Well Intercept Methods for Re-Accessing Depleted Fields for Carbon Storage

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Speaker Bio

- 20 Years in the Industry / 18 with Halliburton
- 13 Years as Senior Ranging Specialist
- 9 Years In Current Position
- Personal Experience Includes 70+ Well Intercepts
- 20+ Precision Well Placements
- 2 Open Hole Recoveries
- 100% Success Rate

Target Well Categories

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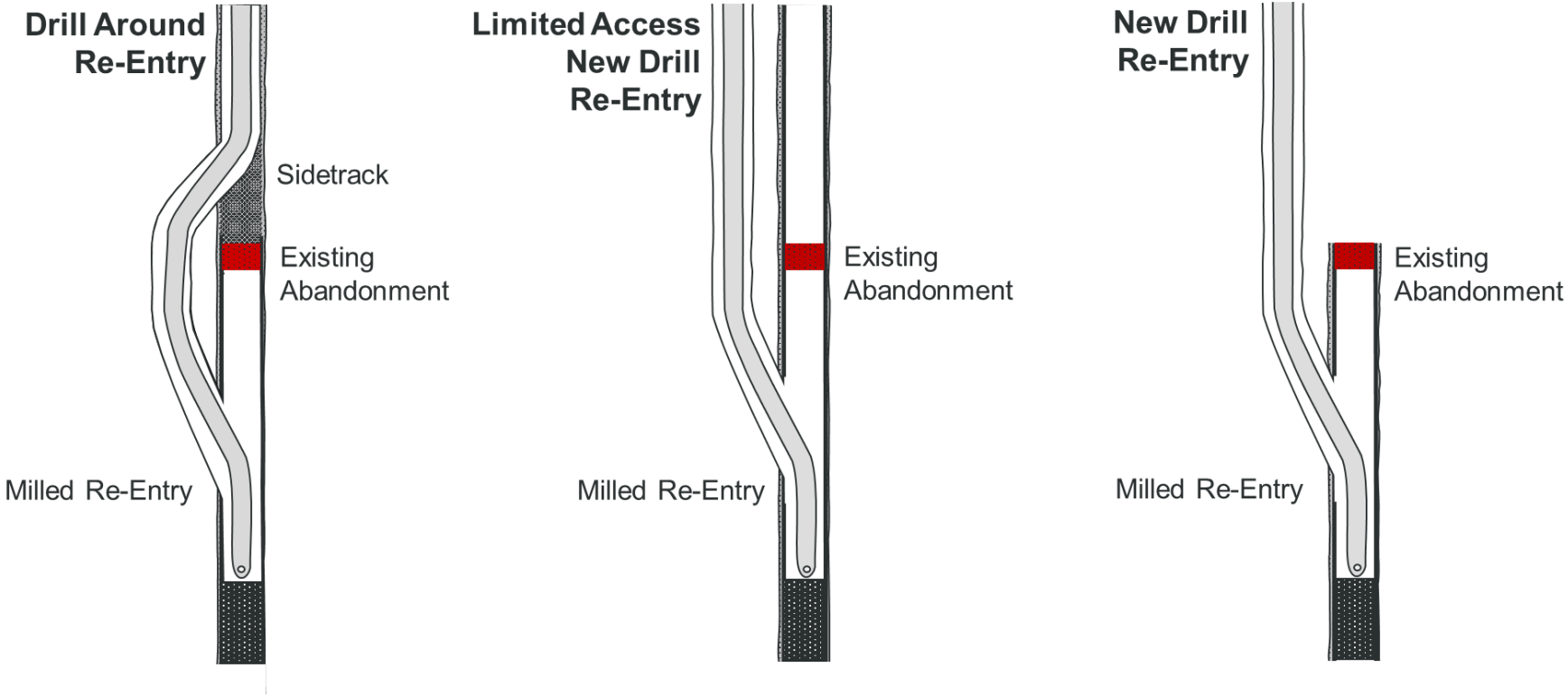
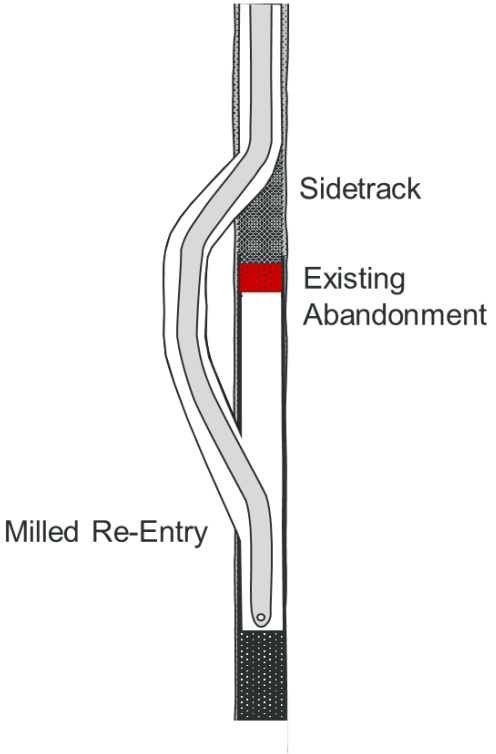
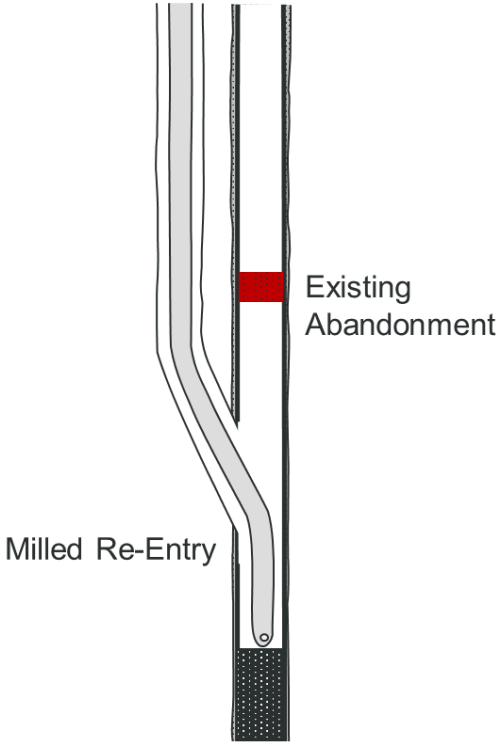


