Advancing Geothermal Well diagnostics with the Utilization of Hybrid Camera Technology

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ABSTRACT

Acquiring reliable data from geothermal wells presents significant challenges due to their extreme environments, where temperatures can exceed 600°F. To accommodate the operational limits of inspection tools, quenching operations are performed to cool the well. However, inspections above the fluid level remain difficult, as the quenching line is shut off, leaving a narrow window for camera inspections before pressure buildup creates risks for the camera equipment inside the wellbore.

This paper presents the operational challenges that the new Optis Infinity Hybrid Camera faced during its successful utilization in the field. The primary objective of well A, its first deployment, was to evaluate a possible metallic obstruction at a depth of approximately 1093 feet CHF. However, the live feedback to the surface was unable to provide a distinct quality of the suspected obstruction because of the well's initially unknown fluid inflow. However, during its post-processing examination, the recording on its high-definition on-board camera offered an incredibly clear recording of the mentioned obstruction. The video from the tool's 360-degree camera capability was also highlighted since it captured the fluid inflow, which affected the survey's primary objective.

Its second operation, Well B, aims to assess the casing integrity of the wellbore and identify another potential problem in the 1930 ft CHF. The turbidity of the water during the manipulation and interaction of the water supply and fluid particles in the well provided the execution team with yet another operational challenge. The preliminary assessment of a suspected obstruction was found to be a parted casing with a significant gap between the two.

These findings provide essential data for assessing the well integrity and help PGPC on planning effective interventions. This innovation provided critical insights into the obstruction characteristics and the origin of the inflows, enabling more informed decision-making for remediation and workover planning. The ability to achieve superior imaging under adverse conditions underscores the immense value of advanced camera technology in addressing complex well integrity issues.

Keywords: Downhole video, DHV, camera, casing integrity, well intervention, geothermal well, PGPC, EV

1. INTRODUCTION

Contemporary geothermal industry practices rely on a range of wireline surveillance techniques to characterize and evaluate various wellbore parameters. These methods commonly include pressure-temperature-spinner (PTS) logging, scale probing, downhole fluid sampling, and other diagnostic tools. Each technique contributes critical information that aids resource management engineers in formulating strategies to maintain or enhance wellbore performance. However, these methods also have inherent limitations, and their effectiveness is often maximized when used in combination.

In this context, integrating downhole video camera technology into surveillance operations provides a valuable alternative approach. Unlike conventional tools that require multiple runs and may not provide immediate clarity, downhole cameras offer real-time visual inspection, enabling operators to observe and document actual wellbore conditions as they occur. This capability reduces the risk of misinterpretation and enhances operational efficiency by minimizing the number of tool deployments required.

Accurate visualization of subsurface environments is crucial for optimizing geothermal well performance, ensuring structural integrity, and informing maintenance strategies. Downhole video systems facilitate the identification of casing damage, mineral scaling, obstructions, and other anomalies that can compromise output and safety. As a result, downhole video inspection has emerged as a vital diagnostic tool that supports informed decision-making and contributes to the prolonged operational life of geothermal wells.

Optis Infinity Hybrid Camera

The Optis Infinity Hybrid system features four azimuthally distributed cameras and incorporates both real-time transmission and onboard memory recording capabilities. This configuration allows for simultaneous data acquisition from all camera arrays, delivering high-resolution live video to surface while preserving footage for post-run analysis. The system enables full circumferential visualization of the wellbore, thereby enhancing diagnostic accuracy, optimizing intervention planning, and reducing operational risk during downhole investigations.

Applications of Optis Infinity Hybrid Camera for Geothermal Wells:

1. Casing and Completion Integrity Assessment - Enables the detection of corrosion, erosion, and structural damage to tubulars and completions under high-temperature geothermal conditions.
2. Scale and Debris Characterization - Facilitates the identification and spatial mapping of mineral scale buildup and foreign material that may impair fluid flow or reduce injectivity performance.
3. Leak Path Identification - Assists in root cause evaluation and validation of corrective measures, such as assessing the effectiveness of casing patch installations.
4. Fishing Operations Support - Provides visual and dimensional data to aid in the retrieval of downhole obstructions and optimize bottom hole assembly (BHA) design using digital measurement tools to define the top-of-fish profile.

