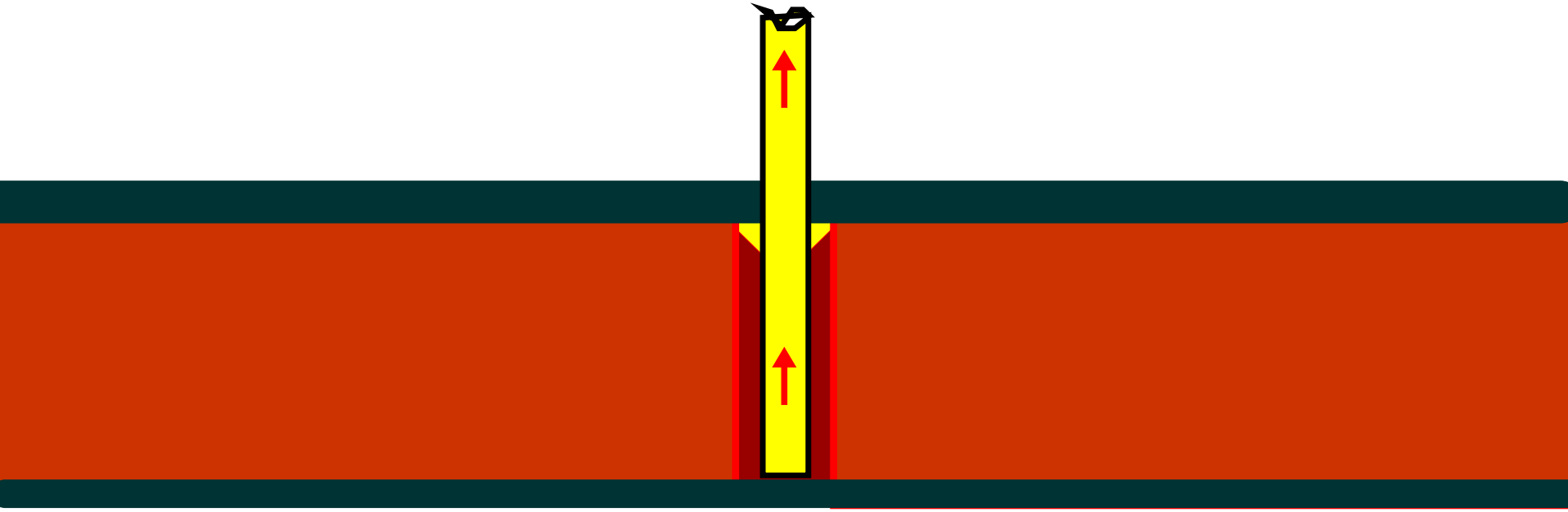
Static Reservoir



Well Turned On



Shock Wave Advances Creates Active Reservoir Volume Pressure Depletes Behind Wave



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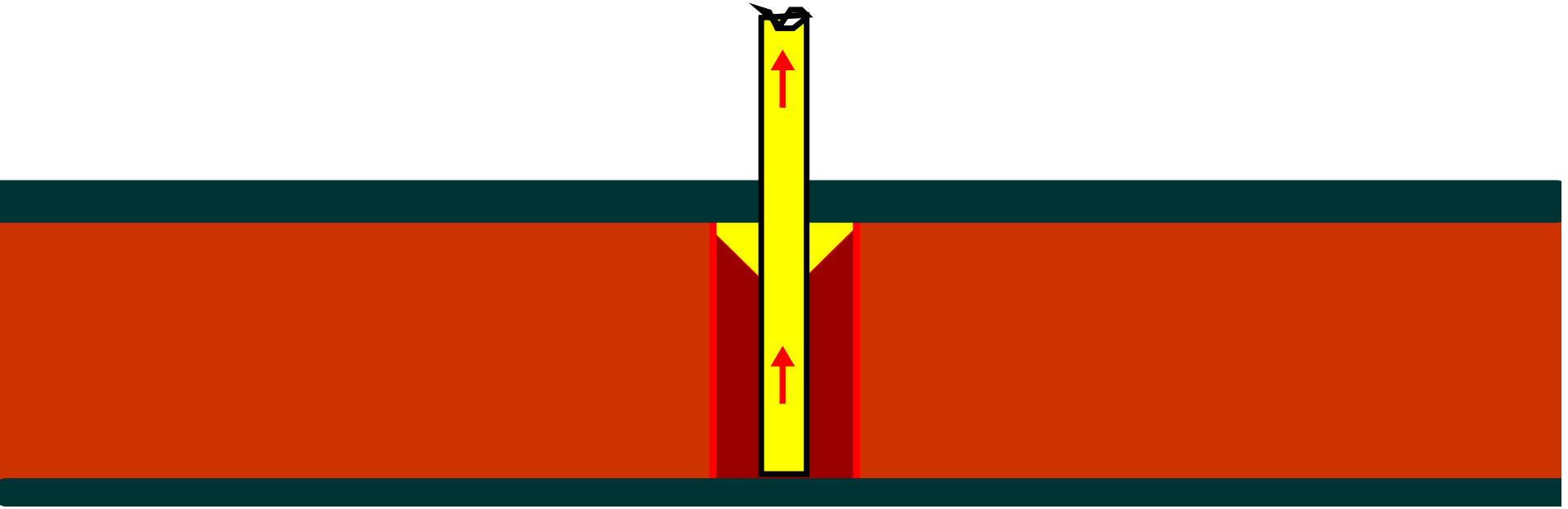

