# WATER INJECTION PERFORMANCE MANAGEMENT

| Prepared by | Checked by | Approved by | Revision | Edition | Date |
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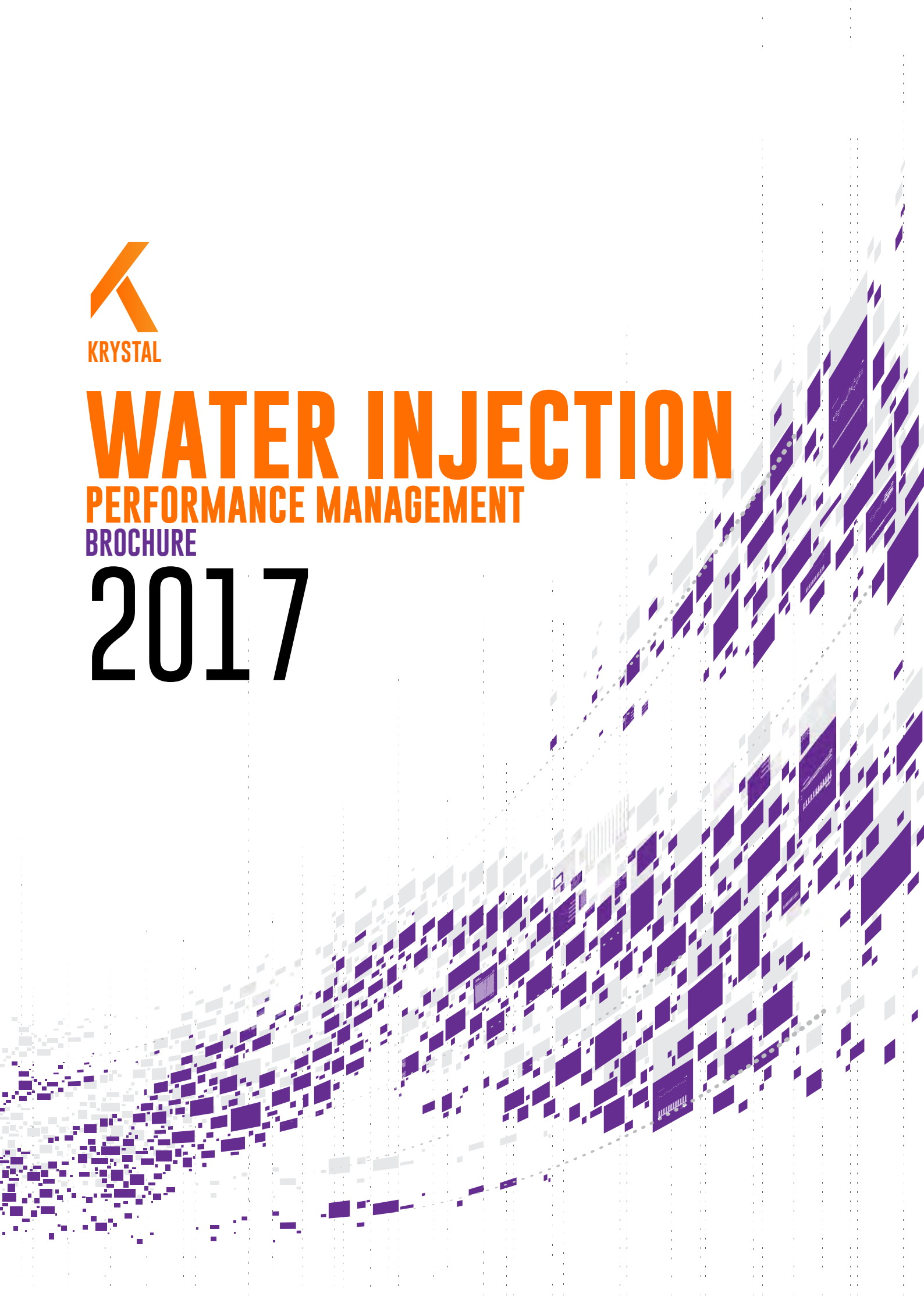
KRYSTAL

# WATER INJECTION

## PERFORMANCE MANAGEMENT

## BROCHURE

## 2017



# MOVING FORWARD


“..IMAGINEERING
IN ACTION..”