Table 1: Comparison between Basis R125 and Optis Infinity H125

	Basis R125	Optis Infinity H125
Deployment	Real-time only	Real-time and/or Memory
Camera Types	Monochrome single side view and down view	4x colored side view and 1x colored down view
Frame Rate	4 fps	25 fps
Visual Analytics Capability	No	Yes
Field of View	360° with rotating sideview	360° circumferential coverage
Resolution	520 x 288	2880x Infinity side view; 1280 x 960 down view

As geothermal well environments become increasingly complex, the Optis Infinity Hybrid system provides a comprehensive solution to evolving wellbore diagnostic challenges. Its enhanced data acquisition capabilities reduce reliance on assumptions during well intervention planning, thereby minimizing operational risks and supporting more accurate decision-making. Additionally, the system contributes to operational efficiency by significantly reducing inspection time. This, in turn, decreases the need for extensive quenching procedures and associated support services, which ultimately lowers overall operational costs. The upgraded frame rate of the Optis Infinity Hybrid also improves image capture in wells experiencing fluid injection, allowing for clearer visualization of obstructions and downhole features under dynamic flow conditions. This makes the tool particularly valuable in environments where traditional imaging systems may fall short due to motion blur or fluid disturbance.

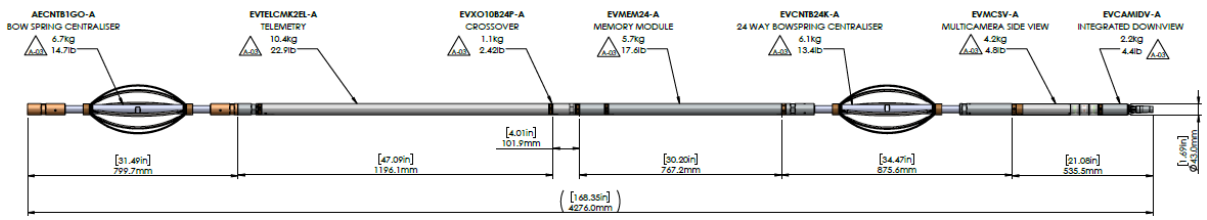

Figure 2: Diagram of the tool string during the campaign (EV, 2019).

The Optis Infinity H125 system features a down view camera and four azimuthally aligned sideview cameras, each equipped with advanced illumination—ideal for inspecting large-diameter wellbores such as those found in geothermal applications. It includes an onboard memory module capable of capturing 8 to 12 hours of high-resolution, high-frame-rate video. A dedicated telemetry section enables real-time video transmission to the surface.

The Optis Infinity Hybrid camera system incorporates advanced functionalities that significantly enhance downhole visual diagnostics. Its hybrid mode enables concurrent real-time video streaming and onboard recording from multiple camera perspectives, ensuring comprehensive data acquisition during operations. The system is also compatible with Visual Analytics™, allowing for quantitative image analysis and statistical reporting to support more informed decision-making. Additionally, the integration of mosaicing technology facilitates the creation of continuous, stitched visual maps of the wellbore, improving spatial interpretation and condition assessment. Furthermore, the device is engineered for seamless integration with supplementary logging tools, enabling a more holistic evaluation of wellbore environments.

