Horizontal and Multilateral Drilling

Prof. Dr. M. Enamul Hossain

CEO & President
NSRIC Chair Professor in Sustainable Energy
Online Education Division (OED)
NSRIC Inc.
London, ON, Canada
E-mail: enamulh@nsric.ca

Lecture 3

(Basics of Horizontal Drilling – 2)

Horizontal Drilling Cont.

Descriptions of different well types

In general, directional wells can be classified as:

1. Straight (Vertical)
2. S-type
3. Slant (J-type)
4. Horizontal

The selection of the type of directional profile depends upon the **geological objectives** and the **production mechanism** of the well.

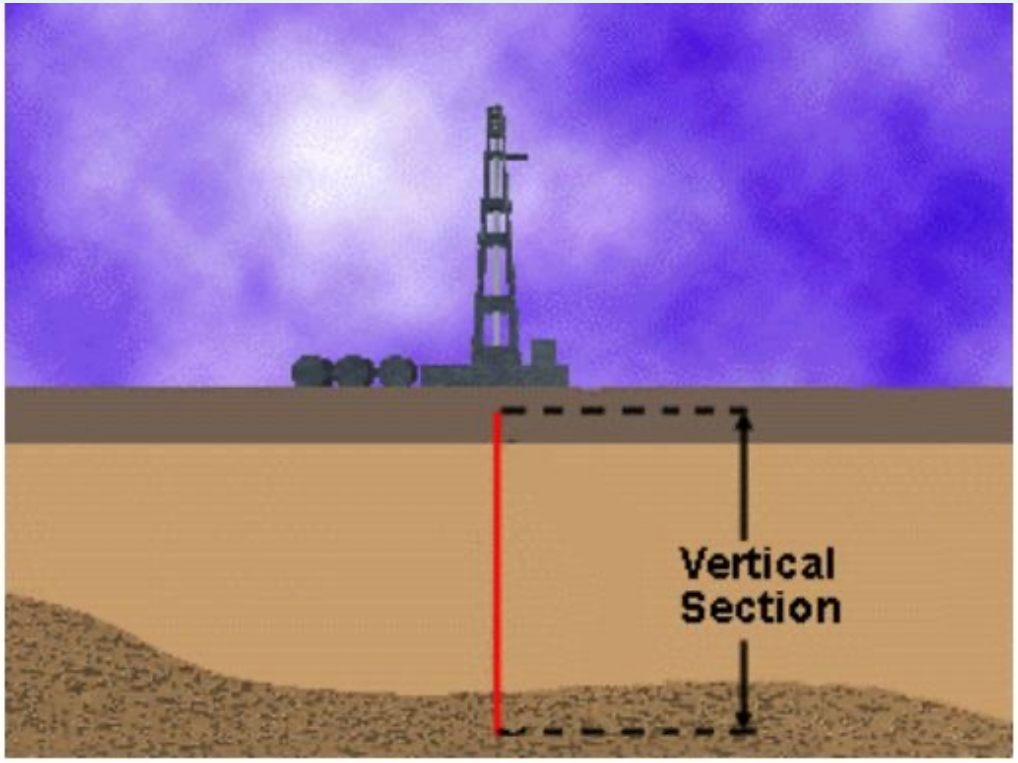

Figure 13 Straight Well (Vertical)

1. Straight Well (Vertical): Straight wells have a bore with no planned deviation from vertical.

Horizontal Drilling Cont.

Descriptions of different well types

2. S-Type Well:

- S-type wells have a bore with a straight section, a build section, a tangent section, and a drop section.
- This type of well is drilled to improve the efficiency of the well and to assist in the location of a blown-out well.
- In offshore drilling, S-type wells can ensure accuracy in bottomhole spacing when multiple wells are drilled from the same platform.