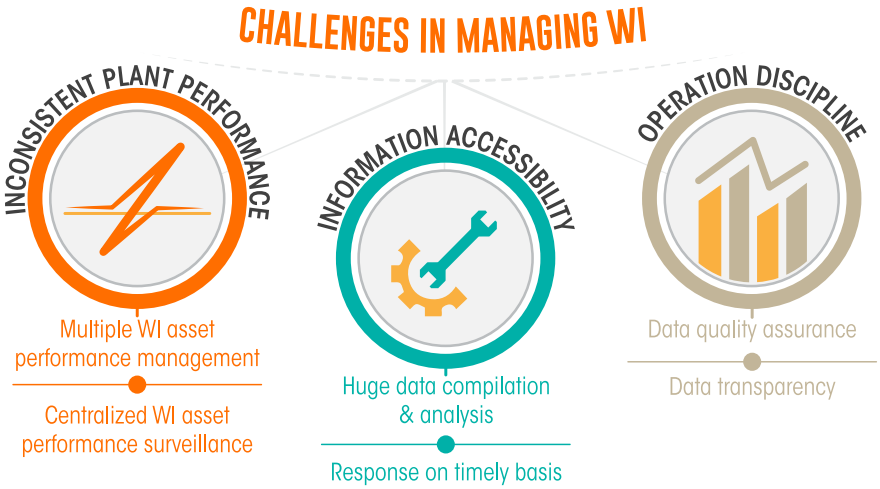
# 01 INTRODUCTION
## Overview And Background

## CHALLENGES IN MANAGING MULTIPLE WATER INJECTION PROGRAMS

In these times of oil price instability, Oil Company (OC) strives to sustain their Return of Investment (ROI) for business stability and sustainability. A strong approach needs to be adopted in order to cope with the market forces. To do this, Oil Company must implement two objectives: 1) Increase oil production with minimal CAPEX; and 2) Reduce production cost with improved efficiency. Hence, in the scheme of available options, Enhanced Oil Recovery (EOR) or Water Injection (WI) has become more significant than before due to its significant contribution to the oil production. OCs must increasingly play a more active role to drive these EOR projects forward in order to achieve these objectives.

As the asset owner, the OCs needs to establish an improved big data analytic program with a strong performance assessment system. The OCs must be equipped with the appropriate tools specifically for active, on-the-spot decision making. Classical tools for data analysis which has eroded trust and confidence, must be replaced with more effective analytical tools.

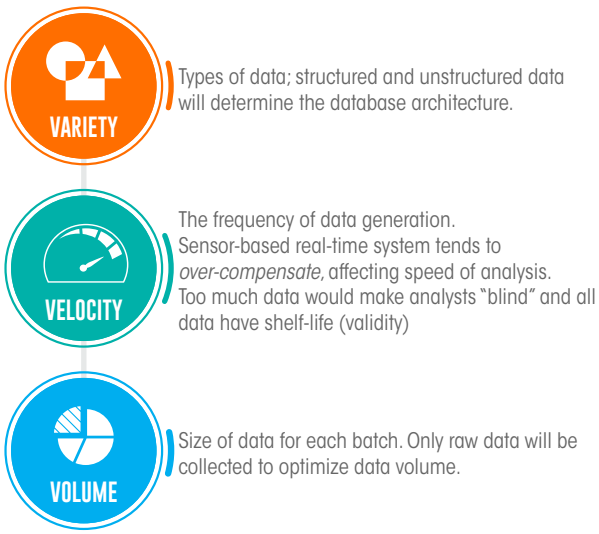
Vision Petroleum Inernational (Vision) has developed such tools and solutions to meet OC requirements. With our experienced technical team equipped with high-end analytical tool, meeting the OC targets and objectives are guaranteed.




## DATA CHARACTERISTICS
Visualization Through Data Fusion

In simple terms, **data fusion** is the process of collating and analyzing raw data from multiple sources, then summarizing and creating effective visualization of the information. KRYSTAL is designed to offer this functionality to visualize valuable insights that lie within production chemical data.

**3Vs - Volume, Variety and Velocity** - These are three characteristics that define data used for designing data fusion. Controlling these parameters will determine the effectiveness of KRYSTAL in crunching data and quickly build the necessary visualization. KRYSTAL is designed to focus on pre-selected data types and volumes on a pre-set frequency basis. KRYSTAL charting engine helps build trends and patterns, allowing the analysts to correlate them to the operating parameters of the water injection program. While KRYSTAL plots the numbers according to pre-set algorithm, we interpret and integrate the data to gain valuable insights.



# CENTRALIZED WATER INJECTION PROGRAM MONITORING

Centralized WI monitoring role makes the top-down approach a more natural choice, but to drive efficiencies and improve oil production, it is necessary for both top-down and bottom-up methods to be adopted, albeit for different purpose.

To ensure success, in our opinion, the Central Management should continue to govern diligently (top-down) while Asset Management actively drives the Water Injection Program forward (bottom-up). This will create an environment of efficient and effective interactions between the Asset Management and the Central Management. The Central Management's focus at all times is on Chemical Program performance, while Asset Management will focus on plant operation.

Using our in-house developed analytical tool called KRYSTAL, we provide OC with immense potential to be proactive. Furthermore, by leveraging KRYSTAL's on-the-fly analysis, performance evaluation, efficiency calculations and fine-tuning can be done quickly.