2. TWO-WELL PILOT TESTING CAMPAIGN

Survey Preparation and Setup

As part of the Philippine Geothermal Production Company's yearly routine surveillance activity, downhole video surveys are conducted to continuously collect data for updating and supporting the constantly shifting geothermal reservoirs it manages. The PGPC Resource Management Team submitted two candidate wells for this campaign that have been restricted in the casing for a considerable amount of time. Over the years, the team have tried various kinds of surveys, but they have been unable to go to the maximum clear depth of the wells based on their completion reports. Additionally, according to the geochemists' analysis and the reservoir engineers' simulations, the prospect wells should not be generating scales at the blocked depth. Furthermore, since the identified abnormality is relatively shallow, continuous flowing of the well may cause a safety concern and may necessitate a safety workover.

Aside from the usual wireline equipment needed for the operations and given the current temperature limitations, PGPC has decided to install two different kinds of water pumps that can be utilized in the well based on the running-in-hole circumstances. High pressure, low volume water can be supplied by one pump, while low-pressure, high-volume water can be supplied by the other. Water tanks and a waterline supply with a maximum capacity of 15 barrels per minute were also sourced by the team. This water supply preparation aims to give a clear water column to the wellbore and quench the well below the downhole camera's maximum limitations.

Well A – High MW Production Well

Well A, a production well completed on April 1994, was drilled to a total depth of 5,835 ftKBE. During a routine surveillance activity, it was discovered that the well depth had significantly shallowed, which has made it difficult for the team to properly characterize the well. Despite this, the well has maintained relatively high production levels, making it challenging to perform any intervention work.

Table 3: Historical Maximum Clear Depth of Well A

Date of Scale Probe/Sinker Bar	Maximum Clear Depth, ftKBE
1999	5,752 (4”)
2000	3,750 (5”)
2013	1,103 (2.5”)
2014	1,103 (2.5”)
2017	1,090 (2.5”)
2019	1,090 (2.5”)

The well was selected as a primary candidate for downhole video survey after all previous wireline surveys failed to reach beyond the casing and were unable to identify the nature of the obstruction encountered. Additionally, geochemists have noted the potential for acidic production, which may further contribute to casing degradation.

Well A – Idle Production Well

Well B, a production well completed in December 1980 with a total depth of 3,497 ftKBE, has also been identified as a candidate for DHV survey due to casing obstruction that prevents successful wireline surveys. Like Well A, it has no known history of scaling, and previous survey attempts were unable to determine the nature of the blockage.

Table 4: Historical Maximum Clear Depth of Well B

Date of Scale Probe/Sinker Bar	Maximum Clear Depth, ftKBE
1992	2,888 (2.5”)
1995	2,888 (2.5”)
2004	1,931 (2.5”)
2014	1,940 (2.5”)
2021	1,930 (2.5”)

3. RESULTS AND DISCUSSIONS

The images below are sourced from PGPC’s downhole video survey operations conducted in 2022, which employed the Optis Basis R125 camera system. This previous-generation tool was limited to black-and-white, low frame rate imaging. Both down-view and side-view modes were utilized to evaluate wellbore conditions. In comparison with more advanced imaging technologies, the visual outputs from this earlier system reflect its limitations in resolution and clarity, often hindering accurate identification and characterization of downhole obstructions.