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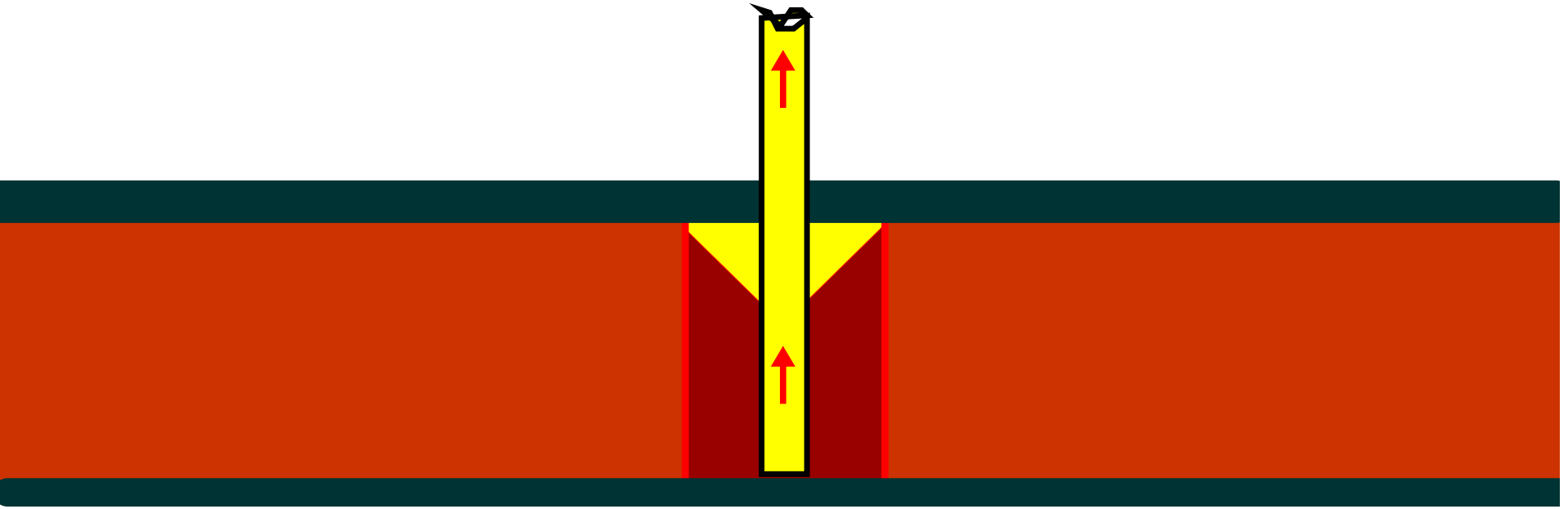

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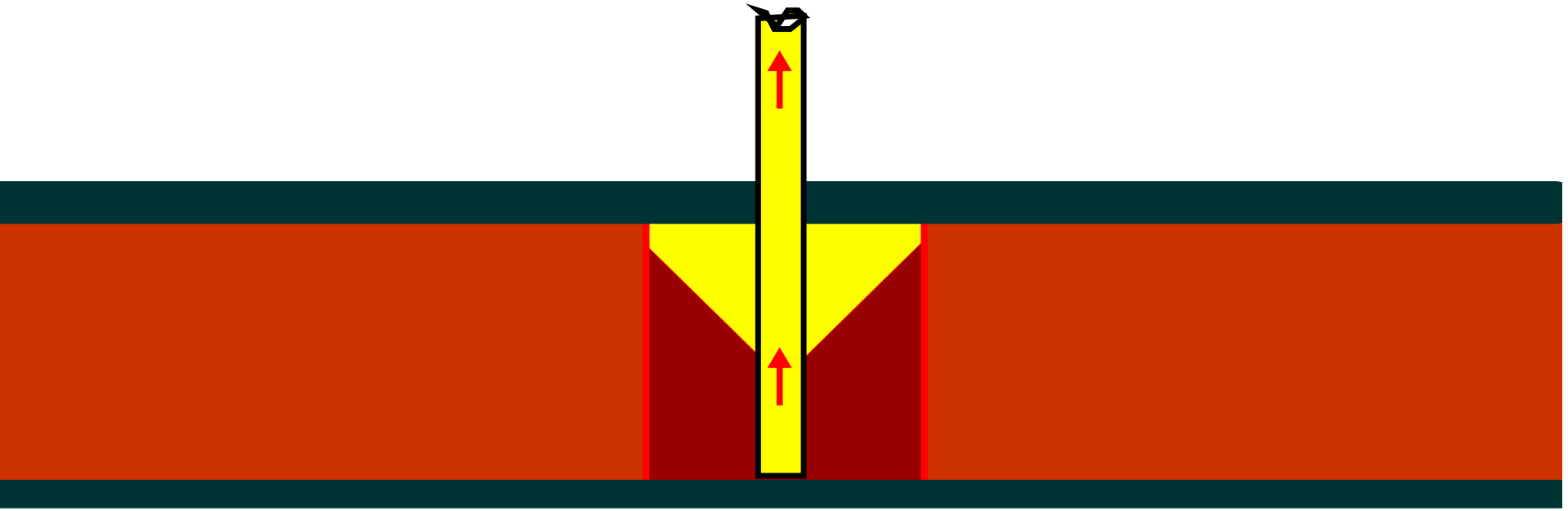

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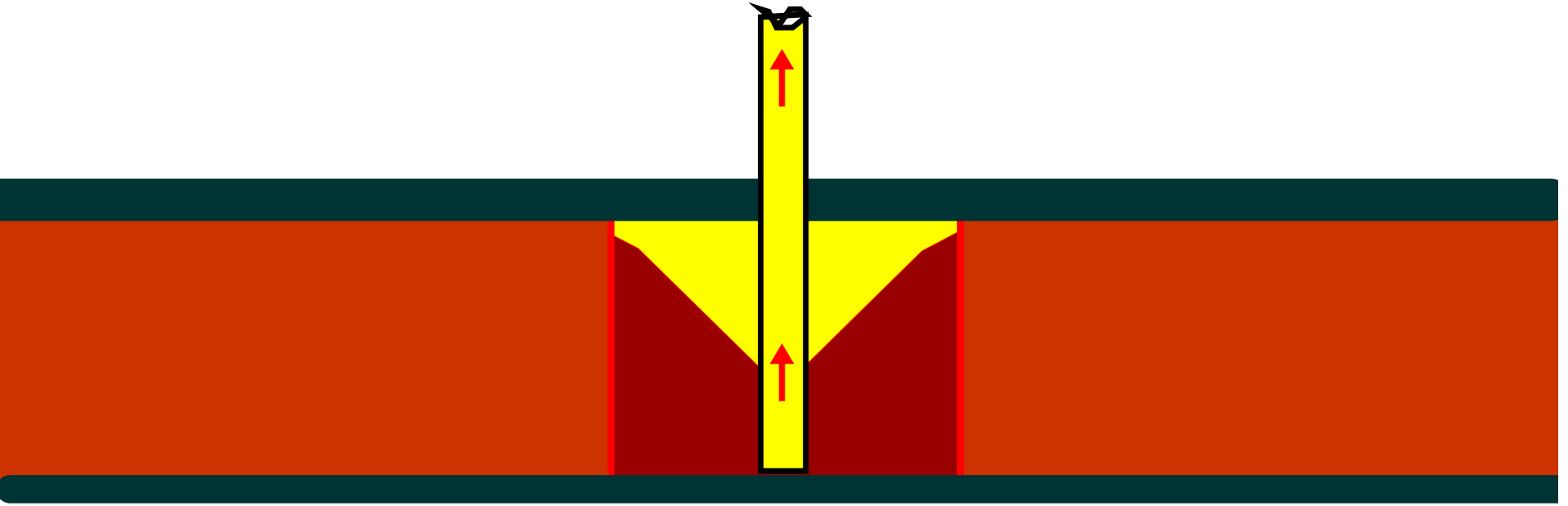