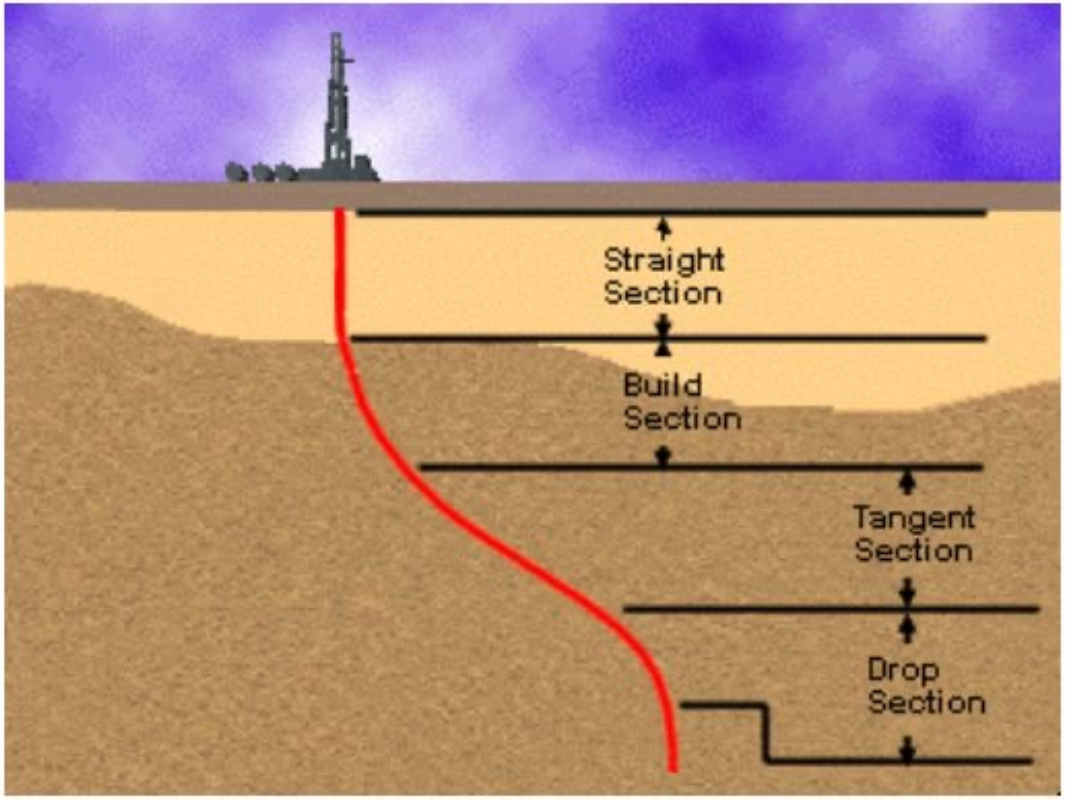

Figure 14 S-type wells

Horizontal Drilling Cont.

Descriptions of different well types

3. Slant Well (J-Type):
Slant wells, sometimes called J-type wells, have a bore with a straight section, a build section, and a tangent section straight to the target Slant or J-type wells are drilled where it is not desirable or possible to locate the surface location directly above the target or a multiwell platform.

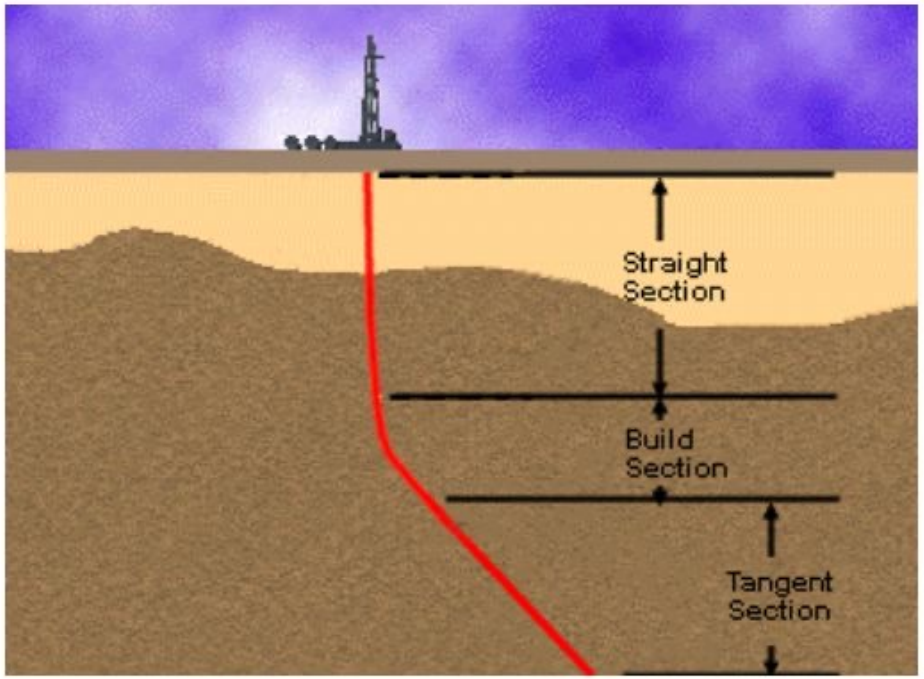

Figure 15 J-type wells

Horizontal Drilling Cont.

Descriptions of different well types

4. Horizontal Well:

Horizontal wells have a bore with a straight section, a build section, tangent section, a second build section (most of the time), and a horizontal section. The well is drilled to a point above the reservoir; then it is deflected and the angle increases until it reaches 90 degrees or more. When properly applied, one horizontal borehole can produce a reservoir better than several vertically drilled wells.