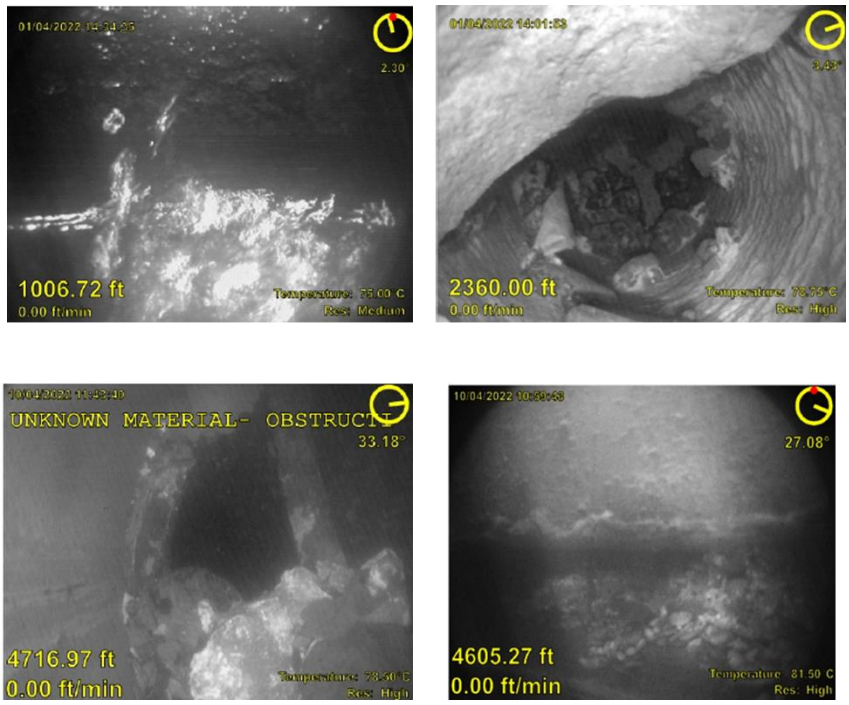

Figure 5: Snapshots from Basis R125 Black and White Camera (EV, 2022).

Well A – Metallic obstruction, pitting, and fluid inflow

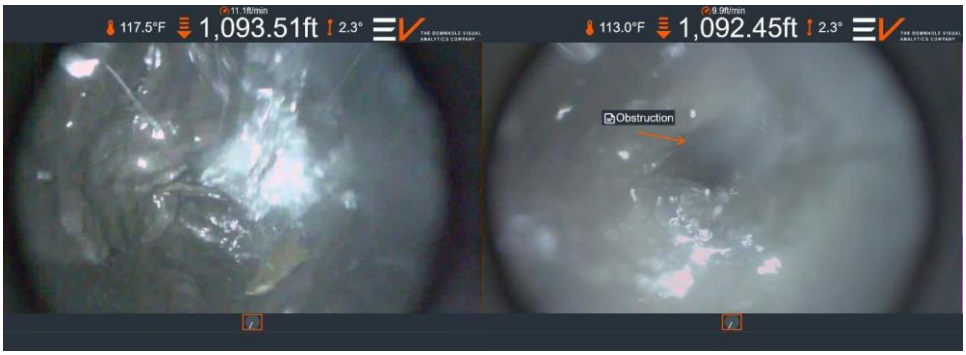

Figure 6: Down view of the metallic obstruction, at 1,092 .45 ft. (EV, 2025)

The metallic obstruction identified in the captured images was recorded through the camera's onboard memory, as real-time visual monitoring was hindered by an unanticipated fluid inflow within the wellbore. This inflow occurred despite the complete shutdown of surface pumps and the full isolation of external water sources. To prevent potential damage to the downhole video tool, the operators elected not to proceed further toward the obstruction. Although limited glimpses of the anomaly were observed via live feed, the persistent fluid ingress compromised image clarity and hindered positive identification. As a result, the team decided to pull out of the hole, conduct a detailed assessment of the fluid inflow, and analyze the memory recording to address the initial objectives of the downhole video survey.



Figure 7: Down view of the metallic obstruction, at 1,092 .45 ft. (EV, 2025)

The image above reveals casing pitting in the section approaching metallic obstruction. Although this observation was not part of the initial survey objectives, it provides valuable supplementary data for PGPC's resource management team. A review of the most recent Casing Inspection Caliper (CIC) data for the well showed no prior indication of such pitting. Therefore, the identification of this feature during the downhole video survey significantly enhances the team's understanding of the well's current condition and contributes meaningfully to its ongoing integrity evaluation.