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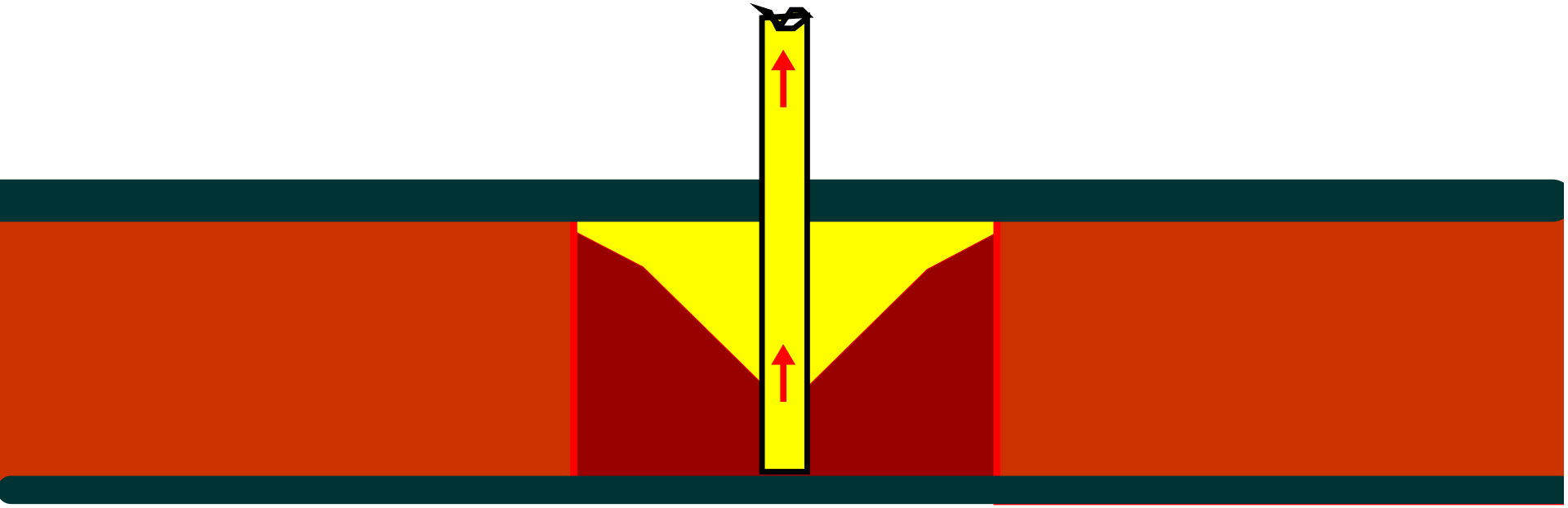

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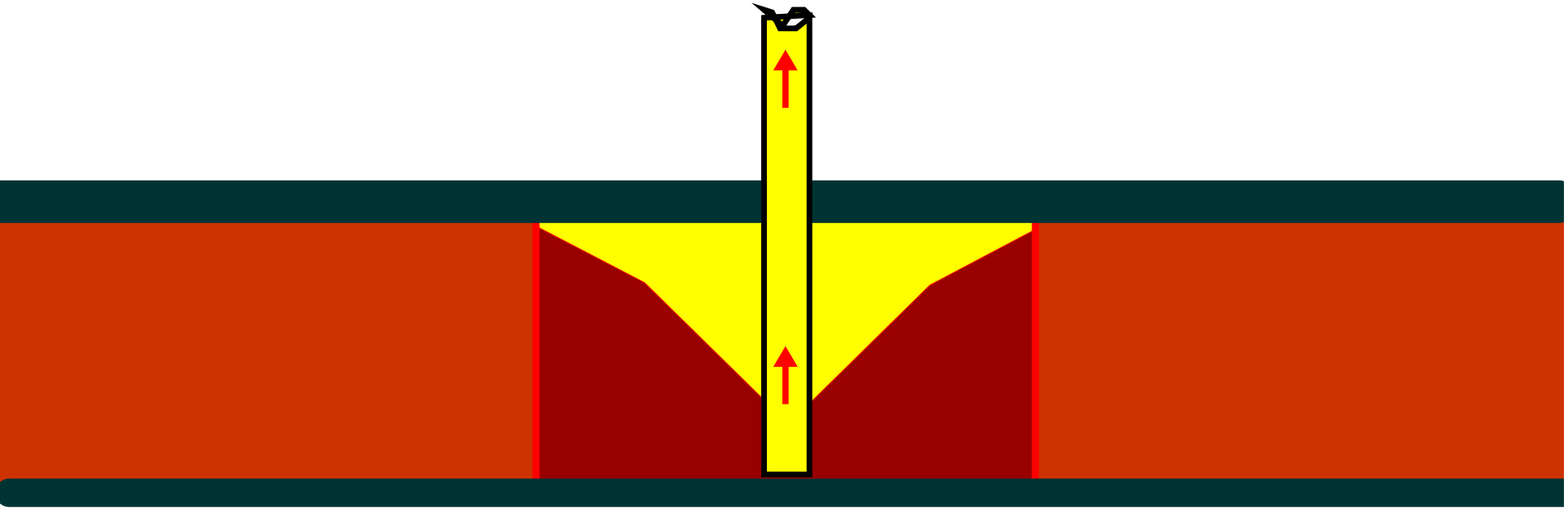