Drill Around Re-Entry



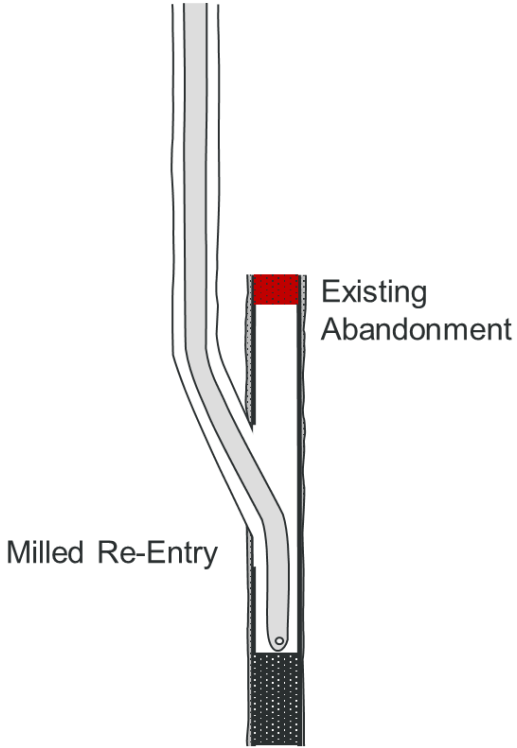
- Used to either P&A or regain access to the reservoir
- Maximizes cost savings by reusing existing surface casing
- Well is sidetracked above existing plugs
- Re-entry is completed below any obstruction
- Access Independent AMR used for alignment and milled re-entry

Limited Access New Drill Re-Entry



- If Surface access exists before the barrier an Access Dependent AMR system can be used to range before the obstruction
- After the barrier the Access Independent AMR will be used to follow existing well and align for re-entry
- Well can be re-abandoned or connected to be used for CO2 injection

No Access Re-Entry

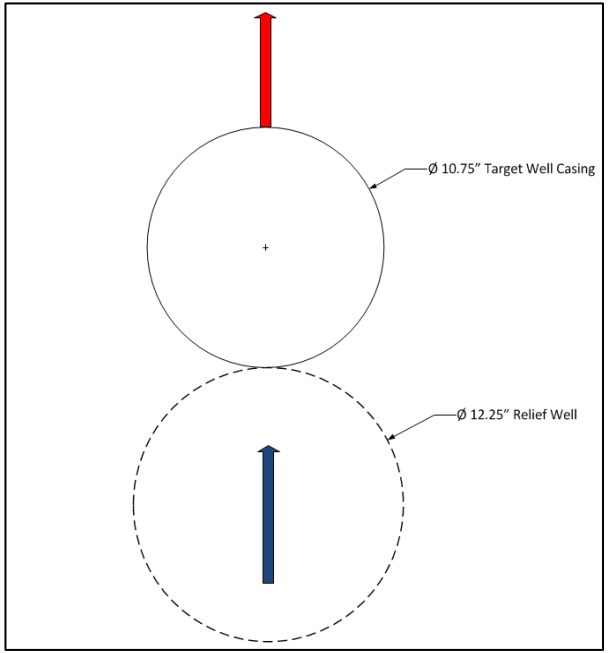


- Access Independent AMR used to follow existing well and align for re-entry
- Intercept method typically used for BO control or P&A re-abandonment.
- Well can be re-abandoned or connected to be used for CO2 injection