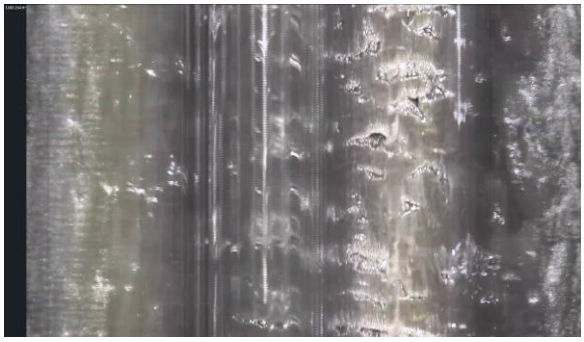

Figure 8: Stitched side view image of pittings found at 1,081 ft. (EV, 2025)

An important advancement of the tool lies in its ability to generate a composite image by stitching together outputs from the 360-degree cameras, allowing for holistic analysis rather than segmented review. This feature provides the resource management team with a comprehensive visual representation of the casing section affected by the observed pitting.

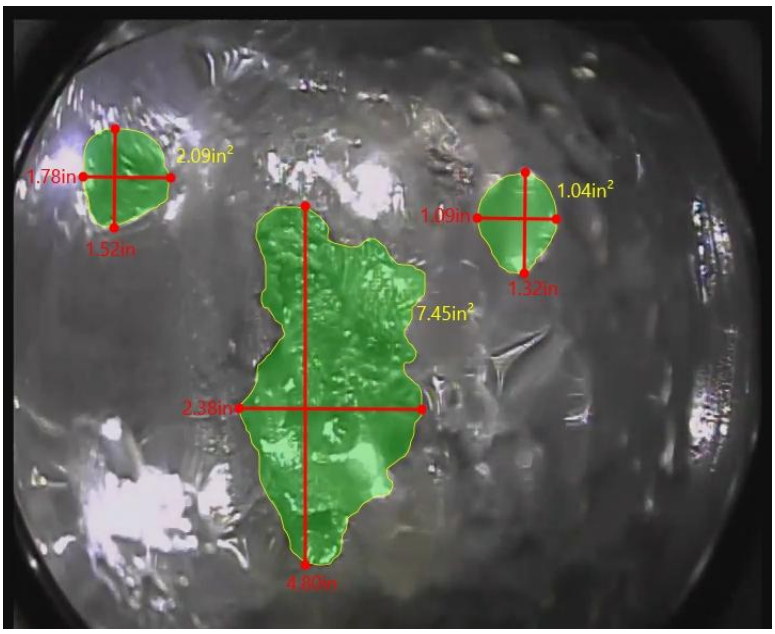

Figure 9: Analyzed side view image of pittings found at 1,081 ft. (EV, 2025)

The ability to measure the size of the pitting has been recognized as highly valuable by PGPC's resource management team. This advanced technology and method of identification enabled a more thorough analysis of the potential factors contributing to the issue within the well. Based on the captured images, the pitting on the left is estimated to be 1.52 inches in length and 1.78 inches in width, with a total area of 2.09 square inches. The center pitting measures approximately 2.3 inches by 4.8 inches, with an area of 7.45 square inches. Lastly, the one on the right is estimated at 1.32 inches by 1.09 inches, totaling 1.04 square inches in area.



Figure 10: Side view and stitched images of fluid inflow found at 891.5 ft. (EV, 2025)

The images presented above illustrate fluid inflow that hinders the effective visualization and characterization of the survey's primary objective, which is metallic obstruction. This inflow is observed despite the well pumps being shut down and the valves fully isolated. Given that the inflow originates at a depth of less than 1,000 feet, the location is considered critical and warrants further review and potential consideration for workover operations.