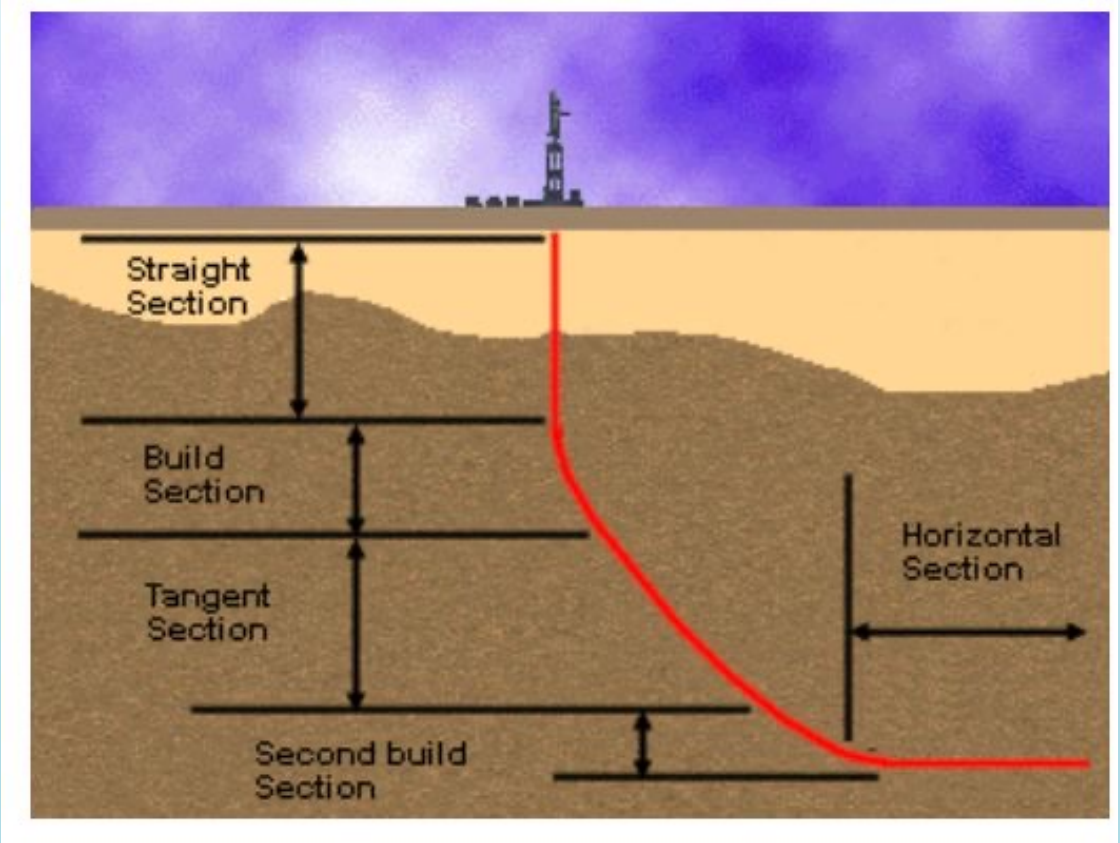

Figure 16 Horizontal wells

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells

Figure 17 shows the vertical plot or sectional view of the different sections of a horizontal well

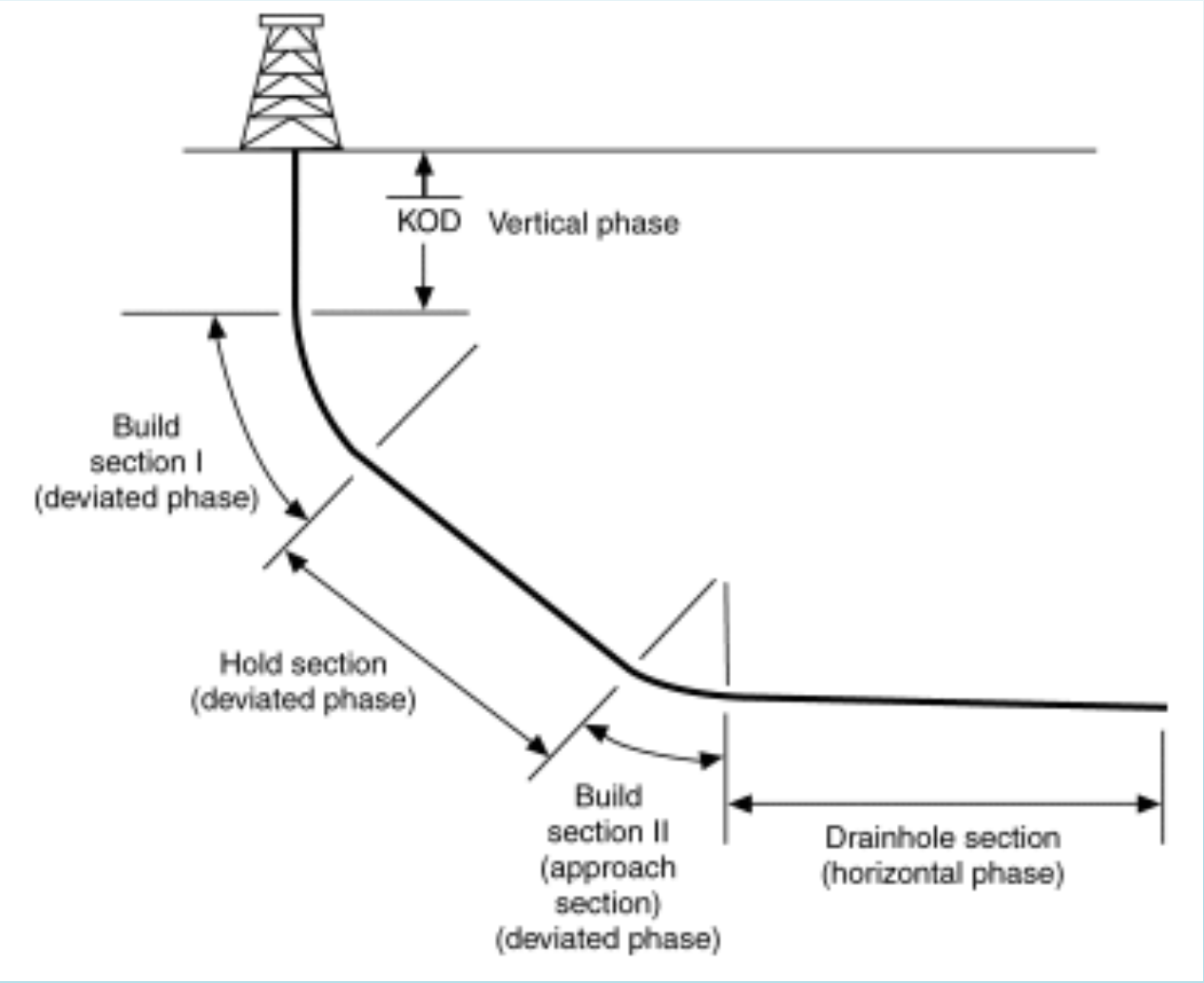

Figure 17 Different sections for horizontal wells

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells Cont.

Measured Depth (MD)

It's the depth measured along the actual well bore from the surface reference point to the survey point.

Measured depth, inclination & azimuth are the set of measured data from which other values can be calculated.

True Vertical Depth (TVD)

TVD is the vertical depth measured from the surface reference point to the survey point. This depth is always calculated from the deviation survey.

Kick-off Point (KOP)

KOP is the point in the well bore where change in inclination and orientation of well in a particular direction is initiated.

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells Cont.

Building Section

Building section ranges from KOP to the point, along measured depth of the well where maximum planned angle of the well is achieved.