Milling

Optimal Milling Alignment

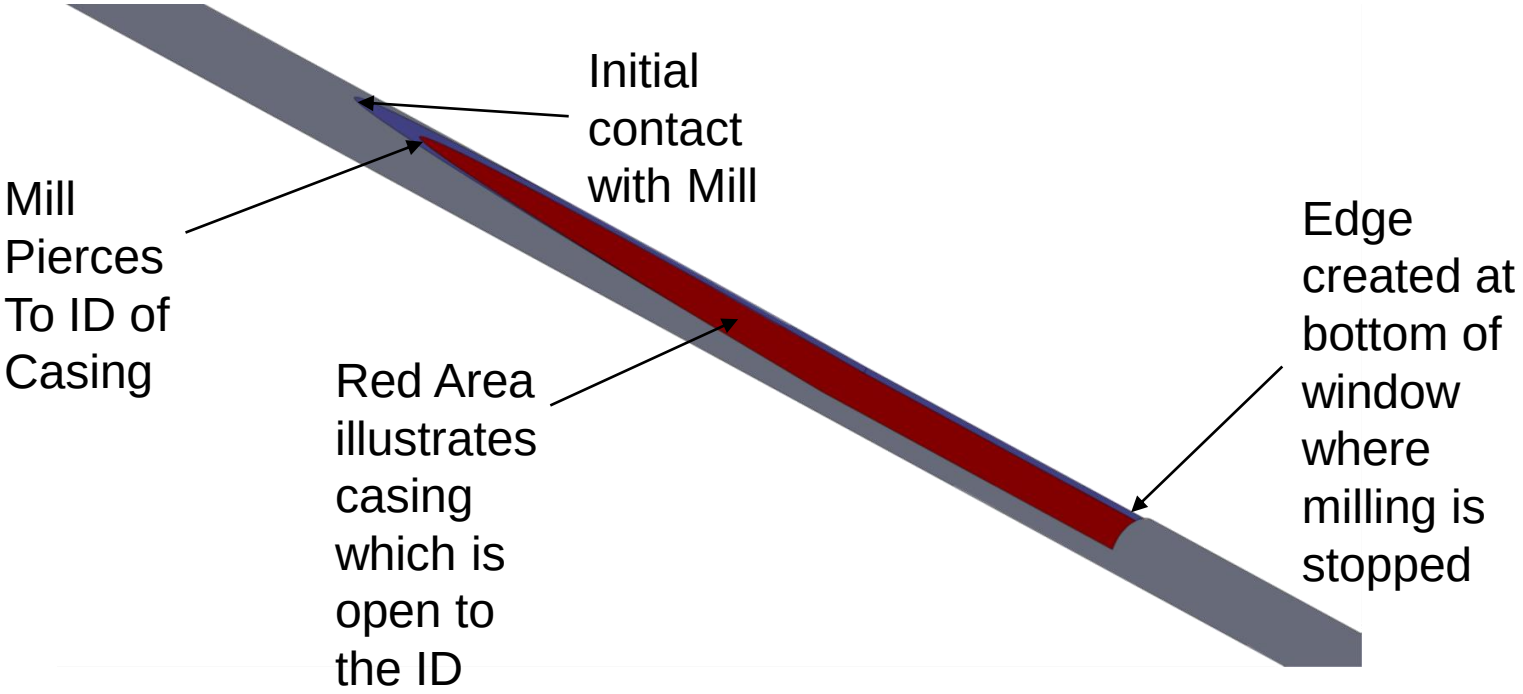
- In general, at the interception depth, TW alignment directly Highside or Lowside to the RW is preferred for milling and re-entry.
- The TW aligned to the highside of the RW is the preferred alignment for low inclination wells
- The TW aligned to the lowside of the RW is typically reserved for an alternate RW wellpath, or for high inclination wells



Milling Operations

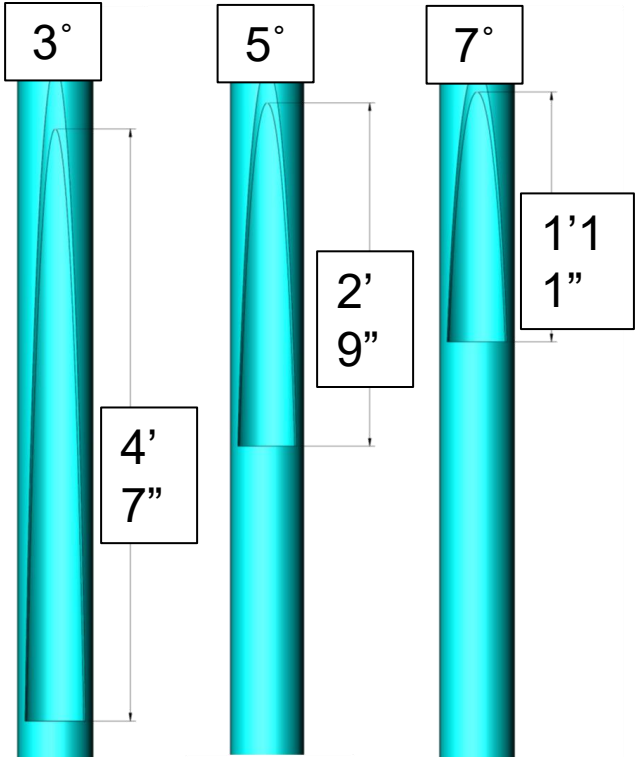
- Once Bit soft tags casing, a ranging run is completed to confirm alignment prior to milling.
- Mill is ran on the bottom of motor and pointed towards casing with recommended Tool Face.
- Time milling is used to mill window.
- Progress is monitored by tactile feedback, WOB and differential pressure.
- Concave mill is used to because it keeps the mill on the casing.
- Removal of swarf can be limited due to flow rates and/or loss circulation.
- For re-entry a longer window is milled and the back side of the casing is left intact as a guide for the tubing. Mill can be turned over to keep mill in center of wall and allow for window to be elongated.