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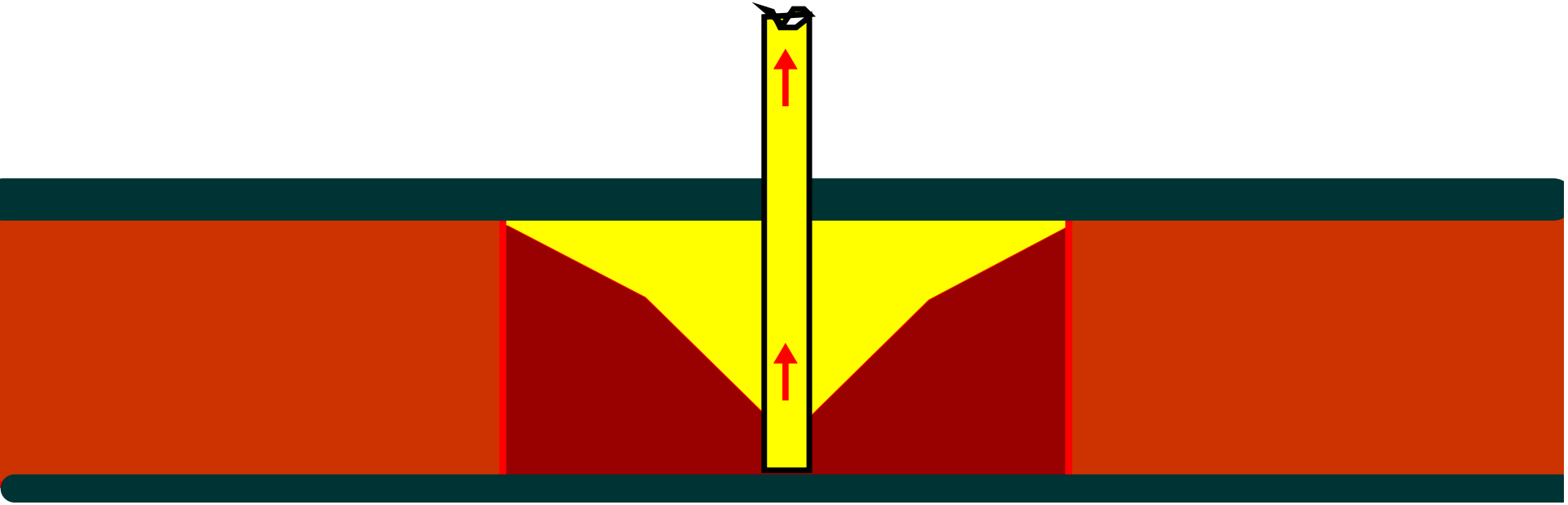

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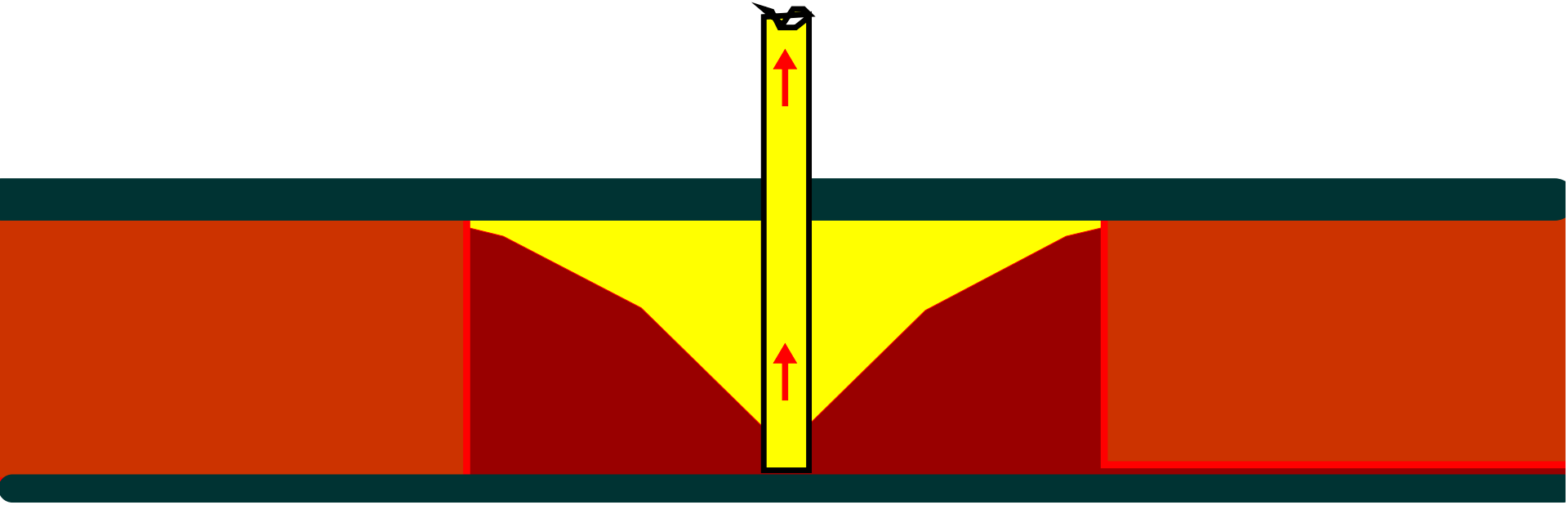