End of Building Section (EOB)

End of Building Section (EOB) is the point along the measured depth of the well, where maximum planned angle is achieved, and it marks the completion of building section or start of Holding section.

Vertical Section (VS)/Departure

VS is the perpendicular distance (or shortest distance) between the survey point and the vertical axis from the rig's surface reference in a Vertical Plot/Section View.

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells Cont.

Build-up Rate (BUR) or Drop-off Rate

It's the rate at which change in inclination occurs and is calculated from one survey point to another survey point.

Build-up rates are shown in +ve.
Drop-off rates are shown in -ve.
They are measured in deg/100 ft or deg/30 m.

Turn Rate

It's the rate at which there's change in the direction of the well bore and is calculated from one survey point to another survey point.

Turn rates are shown in +ve if the azimuth turns to right from the previous reading and -ve if left.
They are measured in deg/100 ft or deg/30 m.

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells Cont.

Holding (or) Tangent Section

Holding section specifies to the portion of the well bore along the measured depth where, there is no change in inclination and/or azimuth. Generally it ranges from End of Build (EOB) to End of Hold (EOH) or Start of Drop (SOD).

Tangent (or Drift) Angle

It is the inclination of the holding section of the well. It is also referred as tangent section because it forms tangent to the arc formed by building or dropping section of the well.

Dropping Section

Dropping section refers to the portion of the well from where there is start in decrease of inclination to the final decreased inclination. Generally. it ranges from EOH or SOD to End of Drop (EOD).

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells Cont.

Dog Leg

Dog Legs are referred as the crooked place in the course of well bore where profile of the well changes rapidly. High dog legs are generally associated with unwanted problems in the hole.

In directional drilling, since the changes in the well bore profile are made intentionally there has to be ways of measuring these changes.

Dog Leg Severity (DLS)

DLS measures the changes in inclination and/or azimuth from one survey point to another survey point. It's measured in deg/100 ft or deg/30 m.

Common Terminologies used to Describe Horizontal Wells Cont.

Dogleg severity (DLS)

Dogleg severity refers to the measure of change of inclination and or direction of the borehole (Figure 10) expressed in degrees per 100 ft of course length (oil field units) or 30 m of course length (metric units). The knowledge of DLS can be used to estimate/predict; stress fatigue in drill pipe (DP), casing wear and casing design loads, and stuck pipe. The DLS can be classified basing on the path angle, Skalle, (2018) grouped DLS severity into light, medium and severe as seen in Table 3.

Table 3 Classification of DLS (Skalle, P. 2018)

DLS (deg/30 m)	Implication
Change in PA < 1	Light DLS
1 < Change in PA < 2	Medium DLS
Change in PA > 3	Severe DLS

Horizontal Drilling Cont.