Window Geometry

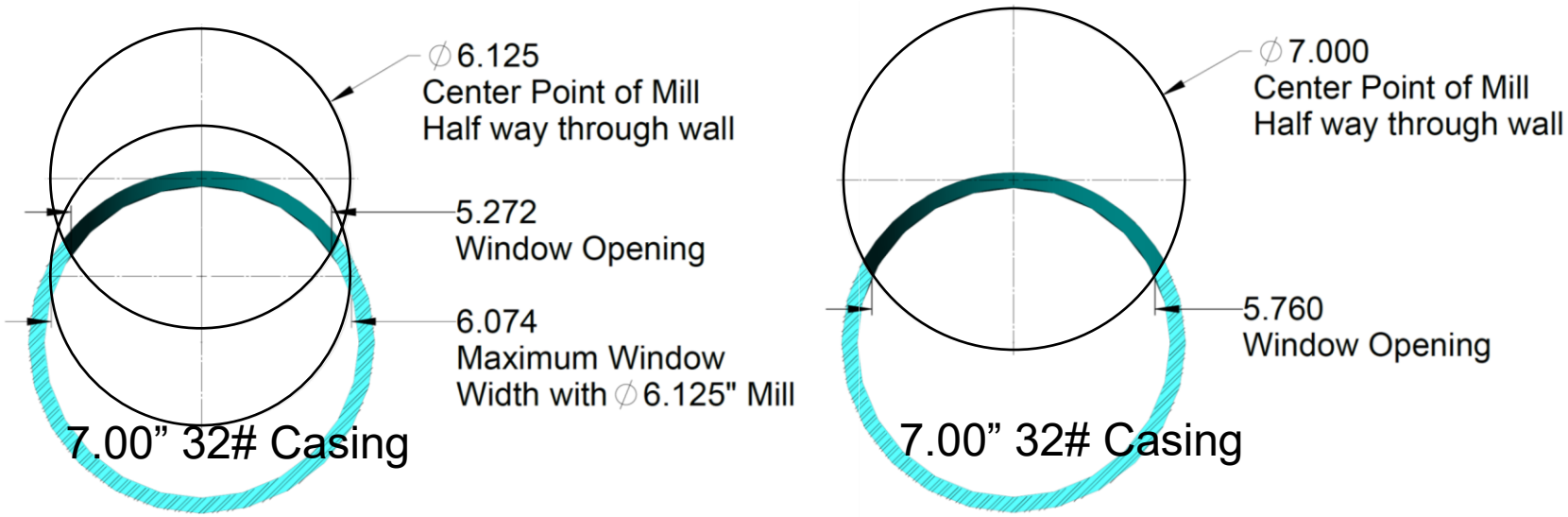


Window Geometry

- Incidence angle between 2˚-5˚ is ideal
  - Some incidence is required for Milling
- Window was modelled in Solidworks (CAD) with 7” 23.00# Casing and 6.125” Mill.
- Window was cut in casing from where mill makes contact to where the casing wall is at the center of the mill.



Window Geometry



Mill Wear

- Mill wear provides evidence on how large of a window was milled.
- Grooves on face and wear at center of mill are good indications of how far mill went into casing.

Ditch Magnets

- Ditch magnets are used to capture milling swarf from mud.
- Amount of cuttings can be limited by flow rate.

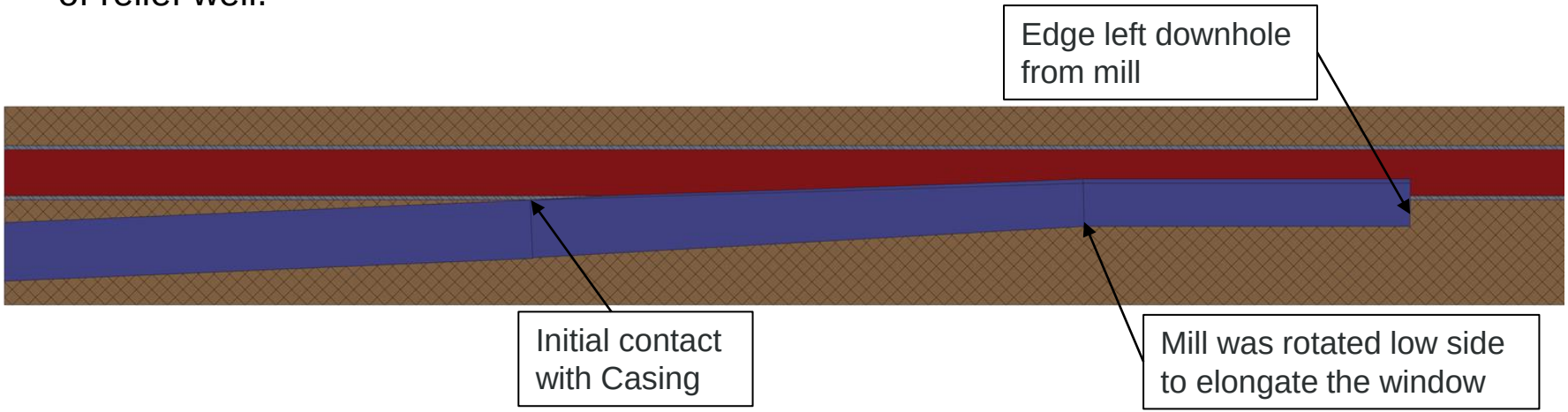
String Magnets

- String magnets can be added to drill string to help remove milling swarf from well.
- Provides further evidence on size of window.