OC performance will evolve to include KRYSTAL Index (KI) benchmarking, continuous assessment of Key Performance Indicator (KPI) for specific Key Performance Areas (KPA), setting delicately fine-tuned Reservoir Management Plan (RMP) targets for each WI programs, and providing guidelines on operating efficiencies to the operation team - based on simplicity, practicality and economics.

## CENTRALIZE PERFORMANCE THROUGH ACTIVE MONITORING


With rapid data fusion provided by KRYSTAL, the OC centralized WI governance can set precise targets and track performance seamlessly. OC central management can actively drive forward the performance of all the Water Injection Programs. Continuous assessment is necessary for the OC to optimize the performance of each Water Injection Program and maximize value creation. We assist the OC by providing a clear 'Line-of-Sight' for all the Water Injection Programs.

# KRYSTAL VALUES

KRYSTAL is a smart tool. It converts vast amount of data into actionable information and valuable insights. Powered with a comprehensive charting engine, data fusion is achieved with just a few clicks. There is no confusing drop-down menus and no typical-fashioned dialog boxes.

Data fusion visualizes patterns and trends to illustrate water injection program performance.

Data insights are shared seamlessly with stakeholders via $360^0$ reviews on-the-fly. There is no more manual data compilation - delays, gaps, errors and redundancies of time-consuming, resource-intensive manual data handling is eliminated. Engineers are focused on analysis.

### INCREASE AWARENESS (Operational Discipline)

01 Provide 'Line-of-Sight'
02 Simplify reporting system via advanced E-Form
03 Improve data quality

### MAXIMIZE CAPABILITY

01 Guide WI performance fine-tuning
02 Improve decision making accuracy through comprehensive information availability

### SUSTAIN OPTIMUM PERFORMANCE

01 Robust observation and consistent surveillance
02 Develop best practices - Standard Operating Procedures (SOP), surveillance matrices, and guidelines

### ENSURE COMPLIANCE

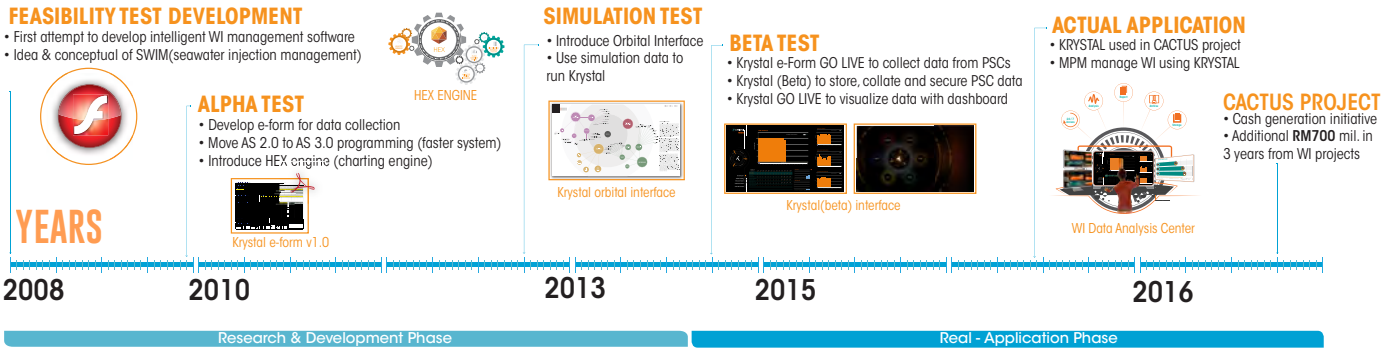
01 RMP compliance
02 Ensures OC meeting Void Recovery Ratio (VRR) targets
03 Maximize Recovery Factor and Estimated Ultimate Recovery (EUR)