Well B – Parted Casing

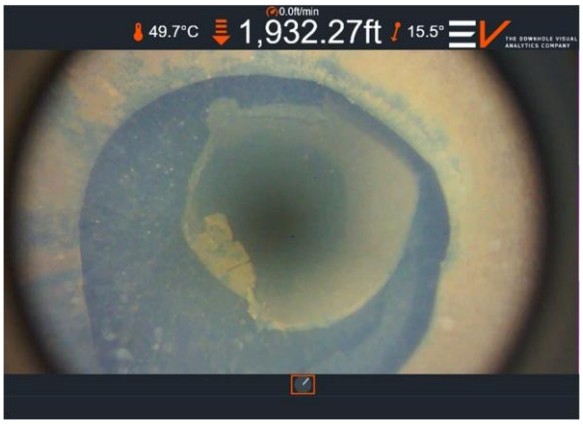

Figure 8: Down view image of parted casing at 1,932.27 ft. (EV, 2025)

The main objective of surveying this candidate well is to investigate a metallic obstruction that has impeded the deployment of wireline tools necessary for obtaining reservoir data beyond the production liner. The image indicates a complete separation of the casing, resulting in a distinct gap. It is suspected that an inward-folded metallic segment is responsible for the blockage, thereby preventing access to the lower part of the well. This scenario, comparable to a previously reviewed case, necessitates further assessment and may potentially require a workover intervention.

Additionally, the operations team faced challenges in capturing clear wellbore images due to disturbed deposits within the well, which significantly obscured the real-time camera feed.

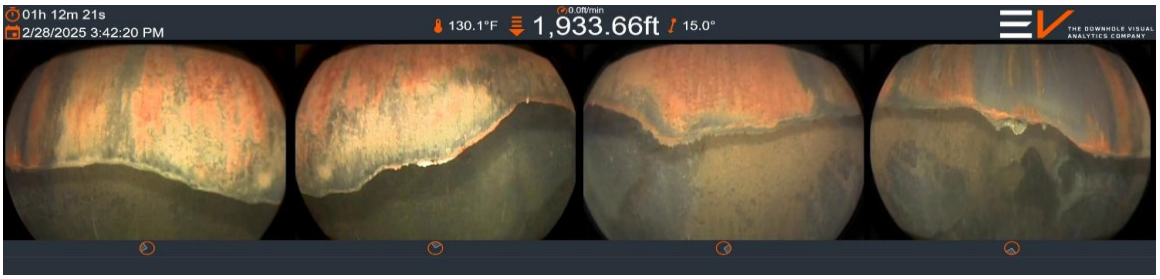

Figure 9: Side view image of parted casing at 1,932.27 ft. (EV, 2025)

The team advanced the tool just far enough into the parted casing to allow the 360-degree camera to capture clear images of the cut and the entire separated section. The images revealed a clean break between the two casing segments. Additionally, the team noted that the separation did not occur at a casing joint, as there were no typical signs indicating a break between joint connections.



Figure 10: Stitched side view image of parted casing at 1,932.27 ft. (EV, 2025)

As with Well A, the team also requested a stitched image showing the clean cut of the parted casing. However, due to the gap between the casings and the limited clearance within the well, the camera was unable to capture both casing sections in a single frame. Nonetheless, the image above clearly displays the clean separation and the cement behind it. Fortunately, no signs of formation breach into the well were observed.



Figure 11: Measurement of the parted casing at 1,932.27 ft. (EV, 2025)

Fortunately, one of the side-view cameras was able to capture the closest measurable distance between the separated casing sections. As illustrated in the image, the left measurement indicates a gap of 6.7 inches, while the right shows 7.2 inches. This represents the nearest spacing observed between the parted casing, as the camera was unable to simultaneously capture the other sections in a single frame.

