BHP’s Next Generation Work Station
Ready Well-Logs

Automate the process of identifying, splicing, scoring and quality assurance of high business-value well-log curves into a composite log curve set and then distribute the data to interpretation applications.

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BHP’s Next Generation Work Station Ready
Well-Logs
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Wouldn’t It Be Nice If…

Field real-time data were available daily in the interpretation applications.

“Why do I have to search for well-log data from well, which BHP is drilling? Why can’t it just show up in my interpretation project, and be permanently saved in the BHP Borehole Data Management System?”

You never had to guess which porosity curve was the best one to use.

“There are 6 porosity curves – I have no idea which one is the right one to use; PHIT_edit, PHIT_merge, PHIS, PHID, PHIND, PHIE, PHIE_SS or PHIT_elan, PHIT_JANE_may_1_99”

We could all see each other’s “ready for consumption data”.

“The geologist is on vacation – I know he has finished picking tops, but they are in OpenWorks and I don’t use that software.”
BHP’s Borehole Data Management System

- Data Governance
- Well log Interpretation Software
- Performance Management
- Data Loading/Data Loaders
- Data Parsing/Drop Site
- Change Management
- GIS
- Integration Software
- Open Works
- Download data

BHP’s Next Generation Work Station Ready Well-Logs
Foundational Things – The BHDM

Work Station Ready Requisites for Building WSR Curves

- Central Store: (The BHDM) where all well-logs are stored
- Validate Header with Global Well Master
- Tag High Business Value Curves
- Assign to each curve a Main Family/Family value
- Assign to each log, legacy values, e.g., Source, Maturity, Log Type, & Tool Type
Work Station Ready (WSR) Gen I

**Laying the Groundwork**
- Observe the manual process
- Collaborate with business to establish selection rules
- Tweak extant QC Rules
- Inspect
- Repeat as necessary until an 80%-90% match is achieved
### WSR Gen II – Business Refinement

**Tweaking the WSR Quality**

- Assign Curve Priority – Do Not Fly List
- Select by Tool & Processing Level Value
- Establish Curve Min/Max Values
- Adjust depth index selection- for TVD’

<table>
<thead>
<tr>
<th>Priority</th>
<th>Tool Technology</th>
<th>Processing Level</th>
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<tbody>
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<td>3</td>
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<td>All others (daily)</td>
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<td>4</td>
<td>LWD or MWD</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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**WSR Curve Standards**

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<thead>
<tr>
<th>FAMILY</th>
<th>CURVE UNITS</th>
<th>Min Limit</th>
<th>Max Limit</th>
<th>Log Activity 1</th>
<th>Log Activity 2</th>
<th>Log Typ 1</th>
<th>Log Typ 2</th>
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**BHP’s Next Generation Work Station Ready**

**Well-logs**

8
WSR The Next Generation – Getting It Right

Expansion Into The Conventional World

- Priority filtering was a good idea, but it removed otherwise good from the selection process
- The process produced WSR curves with incorrect values, e.g., DEN_WSR/OHMM
- Standardized Depth Increment
- Add a Tie Breaker
- Improve WSR job process reporting

<table>
<thead>
<tr>
<th>WORKSTATION</th>
<th>WORKSTATION</th>
<th>WORKSTATION</th>
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<tr>
<td>0</td>
<td>GR_WSR (GAP)</td>
<td>150</td>
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<tr>
<td>0.45_ _ _</td>
<td>NEU_WSR (FRAC)</td>
<td>_ _ _ _ _ _</td>
</tr>
<tr>
<td>0.2</td>
<td>RESD_WSR (OHMM)</td>
<td>2000 _ _</td>
</tr>
</tbody>
</table>

The GR_WSR & RESD_WSR curves have null values at every other sample
WSR Process Step 1: Load Well-Log Files To The BHDM

1. Load the Well-logs for a well
2. Select all curves based on WSR Family
3. Curve Filtering
4. Final curve selection
5. Splice and Resample
6. Create WSR Curves for a Well
7. WSR Reports
8. Auto Deliver to Interpretation applications

Stage the Datasets for bulk loading
Load data to RECALL
Classify the data based on BHP Standards for Borehole data.
Family/Main Assignment

Auto Data Consolidation

Given a input of well name and UWI the solution will Consolidate Digital for Wireline, LWD from multiple data sources into a staging area and populate the Dropsite template.

DROP SITE

Auto Log Classification Assign Raven Score

• Classify the data based on the Technology or Application of data.
• Assign Meta Data and Bulk Data Raven scores

Auto Main Family/Family Assignment

• Assigns Main Family and Family to every curve based on definition
• If the definition does not exist it updates as UNKNOWN_NEW for business review and update the dictionary

RECALL

Initiate WSR Generation

BHP's Next Generation Work Station Ready Well-Logs
The WSR Process selects curves from these Families

BHP has approximately 100 Main Family name and approximately 1000 Family names within its catalogue

Solution is configurable to add or delete families to the preferred list and generate new WSR curves
WSR Process Step 3: Curve Filtering

Obtain the Best, Raw, High-Value Curves

- The WSR process has 3 main rounds of filtering
- Excludes the computed/processed/interpreted (CPI) data, low quality data, TVD data, and low business value curves
- Best curves are clipped if their values are above or below defined thresholds
The WSR process looks for longest curve with the shallowest top depth with a passing Raven Score.

If multiple curves meet the same depth criteria. A tie breaker is used.