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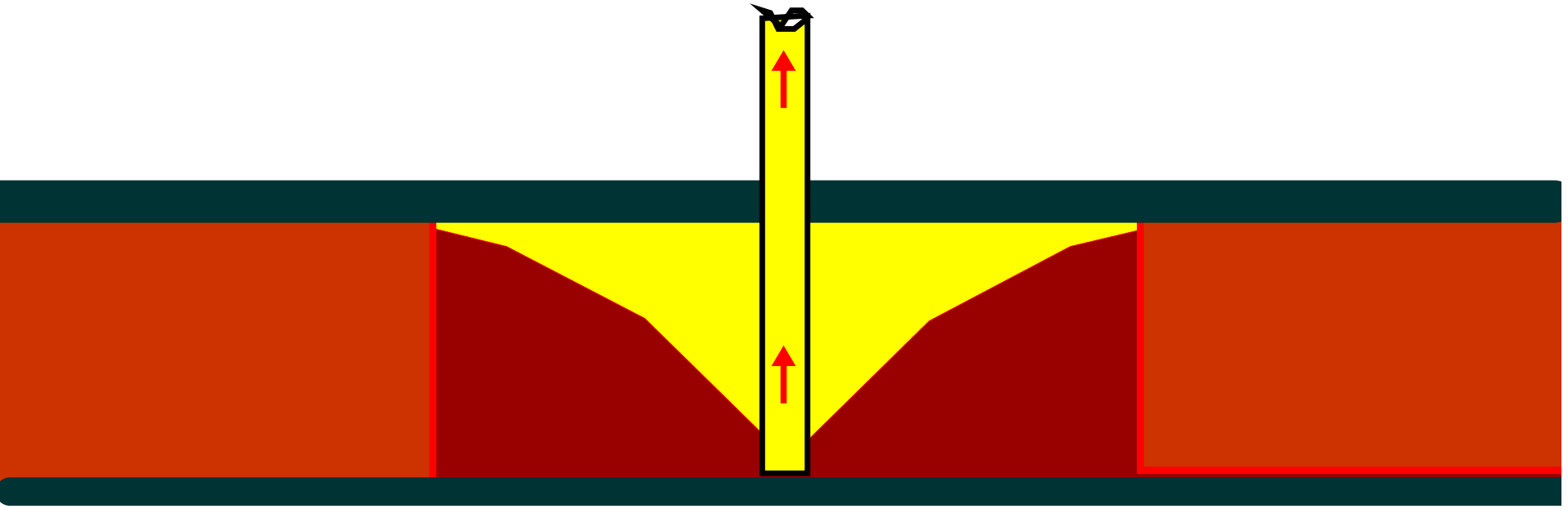

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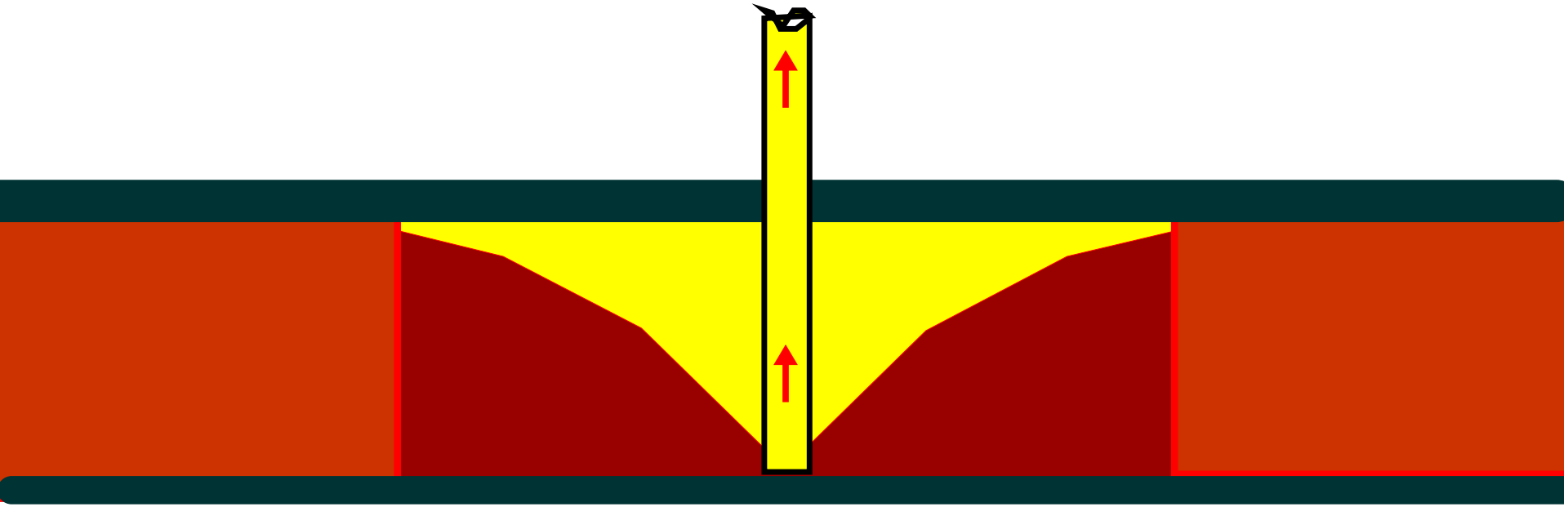

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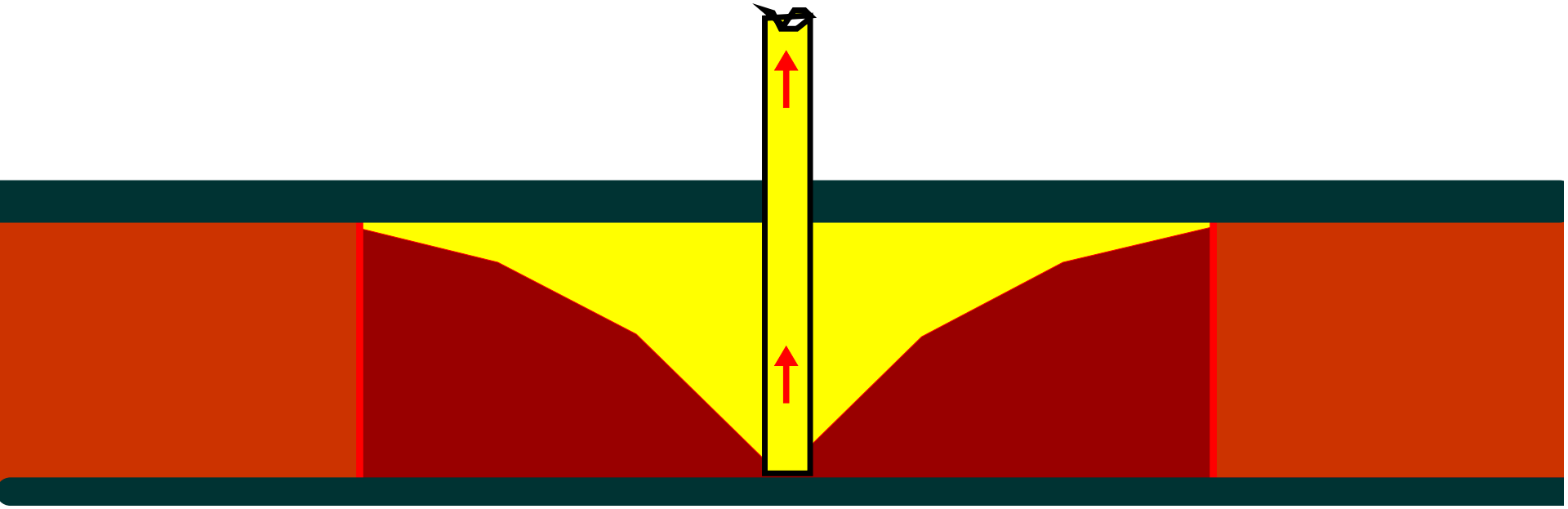


New Technology

- Introduction of Accurate Digital Quartz and Capacitance Gauges in 1977.
- 3D Seismic to Clearly Delineate Geology.
- Introduction of Memory Modules Make Cheap Data Acquisition.