Descriptions of different well types

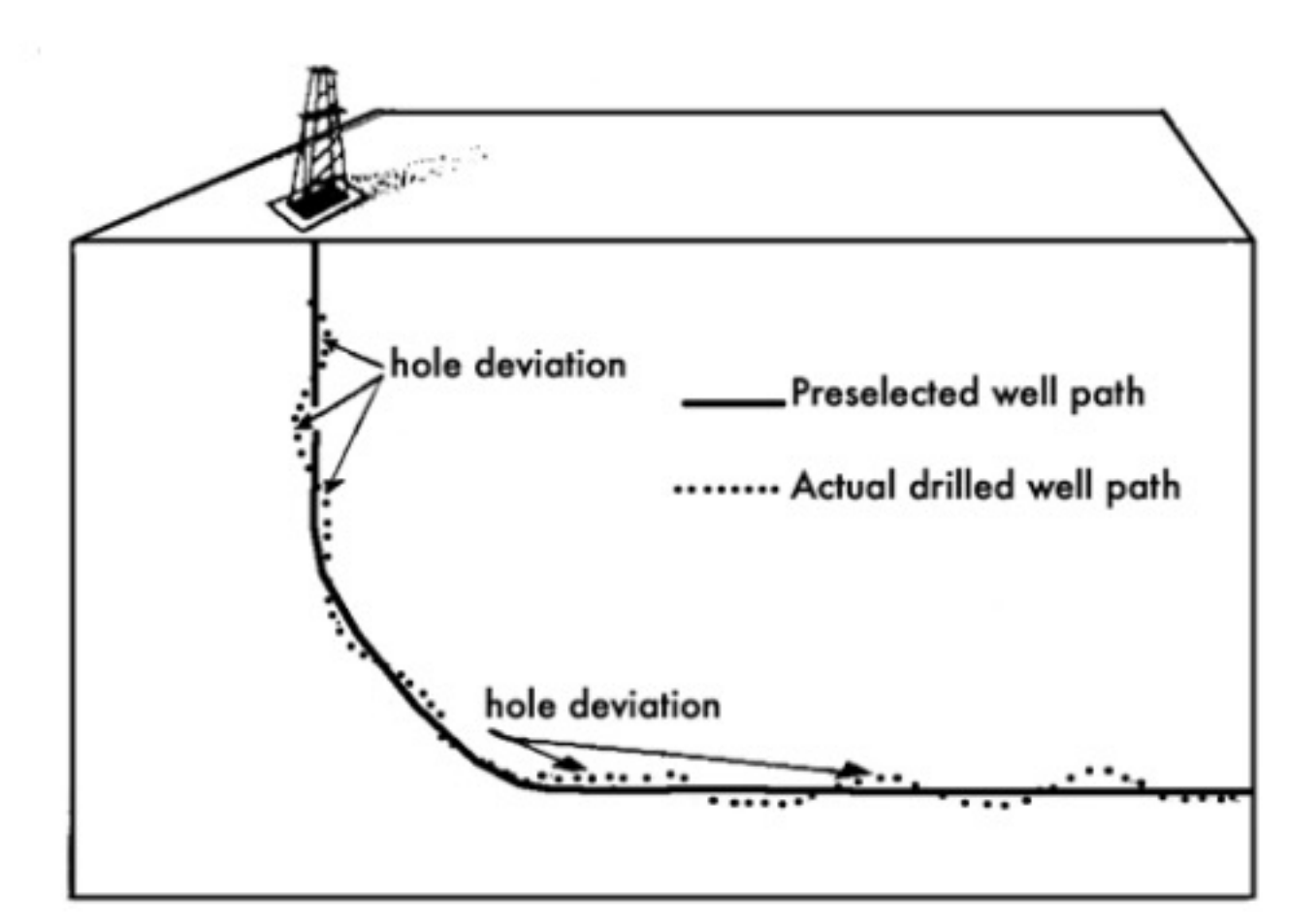

Figure 18 Wellbore deviation from planned trajectory (Mitchell, 2006)

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells

North/South (N/S) and East/West (E/W)

North is a +ve number that indicates the distance NORTH from the rig location, while a -ve number indicates a distance SOUTH.

East is a +ve number that indicates the distance EAST from the rig location, while a -ve number indicates a distance WEST.

N/S and E/W are the rectangular Co-ordinates and are represented on a Plan View or Horizontal Plot.

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells

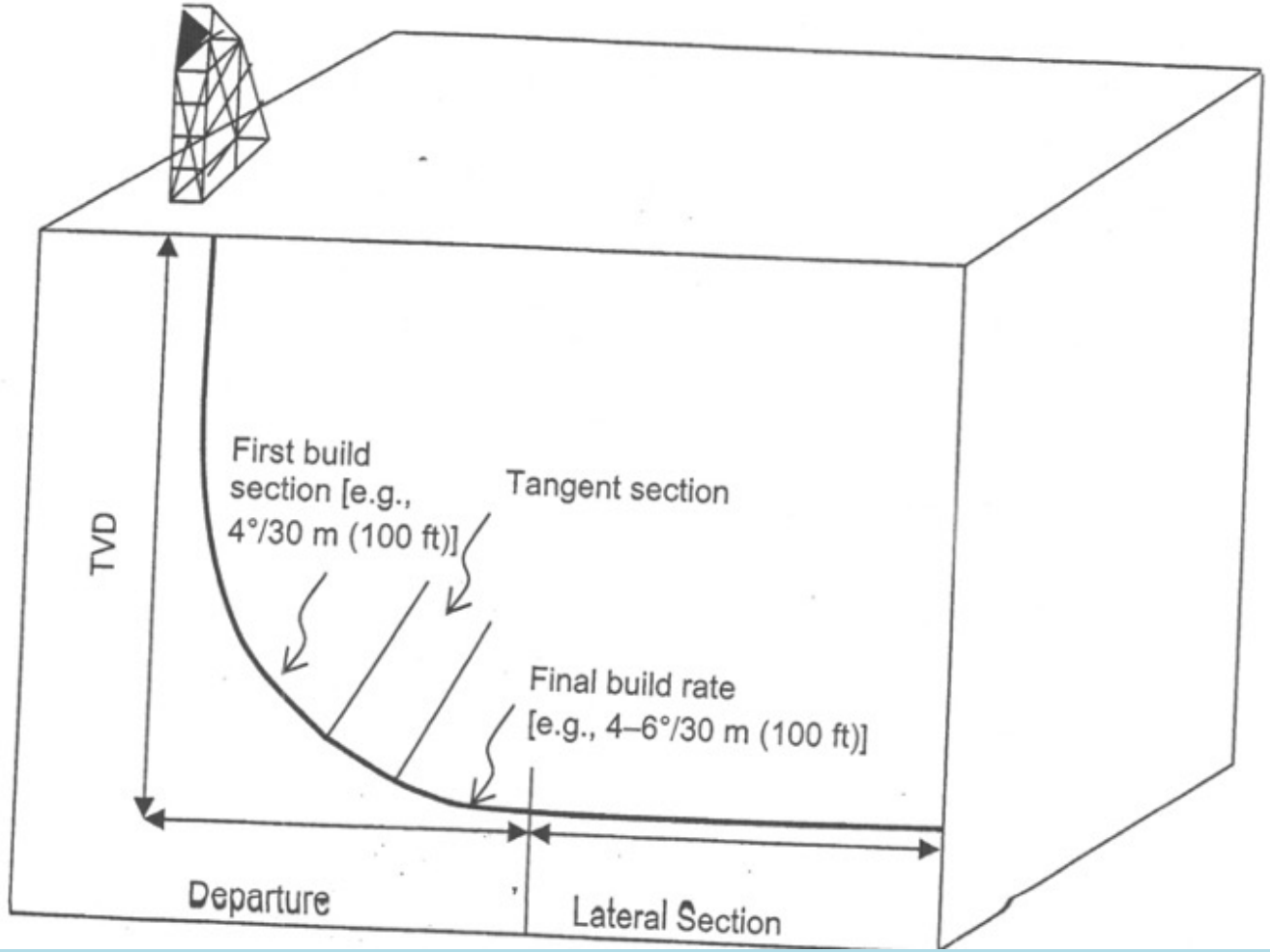

Figure 19 Horizontal well profile consisting of the two build sections

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells

N/S & E/W values will be respectively,

- +ve & +ve if well direction lies from 0° to 90°.
- -ve & +ve if well direction lies from 90° to 180°
- -ve & -ve if well direction lies from 180° to 270°
- +ve & -ve if well direction lies from 270° to 360/0°

Horizontal Drilling Cont.