### INTERVENE ON TIMELY BASIS

01 See patterns and links that leads to actionable plan
02 Run data analysis on-the-fly
03 Discover issues timely

# 02 ENERGIZING TECHNOLOGY
## Moving Forward With KRYSTAL

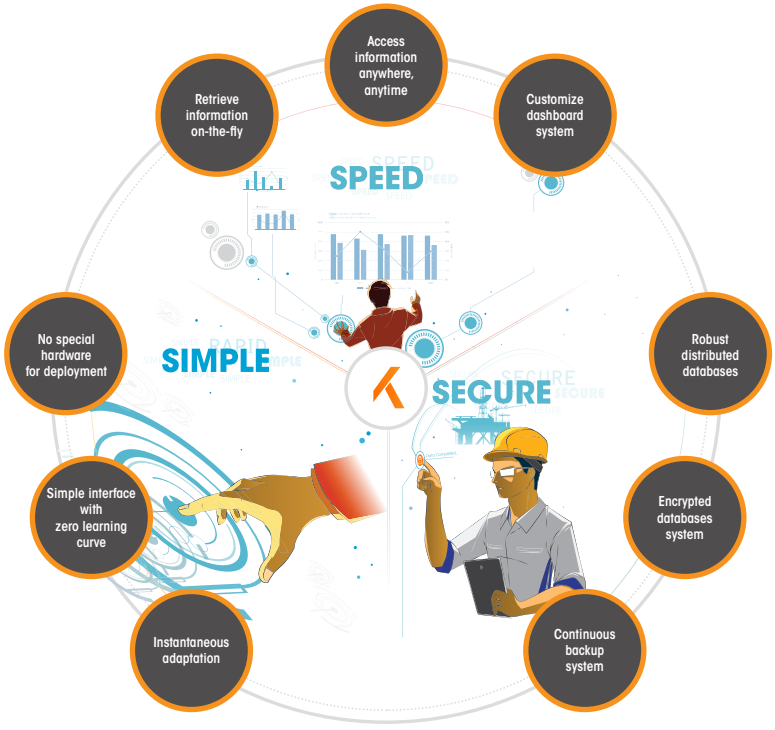
## HISTORY OF KRYSTAL - THE EVOLVING TECHNOLOGY




KRYSTAL is an evolving software. We have been developing this app for almost 10 years. It all started with the idea of having an intelligent software for water injection facilities management. For 2 years, we ran feasibility tests to ensure the concept is reliable. In 2010, we started to build E-Form system, fine-tune the app's performance and launch a more efficient charting engine using updated algorithms.

For the next 5 years, we conducted alpha and simulation testing to ensure the app is robust, reliable and fast. In 2014, we developed the Water Injection Performance Technical Framework (PTF), a conceptual model specific for OCs. KRYSTAL was re-coded to PTF and go live. KRYSTAL is being continuously enhanced to add more features and intelligence in the algorithms including additional custom charts and interactivity to improve user's experience with the app.

## THE THREE PILLARS : SPEED, SIMPLE, SECURE




KRYSTAL is very accessible - simple and direct interface with user. The learning curve is short, ensuring higher adoption rates. User experience to KRYSTAL is intuitive.

Without need for any special hardwares or infrastructure for deployment, the entry cost for KRYSTAL is low when compared to the high cost of adopting other technical softwares.

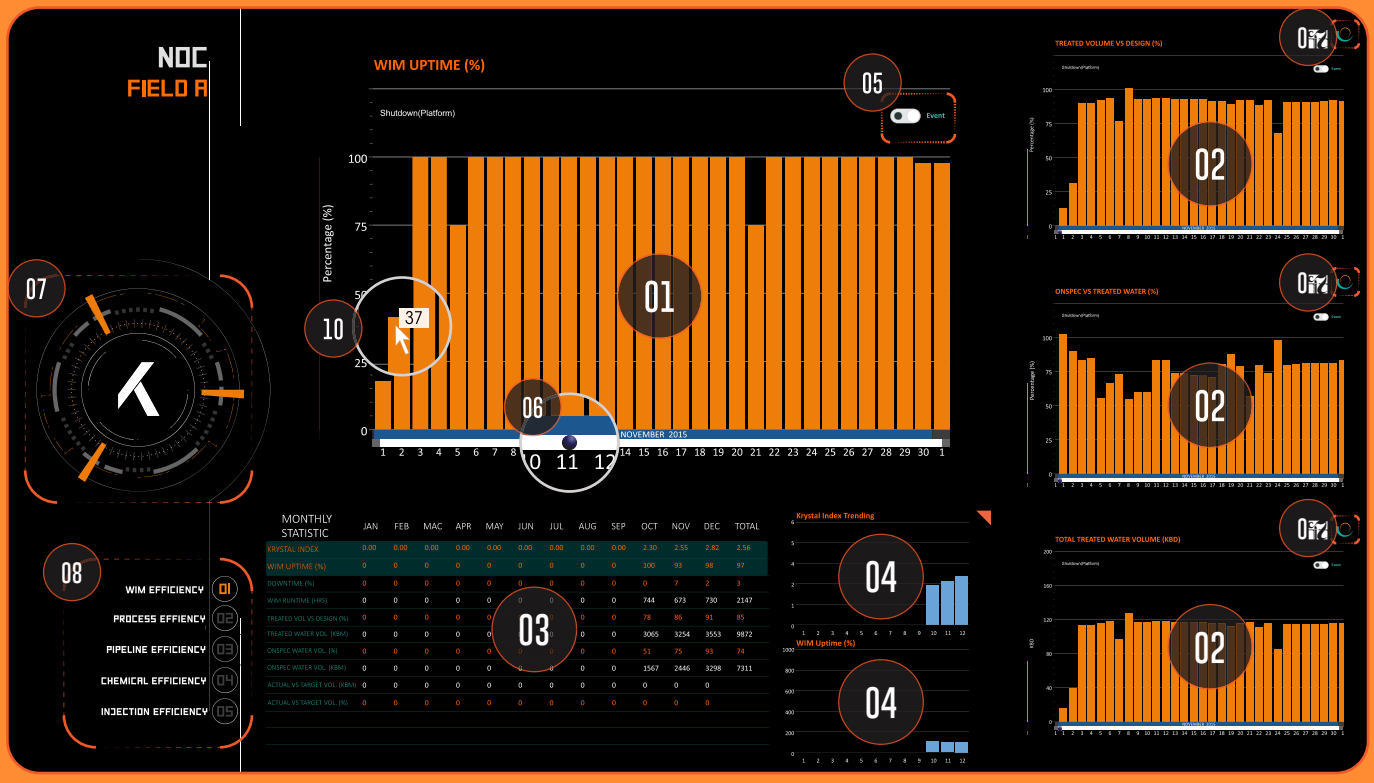
The data fed into KRYSTAL rely on e-mail attachments, which is one of the most secured system for every organizations.