New Observations of Transients

- Instruments Were Placed in all Wells During a New Platform Startup in 1987.
- One Well, the A-9, Is Flowed at a Constant Rate of 17mmscfd in a 500 Md Sand. and Observed by Neignboring Wells in the Same Fault Block.
- Flow Was Smooth and Uneventful.
- The Static A-2 Well is 2000 Feet Away.

Observations Were Surprising

- **28 Hours** Were Required Before any Pressure Event Was Noted in the Well.
- Instead of the Expected Asymptotic Development of Pressure Loss the Arrival was Heralded by
  - A Small Step Loss of Pressure
  - A 30 Minute Duration Half Sine Wave Dynamic Event Pressure Loss and Recovery
  - It Looks Like a Wave with Both Shock and Dynamic Wave Characteristics

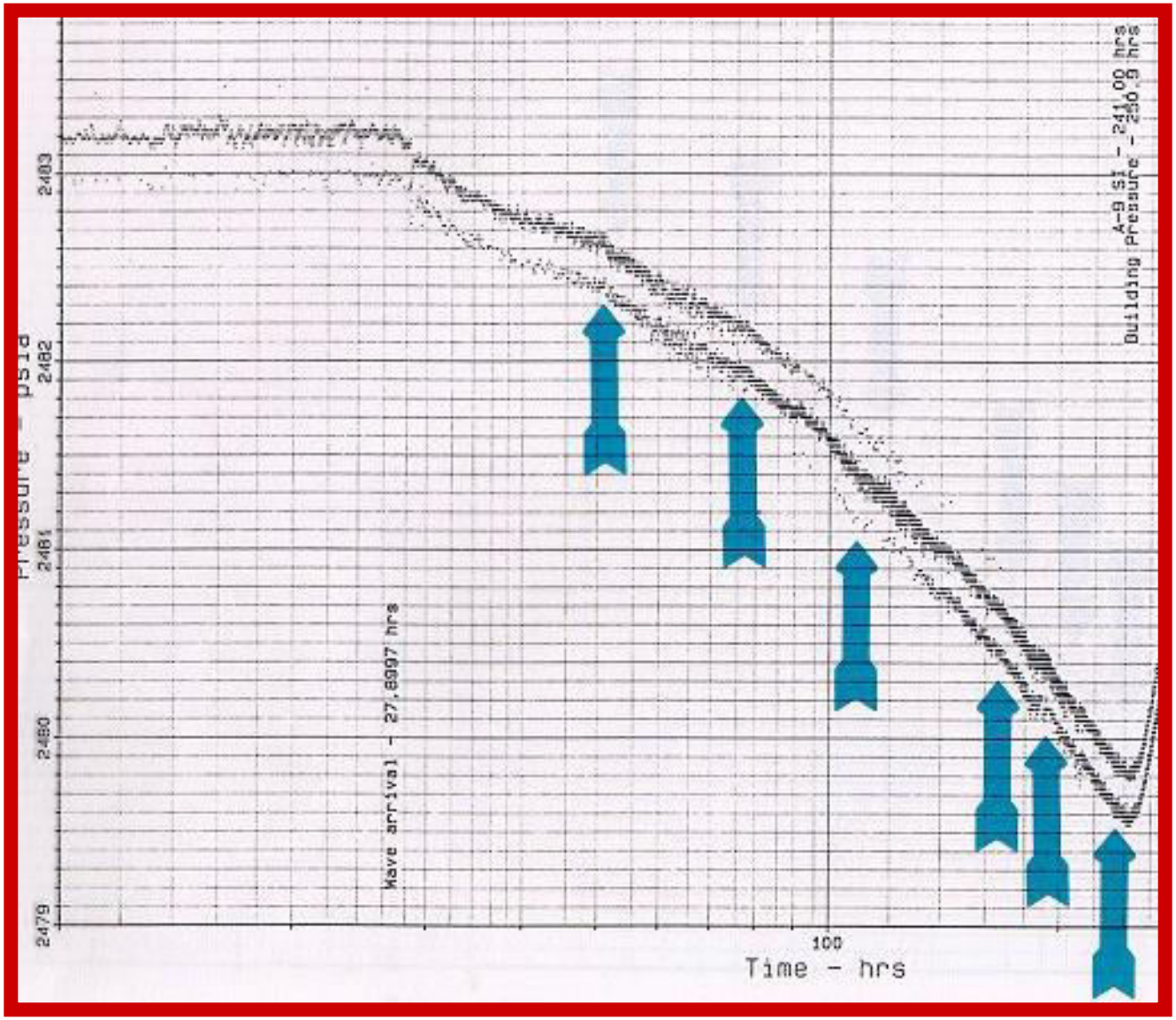
Interference Observed

- A Persistent Decline and Recovery to a Straight Semi Log Slope as Expected.
- The Well Storage Portion of the Curve
  - Lasts 20 Hours!
  - 2000 Feet Away!
  - Can This Really be " Well Bore Storage"?
- A Second Abrupt Step Loss in Pressure Is Followed by an Immediate Doubling of the Semi Log Slope.

More Observations

- Further Step Decreases Appear with Slope Changes.
- When A-9 is Shutin A-2 Responds (Stops Losing Pressure) Within 30 Minutes. It Begins to Rapidly Rebuild Pressure Within 10 Hours.
- **Conclusion:** This is Not a Text Book Picture. A Picture Is Worth a Thousand Words.