Common Terminologies used to Describe Horizontal Wells

Closure Distance (CD) & Closure Direction/Azimuth (CA)

Closure Distance & Closure Direction is the distance and direction of a straight line drawn from the surface reference of rig location to a rectangular co-ordinates on a horizontal plane.

In general, VS/Departure/Drift will be approximately equal or near to the CD values.

Latitude & Longitude

They are the imaginary lines on the surface of the earth running from North-South (longitude) and East-West (Latitude). These are used to represent the Geographical Co-ordinates of the well.

Horizontal Drilling Cont.

Common Terms used to Describe Horizontal Wells

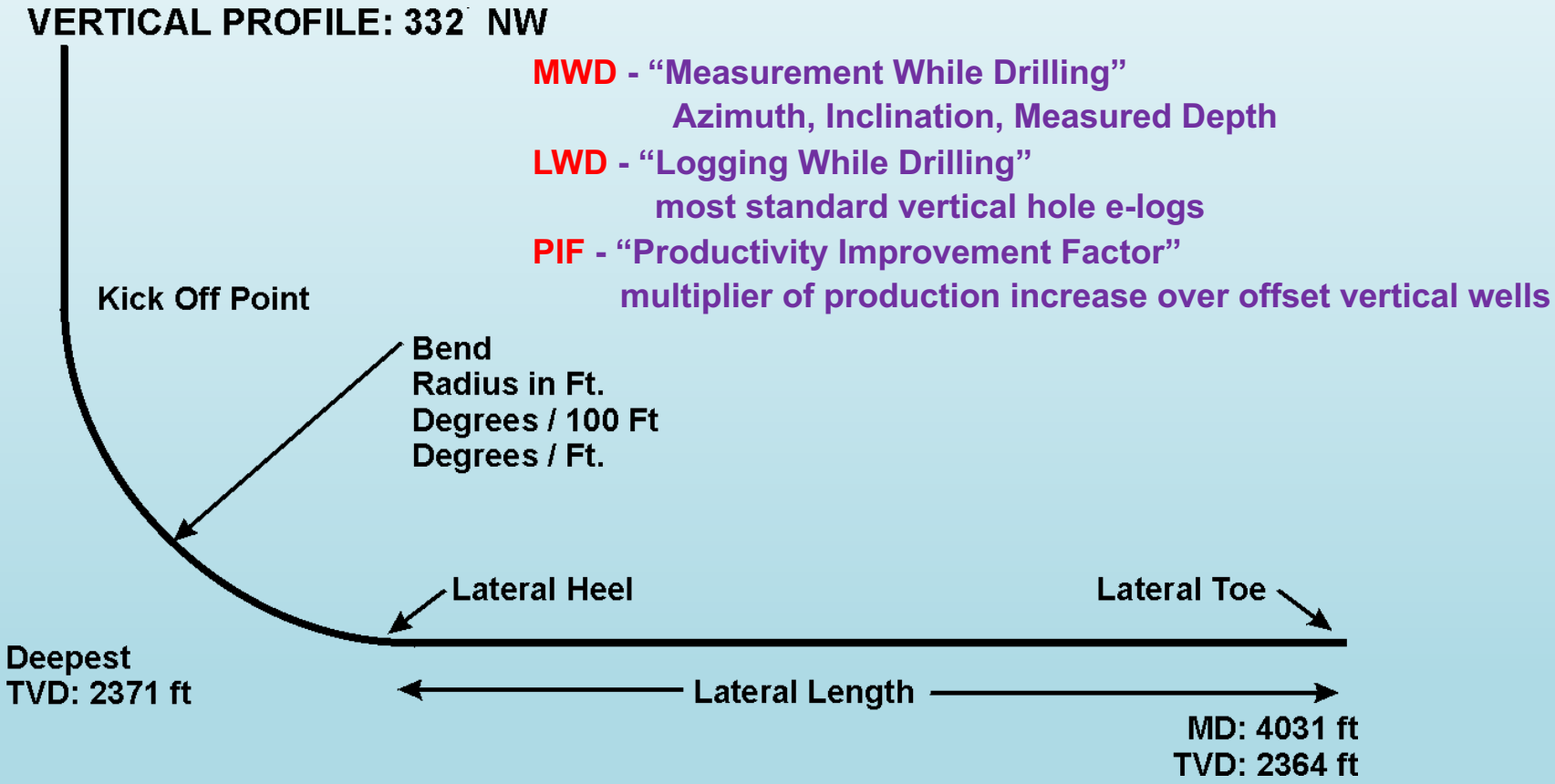

Figure 20 Common terms to horizontal well

Horizontal Drilling Cont.