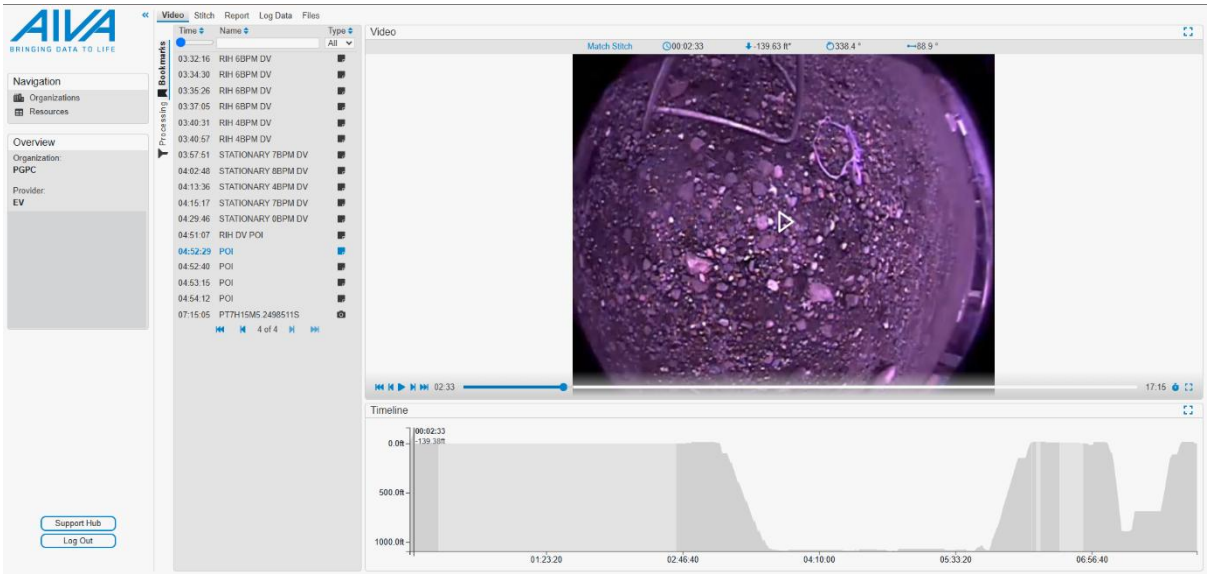

Figure 12: AIVA interface.

Within 24 hours following each camera deployment, the EV team transmitted preliminary survey results and selected excerpts from the memory recordings to PGPC. This prompt sharing enabled the initiation of discussions regarding the captured imagery and footage, which promptly revealed previously unidentified wellbore obstructions. The figure above illustrates the AIVA interface developed by EV, an interactive platform where complete camera recordings and supporting documentation are uploaded.

Upon completion of the analysis, the EV team marks key sections within the interface, allowing users to navigate directly to relevant scenes with a single click. The AIVA also offers a more secure and efficient alternative to traditional methods of transmitting large data files, thereby minimizing the risk of unauthorized access or distribution of sensitive materials.

4. SUMMARY AND CONCLUSIONS

The application of downhole video (DHV) surveys has proven to be a valuable diagnostic tool, offering insights that are often unattainable through conventional wireline techniques. This approach significantly reduced uncertainties regarding the structural and operational conditions of the wells. The pilot implementation of the Optis Infinity camera during the DHV campaign enabled a more comprehensive characterization of the downhole environment, particularly in identifying the nature and extent of obstructions in two candidate wells.

In the case of Well A, which was the first well evaluated in the pilot, the down-view camera encountered difficulty in identifying the obstruction due to an initially unidentified source of inflow. This inflow was subsequently captured by the side-view camera. The real-time video feed was further constrained by compression artifacts, limiting the interpretability of key elements such as the heads-up display. However, these limitations were effectively mitigated by the system's onboard memory recording, which preserved high-resolution footage and enabled clear post-run visualization of both obstructions.

The survey conducted in Well B demonstrated the enhanced capabilities of the upgraded high-frame-rate camera system. It successfully captured the parted casing through both down-view and side-view perspectives just seconds before sediment disturbance, caused by downhole fluid pumping, obscured the visual field.

A significant contributor to the overall efficiency of the campaign was EV's AIVA software platform. The survey data, recorded in both real-time and memory modes, were uploaded and analyzed within 24 hours. Hosted on a secure, cloud platform, the system facilitated interdisciplinary collaboration within PGPC and enabled prompt technical discussions regarding the observed conditions. This streamlined digital workflow eliminated the delays, data integrity risks, and access control issues commonly associated with physical data transfers via external storage devices.

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