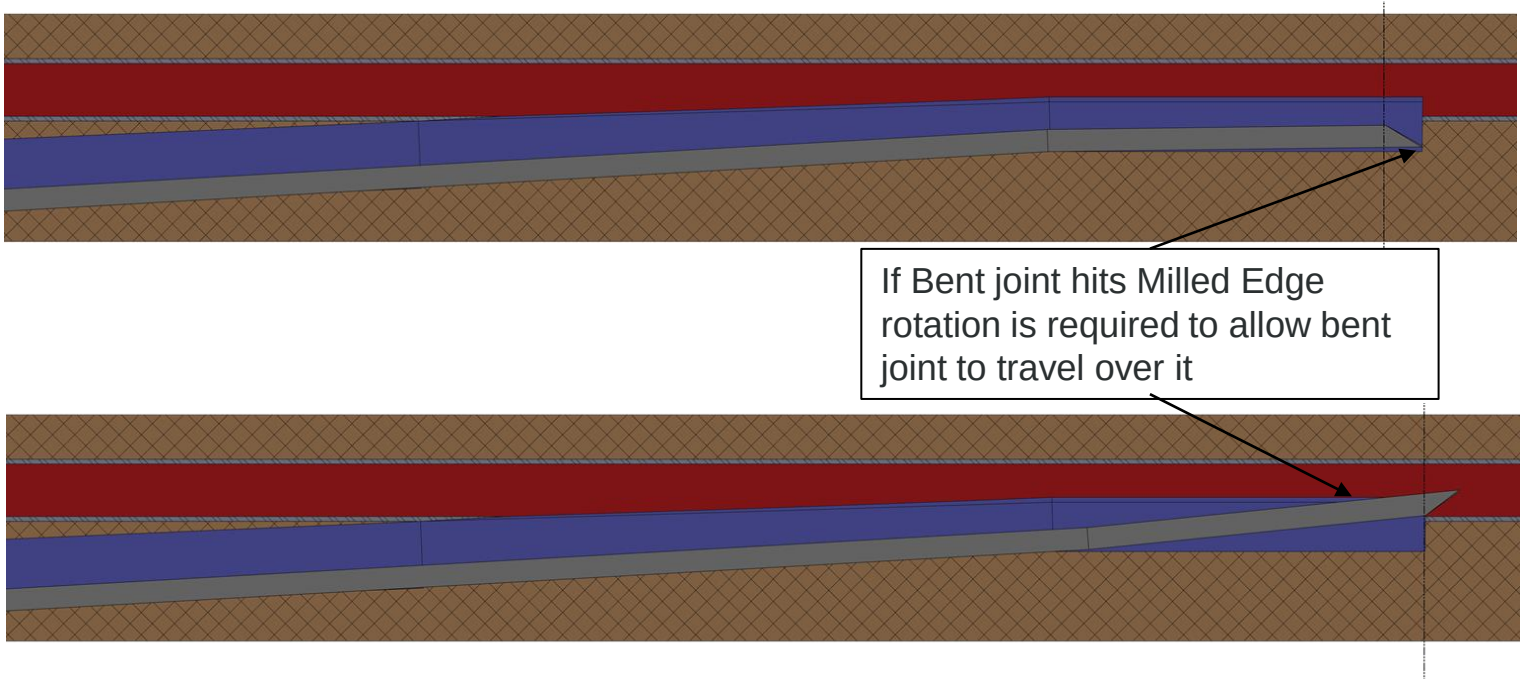
Re-Entering the Well

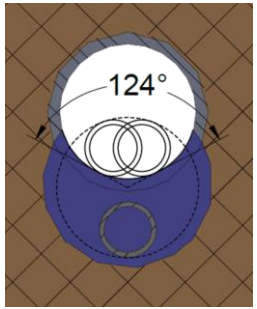
Bent Joints

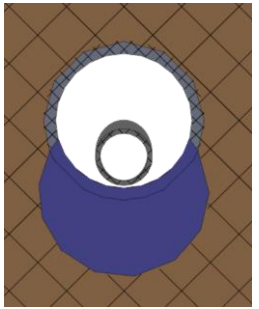
- Bent joints are used to re-enter milled window if no further completion is required.
- Rotation of bent joint may be required depending on Milled Edge downhole and path of relief well.



Bent Joint


If Bent joint hits Milled Edge rotation is required to allow bent joint to travel over it


124°



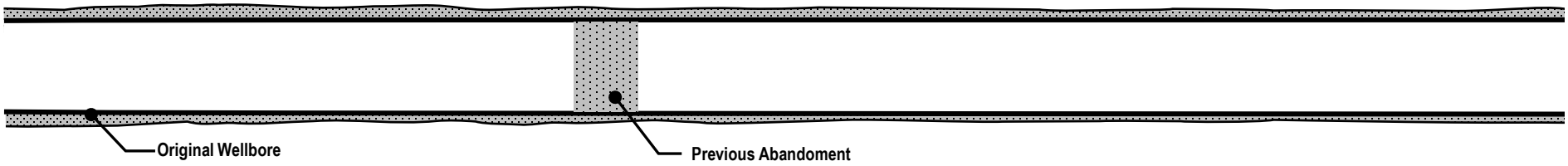
Case History

- Normally we re-enter most wells with tubing to set cement plugs.
- A well in California was re-entered with a packer.
  - Window was 3.048m (10 ft) long.
  - 11-3/4” 60 PPF casing (ID 10.772”).
  - Used a 10-5/8” Cone bit and 10.5” String Mill to clean window after initial milling.
  - 11-3/4” 32A Test Packer (10.5” OD) was ran into window with “No Issues”. Test packer was set and pressure tested casing at 500 psi for 15 min.
- Several Wells in Brazil utilized a hydrojet cutter to penetrate multiple strings of casing.
  - Window was 6.12m (20.08 ft) long.
  - 7” 23 PPF casing (ID 6.366”)
  - Hydro Jet cutter had an OD of 4.5” and 2m long.
- Information is difficult to collect as usually released once we enter back in well.

Drill Around Re-Entry

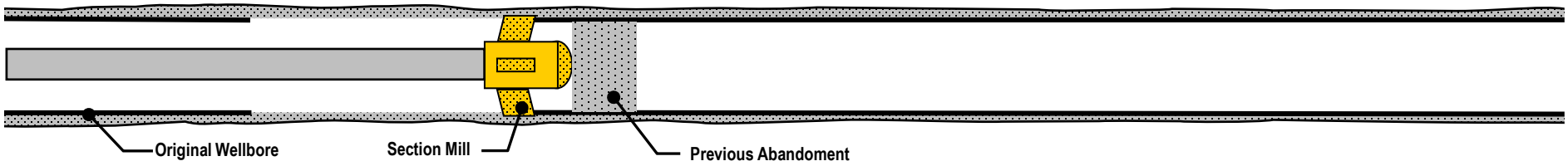
Original WellBore and Abandoment

- Original WellBore is plugged by original abandoment or another issue.