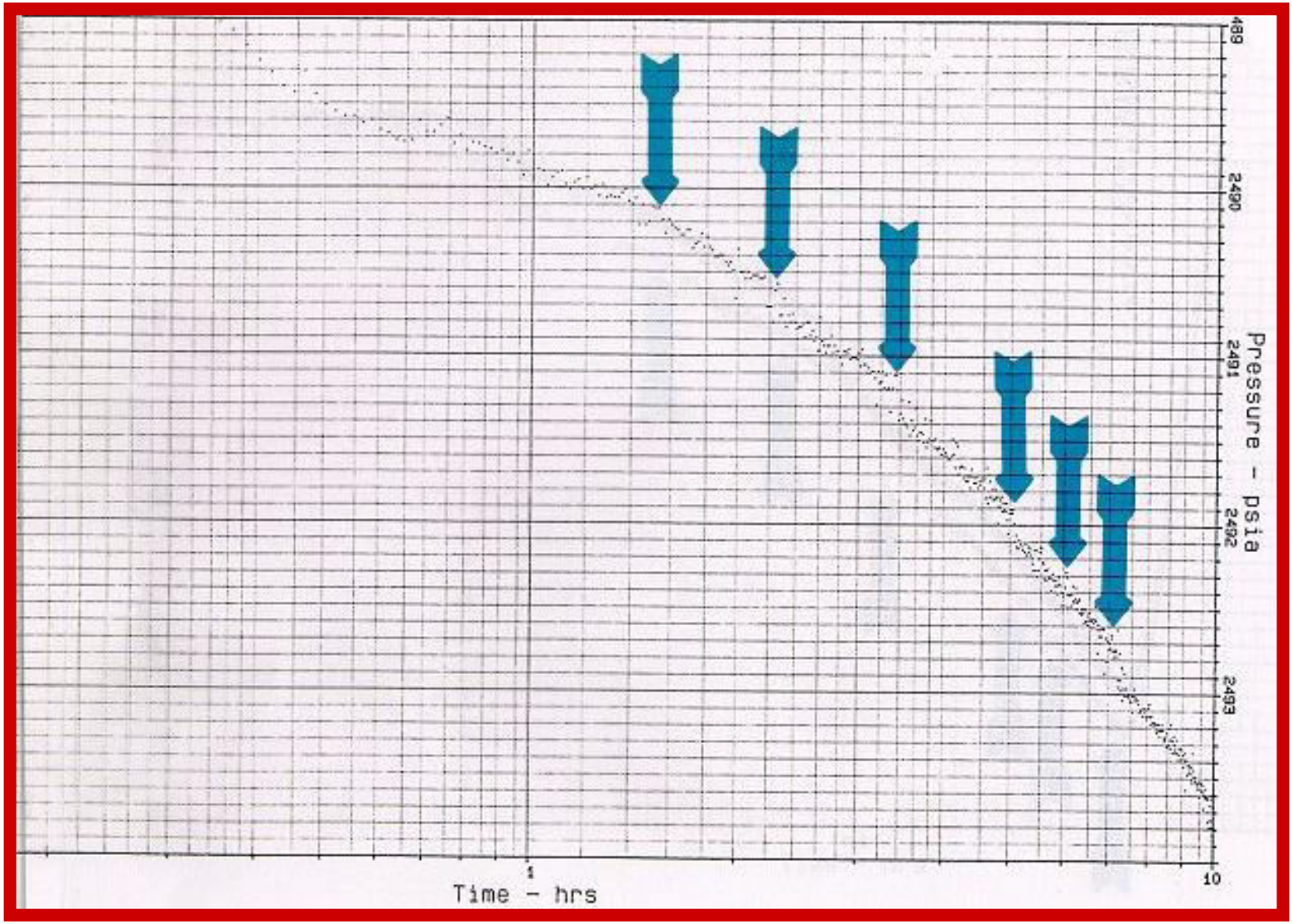
Static Well Sees Passage of Cone of Producer.



The A-9 Buildup

- The follow on Buildup Shows a Series of Step Increases on a Much Shorter Time Scale.
- A Semilog Plot Was Constructed Showing the A-9 Buildup With the Pressure Scale Inverted so that It Can Overlay the Drawdown.