The tie breaker selects the curve with the best bulk data score, then uses a RAVEN Curve Activity score.
WSR Process Step 5: Recall Splice and Resample

1. Load the Well-logs for a well
2. Select all curves based on WSR Family
3. Curve Filtering
4. Final curve selection
5. Splice and Resample
6. Create WSR Curves for a Well
7. WSR Reports
8. Auto Deliver to Interpretation applications

Auto-Stitch Curve Splicing Logic

Third Round
"AutoStitch"
All Curves in Well

"FAMILY CURVE+1" HAS DEEPEST BOTTOM-DEPTH
"FAMILY CURVE" HAS SHALLOWEST TOP DEPTH

Family Curve +1 Spliced to Bottom of Curve Family Curve
Set Sample Rate = 0.50 Feet 0.1524 Meters

Rename Family Curve = _WSR

Does Family Curve +1 Exist?

Given the following raw input curves, the splicing process will select Curve A and Curve B to create the final WSR Curve. The process will use all of Curve A and that part of Curve B, which is deeper than the last curve value of Curve A.

Discard From Curve B
Splice to Curve A
WSR Process Step 6: Recall Splice and Resample

1. Load the Well-logs for a well
2. Select all curves based on WSR Family
3. Curve Filtering
4. Final curve selection
5. Splice and Resample
6. Create WSR Curves for a Well
7. WSR Reports
8. Auto Deliver to Interpretation applications

- Standard set of WSR curves are generated with a sample rate of 0.5 FT or 0.1524 Meters
- Interpolation occurs when the gap is less than 40FT
- Unit conversion will be done, if the raw curve units are different from WSR curve units
- The process assigns a Raven quality score to each WSR curve. This helps the users assess the overall quality of the dataset

WSR Mnemonics and Curve Units

<table>
<thead>
<tr>
<th>BHP WSR Family List</th>
<th>Standard Curve Name</th>
<th>Standard Curve Unit</th>
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<tbody>
<tr>
<td>CALIPER</td>
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<td>BULK DENSITY</td>
<td>DEN_WSR</td>
<td>G/CC</td>
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<td>DRHO_WSR</td>
<td>G/CC</td>
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<td>US/F</td>
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<td>DTS_WSR</td>
<td>US/F</td>
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<td>GR_WSR</td>
<td>GAPI</td>
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<td>SP_WSR</td>
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<td>F/HR</td>
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BHP’s Next Generation Work Station Ready
Well-Logs
Assessing the WSR Data

- Process captures useful data to provide insights into how the WSR was generated
- Users review, if the WSR data are poor or are missing coverage
- Report provides source curves used in WSR generation

<table>
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<tr>
<th>Report category</th>
<th>Report Details</th>
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<tbody>
<tr>
<td>Family Assignment</td>
<td>Family details of the curve</td>
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<td>Log Classification</td>
<td>To type of log does the curve belong</td>
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<td>Log Depth Increment</td>
<td>Sampling rate</td>
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<td>Log Depth Range</td>
<td>Borehole coverage of the log</td>
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<tr>
<td>Curve Data Quality</td>
<td>Captures the curve quality results</td>
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<td>Curve Depth Range</td>
<td>Borehole coverage of the curve</td>
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<td>Curve Stats</td>
<td>Curve related statistics like Min, Max and Mean</td>
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<td>Curve metadata like Curve Name, Curve Units, Curve Description</td>
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<tr>
<td>File Header details</td>
<td>File details like file name, file type etc</td>
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<tr>
<td>Well header details</td>
<td>To which well does the curve belong</td>
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<tr>
<td>Recall Hierarchy</td>
<td>where is the curve stored in Recall</td>
</tr>
<tr>
<td>WSR Curve key</td>
<td>Shows the user which curves were used to generate the WSR curve</td>
</tr>
</tbody>
</table>
WSR Process Step 8: Delivery to Interpretation Applications

1. Load the Well-logs for a well
2. Select all curves based on WSR Family
3. Curve Filtering
4. Final curve selection
5. Splice and Resample
6. Create WSR Curves for a Well
7. WSR Reports
8. Auto Deliver to Interpretation applications

**Delivery Automation**

- Automatically transfer the WSR to G&G applications
- Populates the details of raw curves and source file name into the comments section
- If user edits the WSR curves in G&G applications then it will sync it back to Recall
Fit-For-Purpose Data Within Minutes

**Results**

- Equivalent Manually-Created WSR Set Requires About 4 Hours
- An 80-90% Solution
- Tend to have better depth range
- Standard, recognizable mnemonics
- Automatically Delivered to Interpretation Applications
- Used only for
  - Tops
  - Well Correlations
  - Basin Quick Looks, etc.

WSR-BHP Overlay
Value Delivered

• Reduced cycle time
  • Loading
  • Compositing
  • Allow technical staff to work on more productive tasks

• Build Data Confidence
  • Improved quality of well-log curves used in the interpretation application
  • Improved available quantity of well-log curve for use
  • Reduce decision risk with complete data
  • Make better decisions with better quality data
WSR Benefits

**Bulk Load Project Data**
- 71,865 well-log files
- 3,756 wells
- 2,782,133 curve arrays.
- BHDM distilled these raw curves into 23,193 WSR curves, and moved them into the proper interpretation projects

**Survey Results**
- Fills the gaps between BHP petrophysical curves
- They are quality curves I can use for well picks
- Easy to identify
- Good first pass proxy to propose the generation of BHP curves
Future Work

**Improve Process Transparency to the Business**
- WSR Process Reporting - Dashboards and Analytics
- Educating the Business about Load Practices

**Artificial Intelligence opportunities**
- Update Main Family/ Family Catalog
- Update Log/Curve Data Dictionaries
- Automated top picking
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Your feedback is very important to us. Please open the LIFE2019 app to answer a few short questions on this presentation.