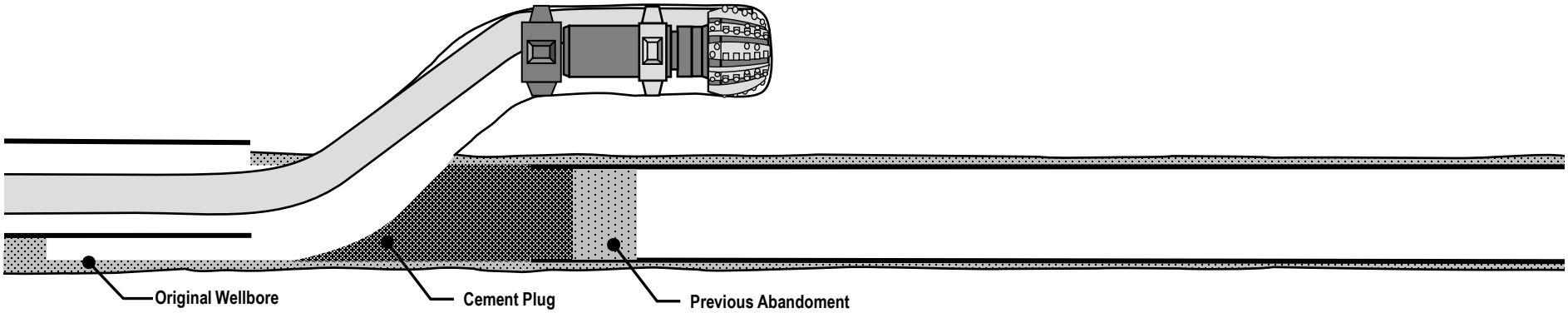
Section Mill Upper Section

- Upper section is section milled or a traditional window can be milled.
- Clean out well as required prior to kicking off cement plug.



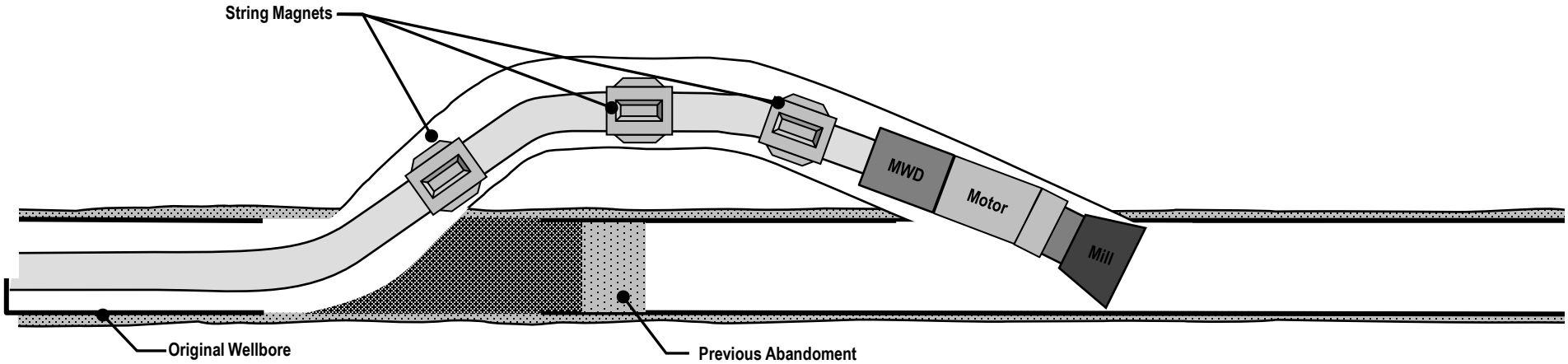
Kick off of cement plug

- Kick off cement plug and drill lateral to required depth.
- Range as required to keep bypass parallel to original wellbore.
  - Ranging requires to trip out drilling equipment.



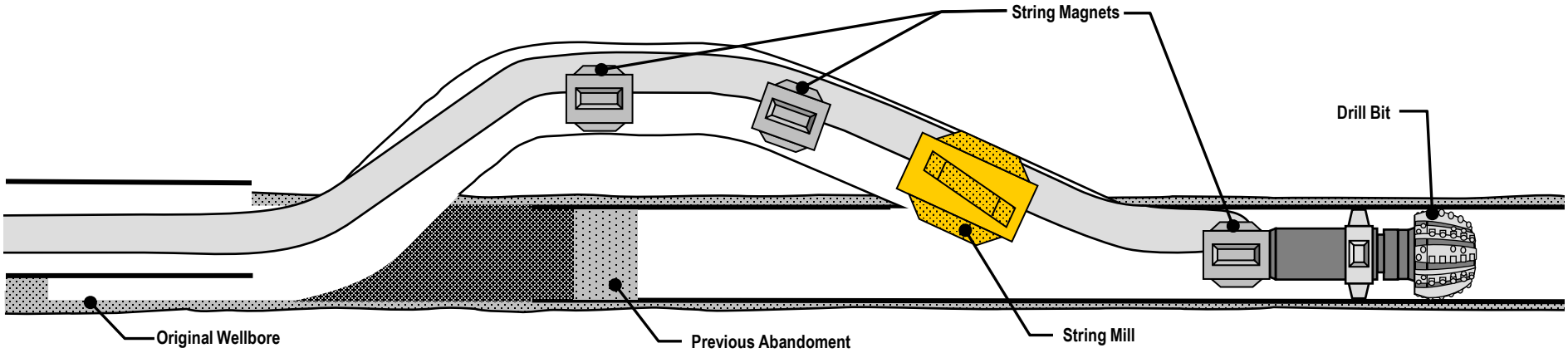
Intercept Well and Mill window

- Intercept well with Active Magnetic Ranging.
- Mill window, use motor to point the mill at the casing.
  - Use Concave Face Mill
- Run string magnets to aid in cleanout.