Name of Different Parts of Horizontal Drilling

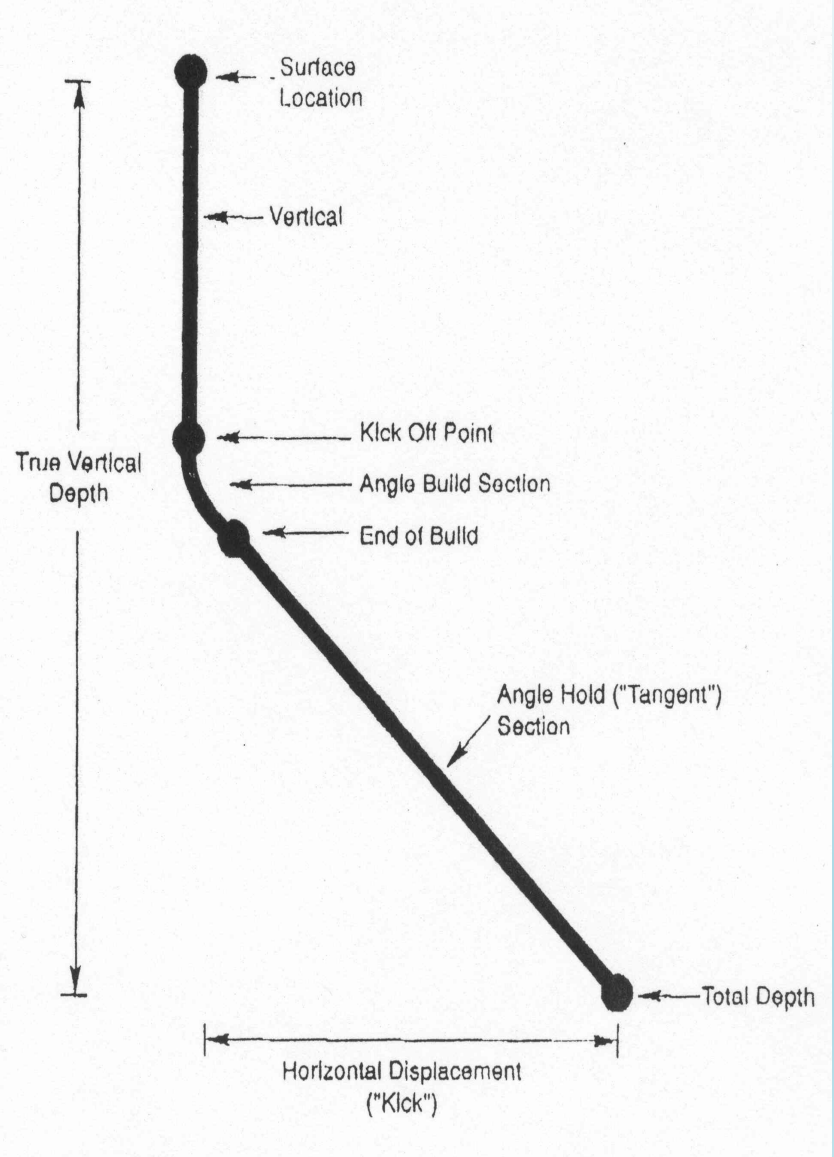

Figure 21 Terminology of a directionally drilled well (slant-hole)

Horizontal Drilling Cont.

Drillstring Configuration

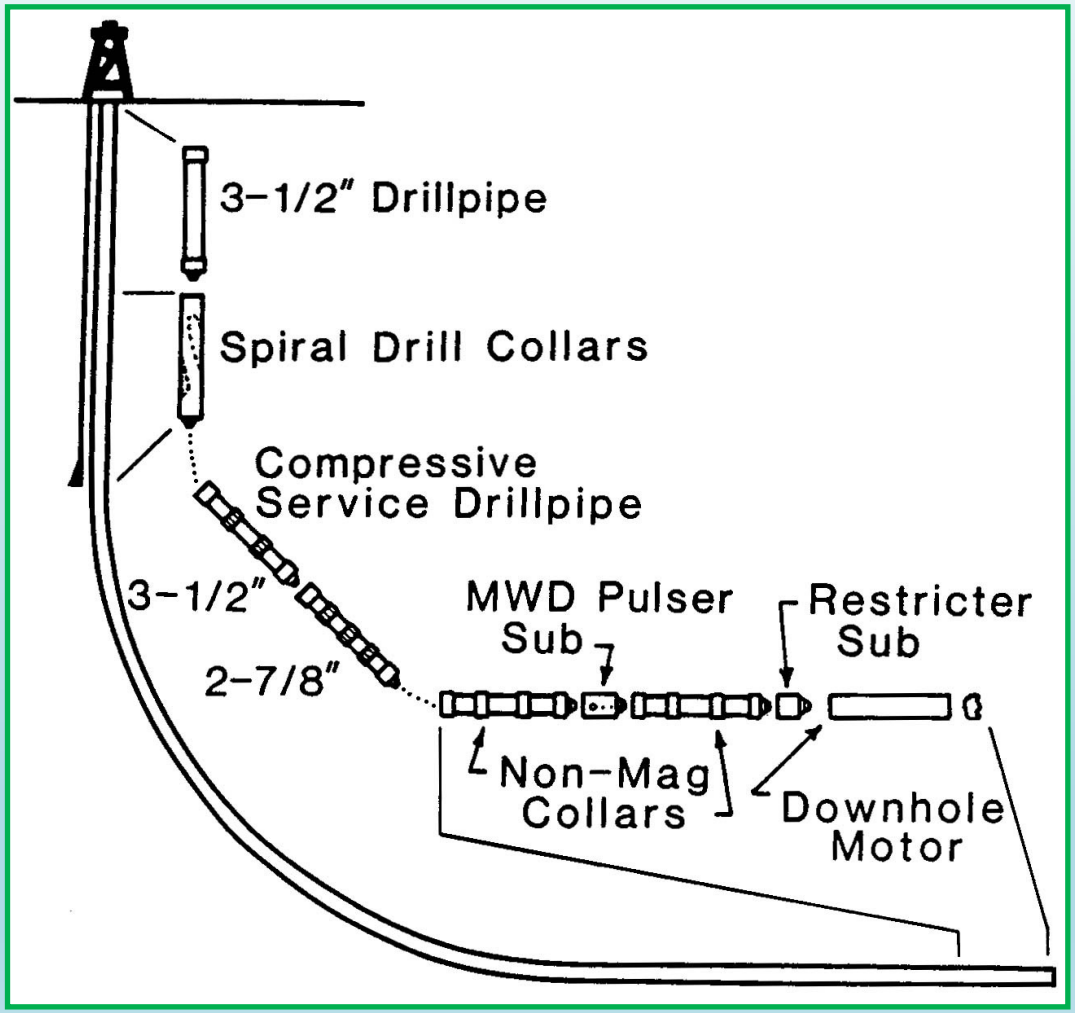

Figure 22 Terminology of a drillstring configuration

Horizontal Drilling Cont.