KRYSTAL adopted the distributed database architecture to ensure it NEVER goes down. Encrypted data reside on individual computers or laptops. There are no servers or central core to hack. KRYSTAL reduces vulnerability while improving efficiencies.

# KRYSTAL FOR MULTIPLE WI PROGRAMS PERFORMANCE MANAGEMENT

When OCs operate WI facilities, huge amount of operating and surveillance data is generated. To be on top of this and diligently manage a single WI Program is a major time-consuming and resource-intensive task. In the case of managing multiple WI programs, the task seems almost impossible. Due to this challenge, OCs tend to rely on summaries and/or highlights of reports, which leave significant gaps in the performance analysis and delay prompt action needed to fine-tune RMPs.

We utilized our own in-house custom analytical app, KRYSTAL, to compile, organize and analyze raw data from OCs. The illustration below is a snapshot of KRYSTAL's analysis screen (dashboard). Various charts are generated daily and automatically by KRYSTAL based on data submitted via E-Form sent through internal e-mail systems. Note: Data security is provided by the client's internal e-mail security facilities e.g. firewalls and others.




## 01 MAIN CHART

This is the key chart for each Key Performance Area. Daily data is plotted here.

## 02 SUB-CHARTS

These sub-charts are drawn automatically, whereby the HEX engine will dynamically extract relevant data from multiple databases. Analyst is provided with charts that are synchronized with the main chart. Subsequently, this will help the analyst to understand the current situation promptly and make prompt decision to fine-tune the chemical program target.

## 03 MONTHLY STATISTIC

This section allows for evaluation based on monthly data. These includes calculated data such as KRYSTAL Index, WIM Uptime, WIM Runtime, Sustainability (Treated Volume vs Injectable Volume), Capacity Utilization, Actual Volume vs Target Volume, and others (depending on KPAs).

## 04 MINI SUB-CHARTS

These mini sub-charts allow for quick charting of monthly data.

## 05 EVENT

Event button when turned 'ON' will show relevant information for specific datapoints.

## 06 TIMELINE

Scrolling feature allows analysis on time basis. While selecting timeline on the Main Chart, the sidecharts will also dynamically adjust to the same timeline.

## 07 KRYSTAL CONTROLLER

KRYSTAL Controller will access the StartUp page which is the individual WI Programs selection. However, hovering the mouse cursor without clicking, 3 additional buttons is accessible - Print, Fullscreen display and Help - will appear for user selection.

## 08 KEY PERFORMANCE AREA

These options allow analysis to be done based on specific Key Performance Area.

## 09 SIDE MENU

For in-depth analysis, other relevant charts can be selected from a dropdown list of charts made available by KRYSTAL. This list is pre-selected for specific KPAs (from a total of 288 standard charts).

## 10 BAR VALUE

When the user moves mouse cursor onto each bar, the exact value will pop-out from the respective pointed bar.

# WI PROGRAMS PERFORMANCE TECHNICAL FRAMEWORK

**5** KEY PERFORMANCE AREAS

**12** KEY PERFORMANCE INDICATORS


The Water Injection Performance Technical Framework (PTF) is a concept to define high level performance analysis of Water Injection Programs. Five Key Performance Areas (KPA) are established, with the accompanying measurement elements (including KPIs). With PTF, multiple Water Injection Programs can be benchmarked and ranked. The measurement elements are used to provide depth to the analysis, where events and root causes can be linked.