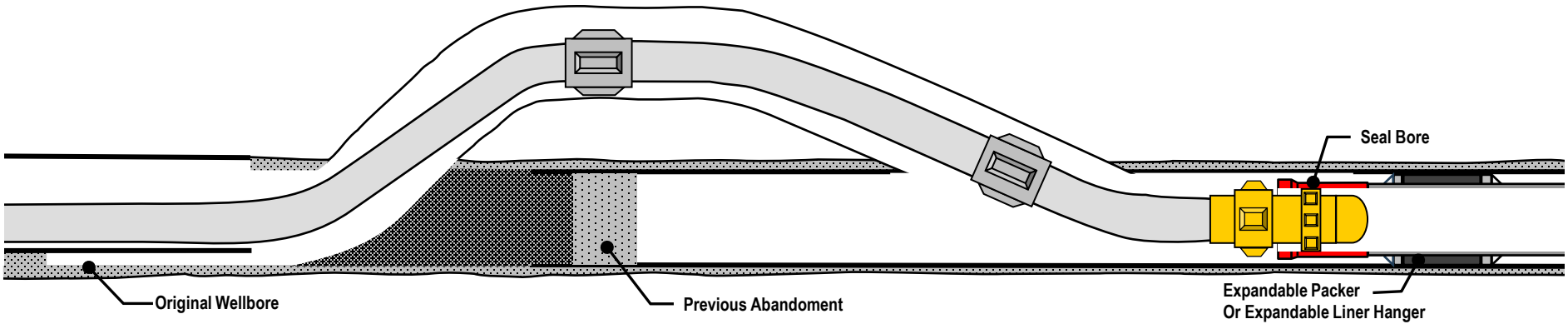
Cleanout Well and Drift Window

- Run Drill Bit (or Mill) with String Mill and String Magnets to cleanout, dress and drift window.
- Allows verification of window dimensions and if TD can be reached.



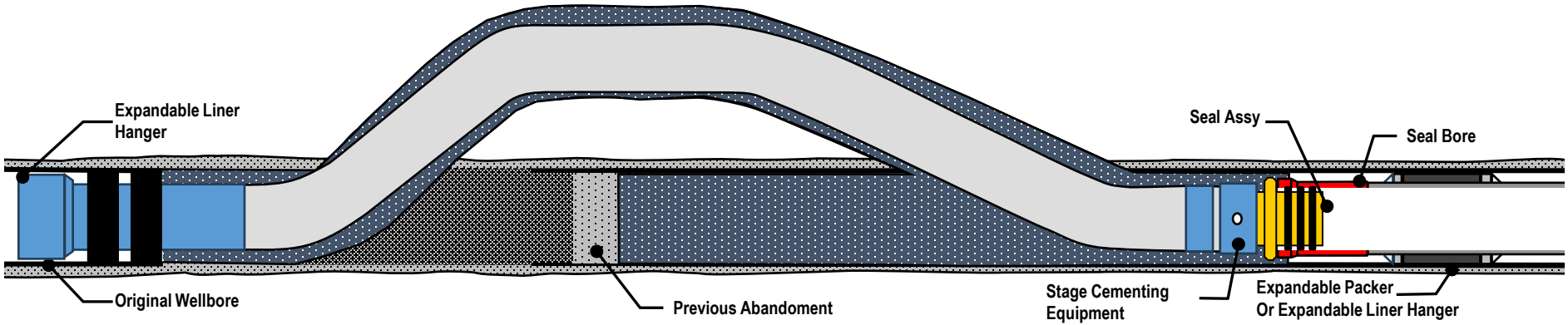
Drop Lower Sleeve

- Drop-off sleeve into the lower casing section below the existing abandonment.
- Depending on the completion requirements could run Expandable Isolation Packer System or Expandable Liner Hanger.



Run Expandable Liner Hanger

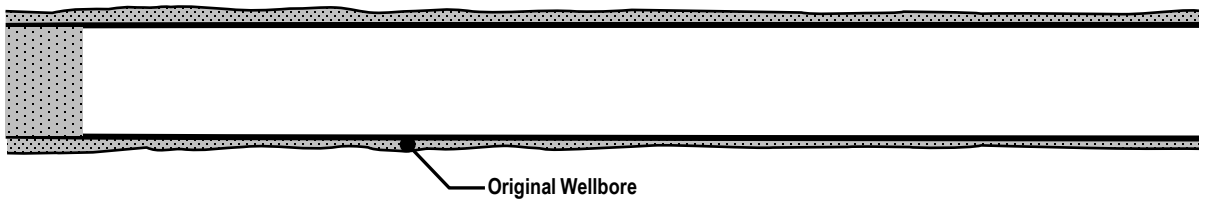
- Run in with an expandable liner hanger, liner and tieback seal assembly. The hanger would be positioned in the upper casing above the exit window and existing abandonment. The liner would be ran through the open hole bypass section and the seal assembly would be stabbed into the drop off sleeve sealbore.
- Pump cement job through Stage equipment to cement the liner in place and set expandable liner hanger.
- Drill out plugs and any cement.
- Clean up and move to completion operations. (Upper Completion with Production packer, safety valve and flow control.)