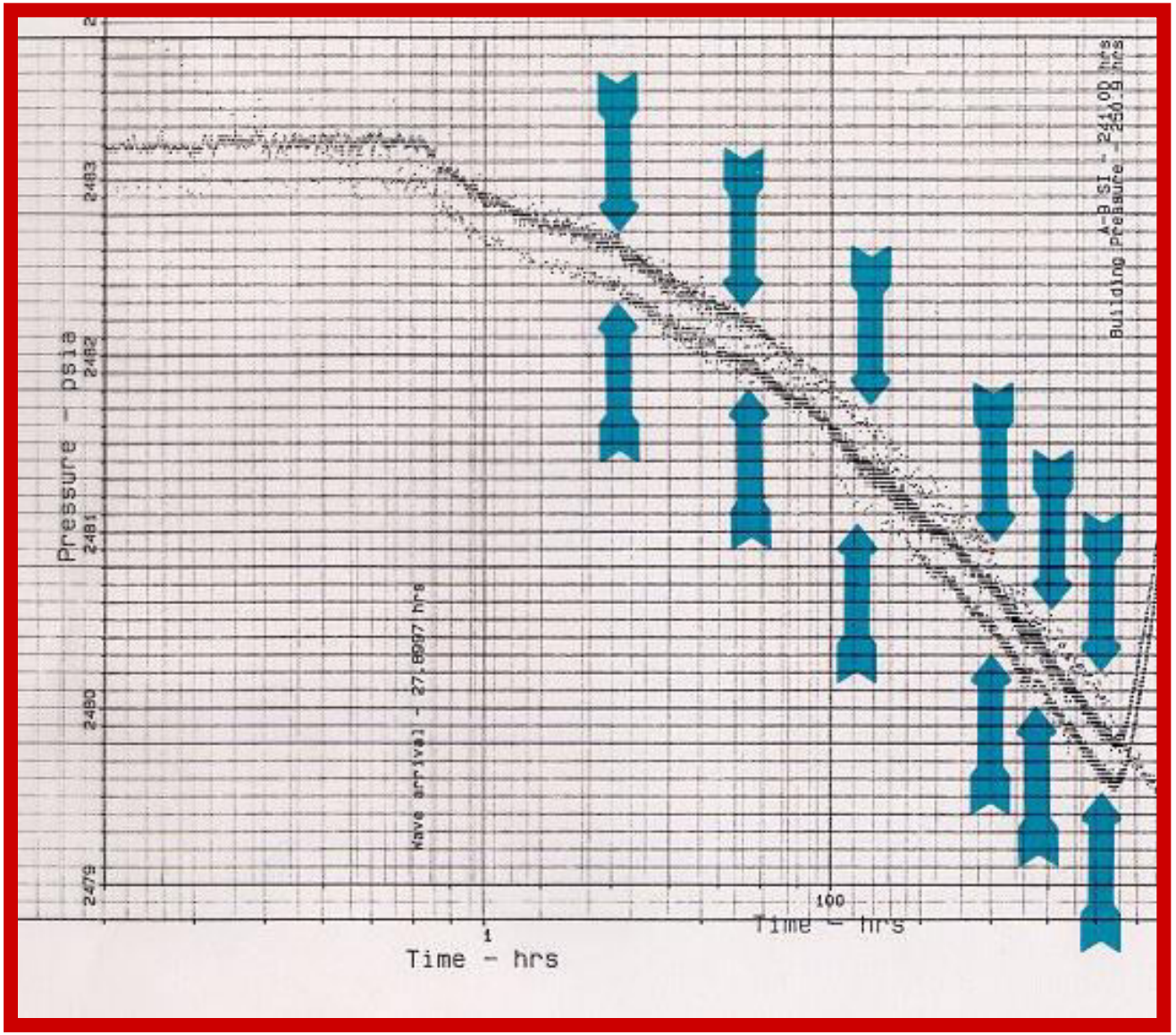
Buildup in the Producer



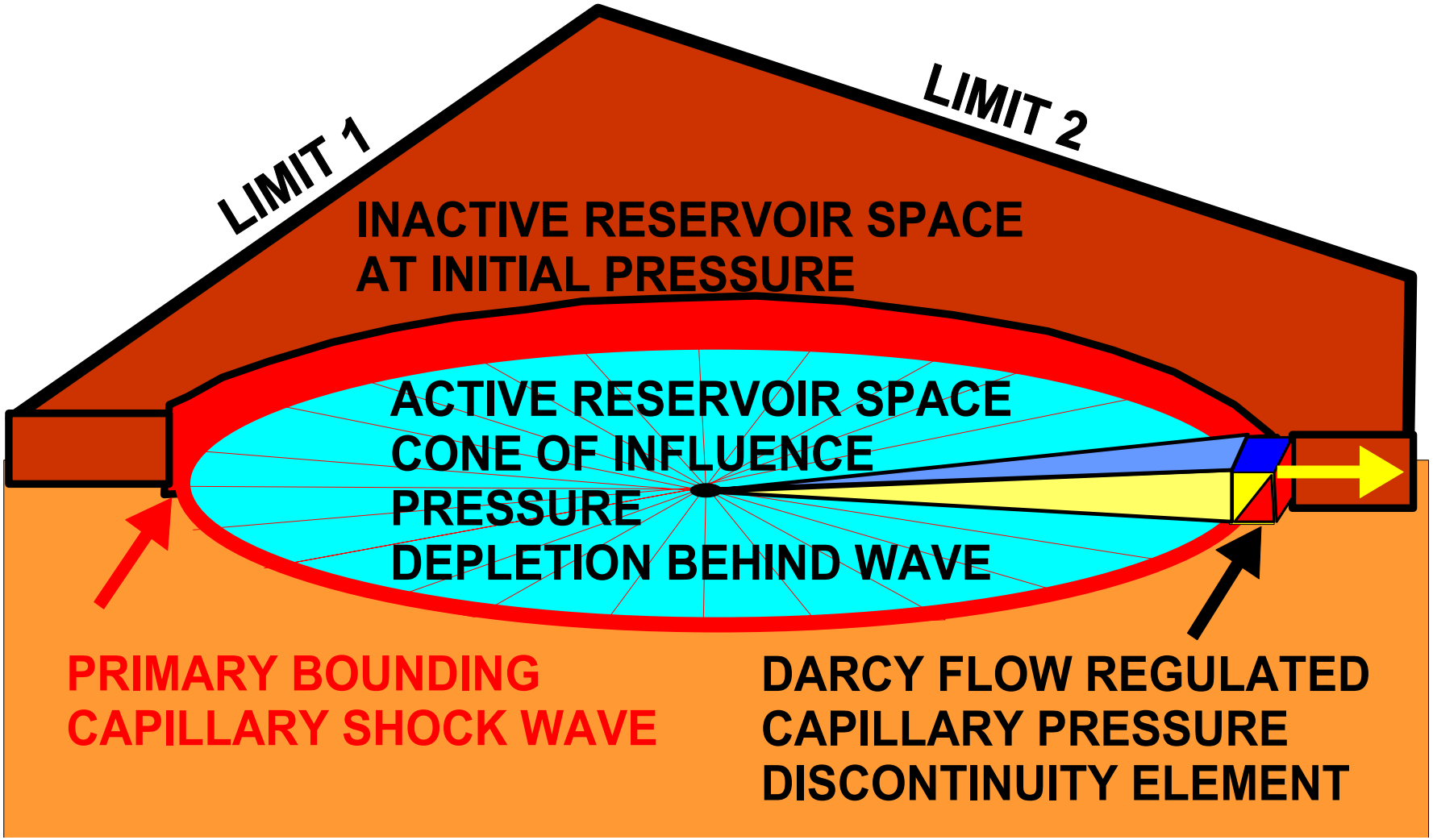
Comparing the Plots.

- Both Use A-9 Flow Time as the Time Scale
- Both Use the Same Vertical Scale.
- The Arrows Denote the Small Step Changes.
- The Triple Image on the A-2 Plot is Caused by the Temperature Correction to The Pressure Calibration Polynomial. If Temperature Is Set to One Value they Will Produce One Curve.
- The Resolution of the PANEX Gauge is .01PSI.
- The Steps are .1 PSI.

The Steps and Slopes Replicate



Moving Capillary Shockwave Boundary



Secondary Cone Inside Primary Cone of Influence