# KRYSTAL DATA PROTOCOL

- Record Daily Data in E-Form
- Ensure equipment to be calibrated
- Verify Standard Operating Procedure (SOP and SSP)

*Submit E-Form Daily*

*Note: The E-Forms used by KRYSTAL for data collection is programmed with auto error-checks as the "first gate" for data quality control, thus ensuring no mistakes during data entry.*

*Submit Verified Data (E-Form)*

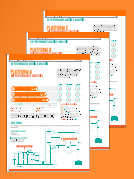
**FOCAL PERSON**
- Update Local Databases
- Data Quality Control

*Update Database and Analyze Data*

**WI SURVEILLANCE SYSTEM**
- Track E-Form Compliance
- Update Databases

**DATA ANALYSIS CENTRE**
- Analyze Data
- Review Event Alerts

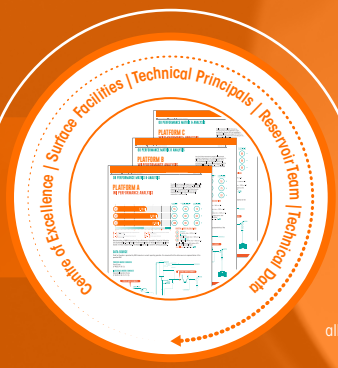
*Generate*



**WI ANALYSIS REPORTS**
Send Analysis//Findings/Alerts to OC

**WI REFERENCES**
- SOP, SSP and Matrices
- Training Collaterals
- Schematic Drawings/P&ID
- Operation Tasklist/Plan
- Design Basis

**OPERATING COMPANIES**
*Engagement*

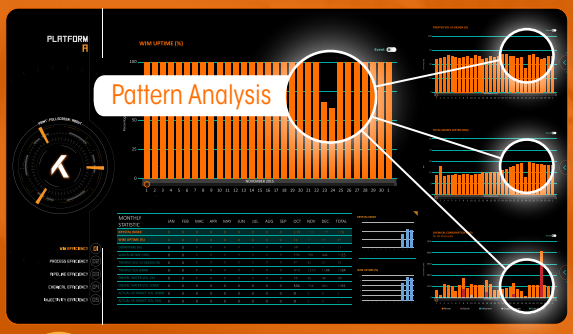



**360° ANALYSIS**
The objective of 360° analysis is to give more holistic view to the findings by capitalizing on multiple stakeholders' perspectives. This helps to harmonize the perspectives of multiple stakeholders into cohesive and reliable decisions. KRYSTAL provides inputs and allows analysis sharing instantaneously.

KRYSTAL Data Protocol (KDP) plays a very important role for data submission tracking and compliance. KDP defines clearly a logical, well-organized flow and transfer of data from data source to KRYSTAL. Key features of KDP is the placement of "gate-keepers" on the front-end to ensure the data owner conduct quality-control of the data before releasing them for KRYSTAL analysis and subsequently for technical and management teams' decision-making purposes.

## DATA PATTERNS

The pattern analysis method relies on daily data feeds to build complex relationships. Subsequently findings are used to formulate "Quick Action" to optimize performance (operating efficiencies and injection targets).