New Drill Re-Entry

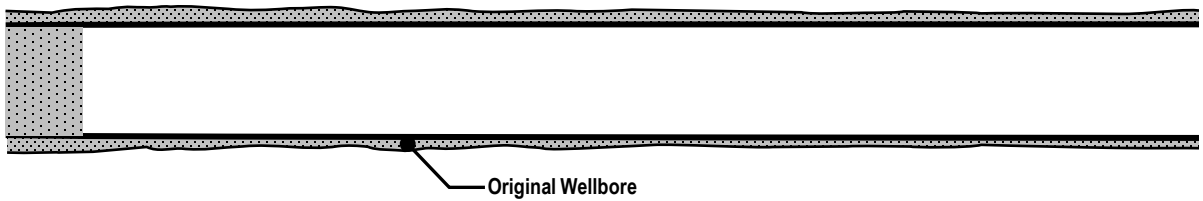
Original Wellbore and Abandoment

- Original Wellbore location is unknown.



Drill Surface Hole

- Drill new surface hole until original wellbore can be located with Active Magnetic Ranging.
- Range as required to keep new well parallel to original wellbore.
  - Ranging requires to trip out drilling equipment and run magnetic ranging tools on wireline.



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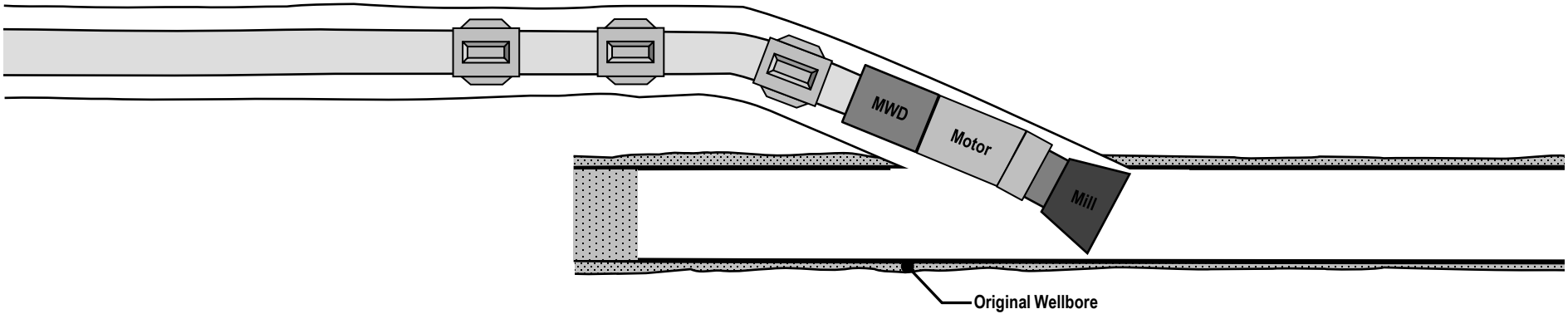
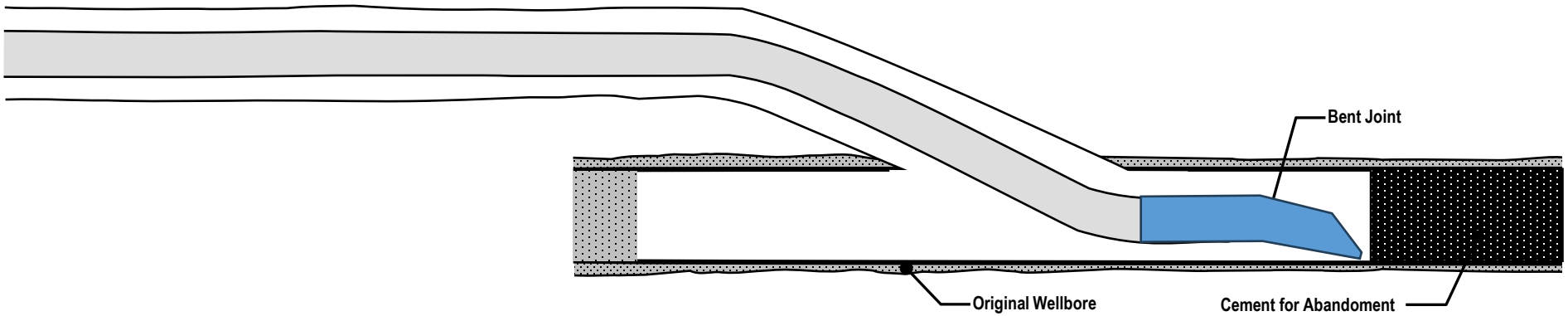


Re-Enter Original Wellbore

- Re-enter well with tubing, regardless of completion requirements.
- Bent Joint is used to re-enter.
- Pump cement as required.
- If a more complicated completion is required window will need to be cleaned, dressed and drifted.



Re-Access for CCUS Projects

Why Use a Depleted Field?

Proven reservoir to store CO2

Revitalize existing Infrastructure including:

- Pipelines
- Platforms
- Previously Abandoned Wells

What are the challenges?

Many depleted fields have been abandoned

Regaining access to the abandoned field can be achieved by:

- Drilling a new well from surface to the reservoir, or
- Re-Accessing a previously abandoned well

Re-Accessing a well can be achieved by either:

- Sidetracking from the existing wellbore and re-entering below the existing barrier, or
- Drilling from a new surface location to re-connect below an existing barrier

Why Access a Previously Abandoned Well?

Significant Cost Savings for on a CO2 injection well by:

- Reusing existing SHL/platform
- Reduce drilling time by reusing existing well infrastructure below the previous abandonment

Some existing wells, not intended for reuse, may need to be re-abandoned to improve the barrier before injecting CO2 into the reservoir