Whether drilling vertical or horizontal, making hole depends on:

- Dip of beds
- Hardness and rock composition
- Bit design
- Drilling parameters
- Faulting
- Fracturing

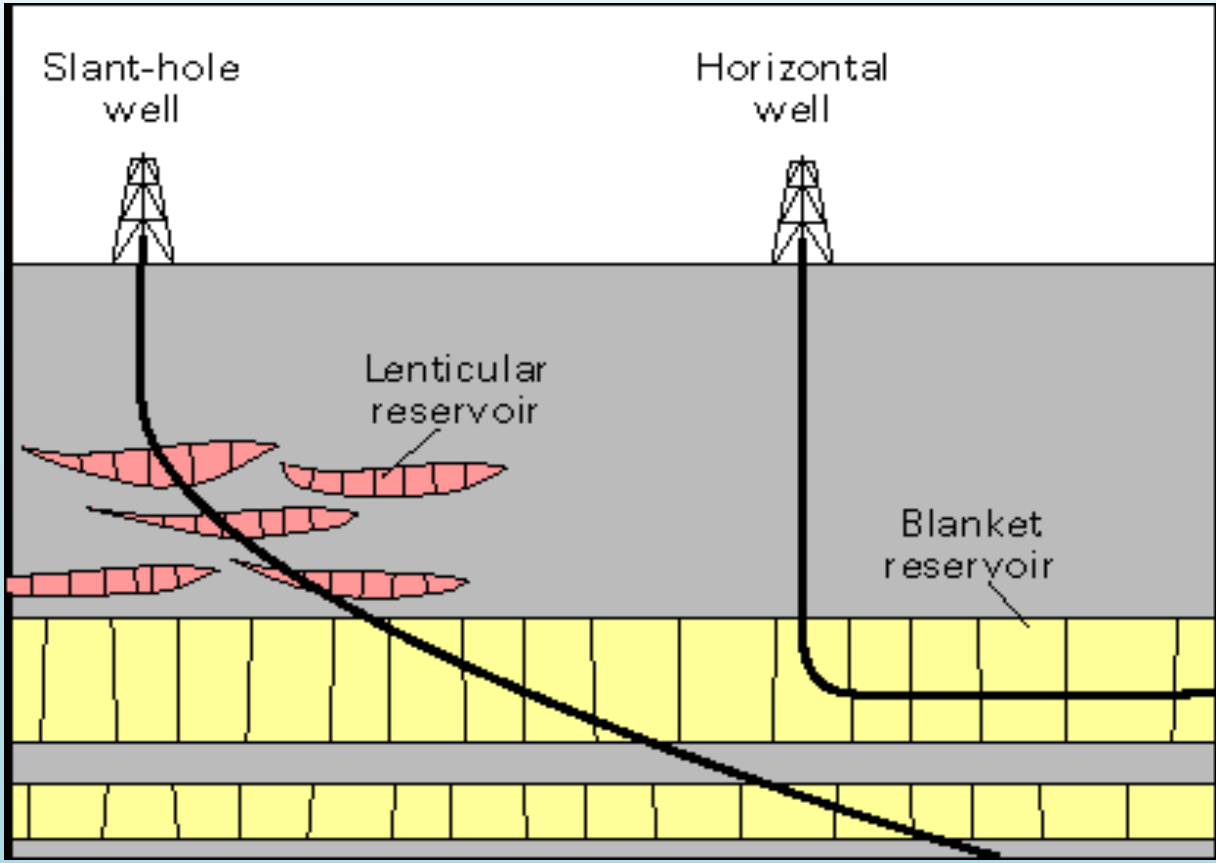

Figure 23 Typical examples of wells

Horizontal Drilling Cont.

Caveat Contemplor

Determining Success of a Horizontal Well Requires:

Assessing if Basic Criteria was Accomplished

- *Where* it is drilled….
  geology - structure & stratigraphy
- *Why* it is drilled….
  reservoir & drive mechanism
- *What* it is drilled for….
  reservoir management
- *How* it is drilled….
  well design, drilling, & completion

Operator Reporting Prevents Accurate Assessment

- *Inaccurate*
- *Incomplete*
- *Non-existent*

Horizontal Drilling Cont.

Horizontal Well Costs

The cost of drilling a horizontal well depends on many factors, contingencies, and circumstances; however, the drilling costs may be reconciled into three sections of the hole:

1. The vertical section.
2. The build (s) section.
3. The horizontal section.

In comparison with vertical holes, horizontal holes most likely will have added costs in the following areas. These costs may be 120% of vertical well costs.

1. Surface location and surface equipment
2. Casing and tubing.
3. Rig rental rate and tool rental.
4. BHA equipment rental (excluding directional tools and motors)
5. Mud and mud handling equipment.
6. Hole loss and fishing (or sidetracking).

Horizontal Drilling Cont.

Horizontal Well Costs Cont.

The cost of drilling a horizontal well is given by the following equation:

$$\text{Cost \$} = \text{Location} + \text{Casing} + \text{Mud} + \text{Tool Rental} + \text{Directional} + \text{Rig Rental} + \text{Drilling Time} + \text{Logging}$$

Table 3 shows a typical example of a horizontal drilling and compares the costs with vertical drilling well.

Horizontal Drilling Cont.

Horizontal Well Costs Cont.

Table 3 Comparative cost of wells

Event	Vertical	Horizontal
Surface, etc.	$80,000	$96,000
Drill to KOP	$326,000	$342,000
Drilled to tangent		$465,000
Drilled to lower build		$483,450
Drilled to horizontal		$495,750
Drilled to bottom of hole	$375, 364	$649, 500

Good Luck

and

Thanks for Being with my Couse

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