**DAILY BASIS**
Analyst is fed with daily data to identify patterns

**PREDICTIVE ANALYSIS**
Predict peak processing limits (bottlenecks)

**MULTI-TASKING**
Access multiple locations for concurrent analyses

**QUICK ACTION**
Timely clarification and intervention

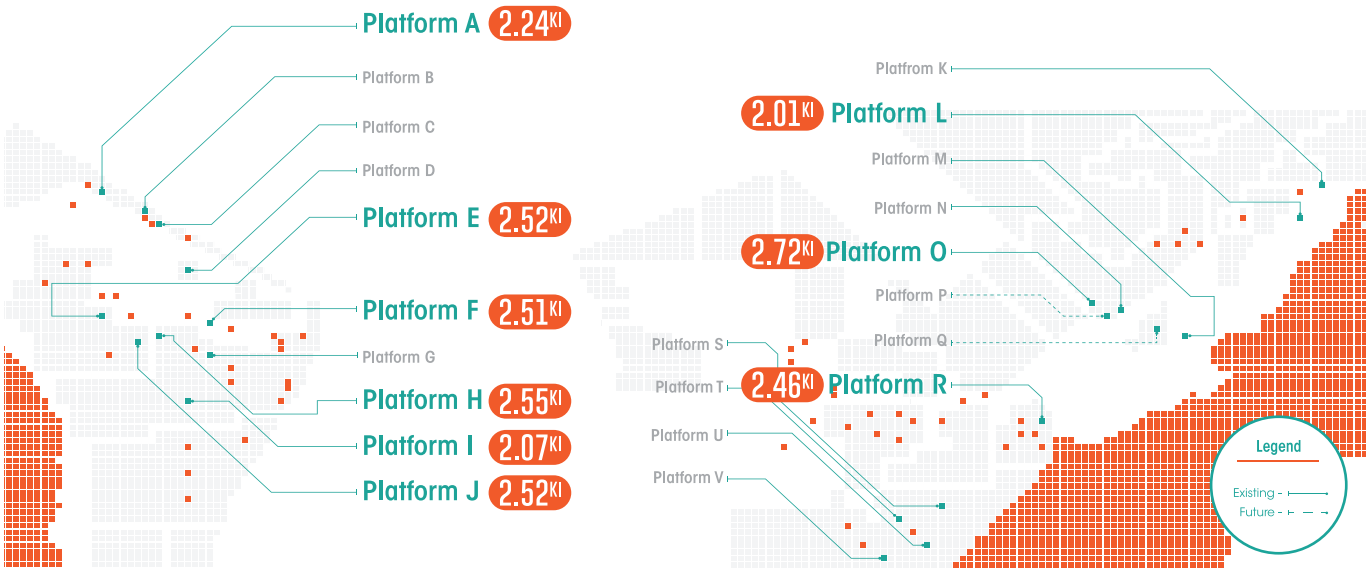
## DATA PATTERN ANALYSIS IN ACTION


KRYSTAL daily charts are used to confirm the target and actual injectable water volumes and focusing on deviating patterns to estimate non-compliance. By linking to chemical charts, losses due to chemical program deficiencies can be calculated. Similar tracking and analysis can be done on-the-fly for multiple WI programs.

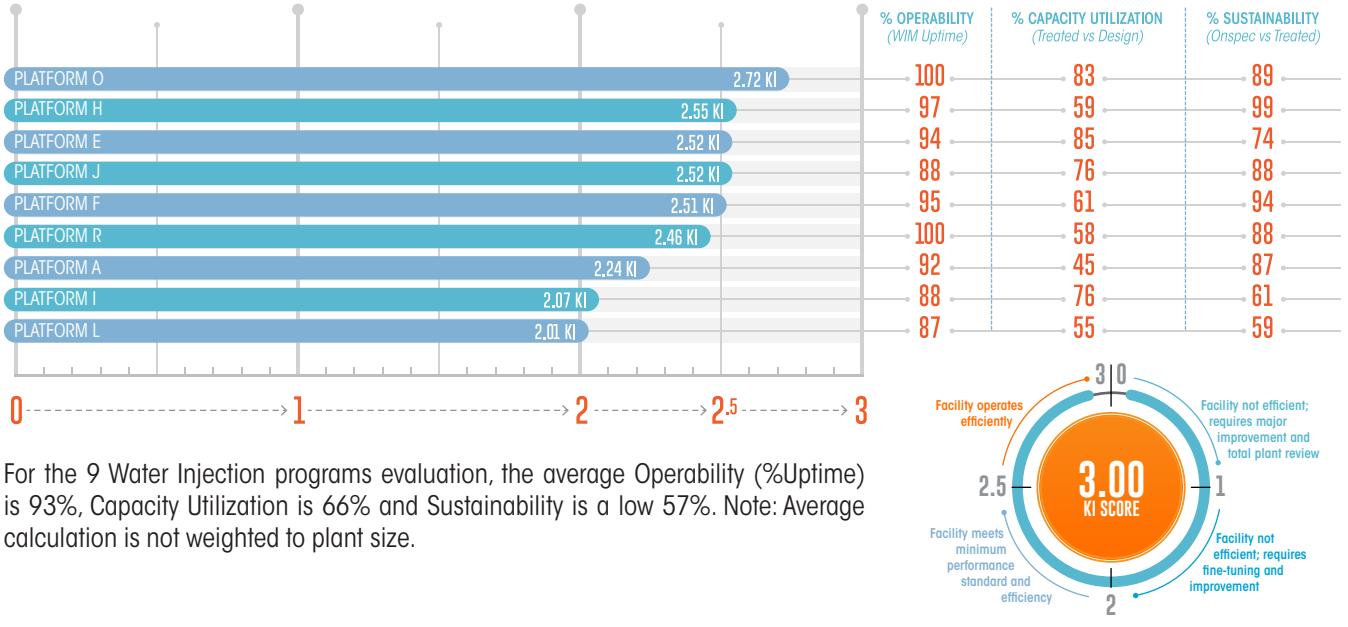
# 03 REAL RESULT
## Water Injection In Malaysia

Based on previous collaboration with National Oil Company (NOC), the performances of nine WI Programs (Surface Facillity), operated by different OCs were benchmarked individually and then ranked using a formula called KRYSTAL Index (KI). KI summarizes the overall performance of each facillity based on 3 main parameters - Operability, Capacity Utilization and Sustainability. By determining KI, not only it is possible to know at what level the facillity is performing but it also made ranking for the 9 WI Programs possible (which ones are the acceptable and which ones require more attention). Thereafter, a standard baseline performance was established to pursue for improvement. The efficiency of each facillity was determined by applying the KI formula and utilizing KRYSTAL software for detailed efficiency analysis.

## PERFORMANCE BENCHMARK AND RANK USING KRYSTAL INDEX




## KRYSTAL INDEX DETAIL BREAKDOWN

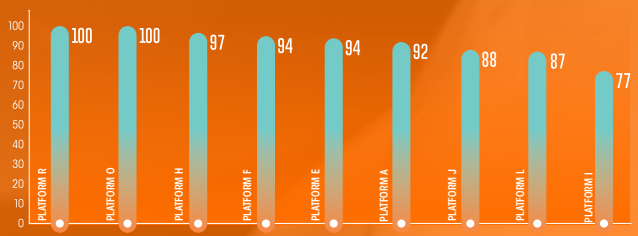



For the 9 Water Injection programs evaluation, the average Operability (%Uptime) is 93%, Capacity Utilization is 66% and Sustainability is a low 57%. Note: Average calculation is not weighted to plant size.

# PERFORMANCE BY AREA [KRYSTAL INDEX ELEMENTS]

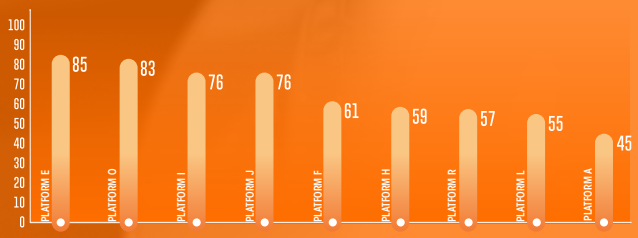
## OPERABILITY
### Uptime Based on Running Hours

The operability performance as measured using %Uptime, showed all 9 Water Injection Programs operate above 85%, with 2 facilities operating at 100% over the 90 days assessment period. Overall, shutdown is less than 10%.



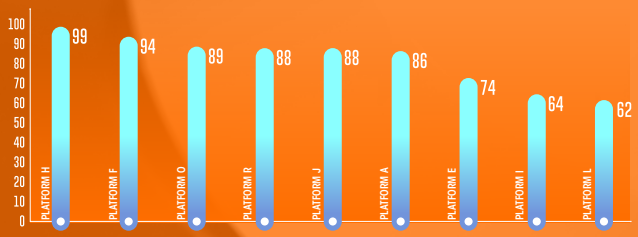

## CAPACITY UTILIZATION
### Current Process Flowrate vs Design Specifications

The highest Capacity Utilization is at two major assets at ~ 85%. However, 4 out of 9 Water Injection Programs operates 50% or below *as-built* specifications. Hence there is capacity to increase Injectable Water flowrate to meet RMP requirements for these programs without OPEX escalation.




## SUSTAINABILITY
### Injectable Water Volume vs Actual Process Volume

Two WI Programs scored low on the Sustainability factor, raising concern of possible water quality issues (suspected pipeline issue). Other 7 programs operate with less than 10% overboarding. However on the bigger WI plants, these still represent large leakage of treated water (and chemicals).




## WI POTENTIAL GAIN
### REVENUE LOSSES DUE TO OPERATIONAL INEFFICIENCIES

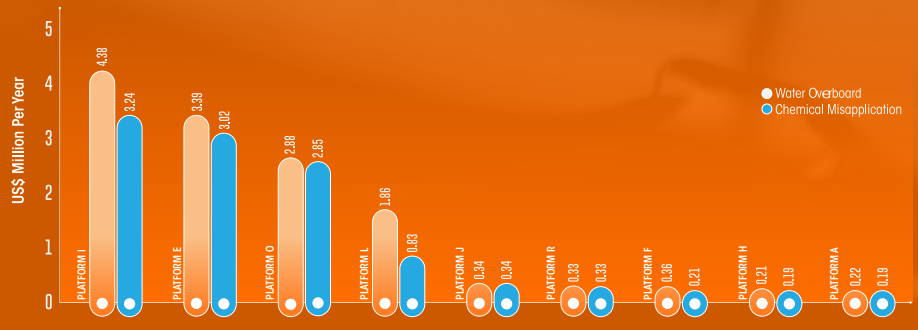
* VRR 1:1
*Oil Price : US$50/bbl


Revenue Loss
**US$13.2mil. per day**
for 9 WI Programs

Revenue Loss
**US$4.8bil. per year**
for 9 WI Programs

There is huge room for improvement to generate cash through efficiency. This analysis showed that there is a potential of US$4.8 billion gain from efficiency improvement. In addition, it is possible to monetize this opportunity without CAPEX.

## SAVINGS THROUGH LEAKAGE REDUCTION
### CHEMICAL PROGRAM DEFICIENCIES AND OVERBOARD OF TREATED WATER




Overboard of Treated Water
**US$14.0mil. per year**
for 9 WI Programs

Chemical Program Deficiencies
**US$11.2mil. per year**
for 9 WI Programs

Chemical application deficiencies and overboarding of treated water incurs estimated losses of US$25.4 million per year. This is equivalent to 508 kbbl oil wasted. Through diligent and efficient operation, these leakages can be minimized.