GP-1105 - Compression and Processing Asset Management Plan

Gas Plan

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1. Executive Summary

This asset management plan provides an assessment of condition and risk of the Compression & Processing (C&P) asset family and includes a program plan detailing risk mitigations based on strategic objectives and asset maintenance, applied over the life cycle of the assets.

The plan is developed with a 5-year planning horizon to align with the Gas Operations 5-year financial outlook and will be updated annually. It describes the physical assets included in this asset family, the current condition and desired future state of the assets, the key risks associated with the asset family, and the investments planned or in progress to mitigate and reduce these risks. Beyond the physical assets, the plan considers the impact on support areas such as training and guidance documents.

1.1 Asset Overview

The Compression & Processing asset family is one of eight asset families into which gas transmission and distribution assets have been grouped. The physical assets within this family include the nine compressor stations, compression and processing equipment at the three PG&E-owned and operated storage fields, and gas odorizers and associated equipment installed system-wide.

1.2 Strategic Objectives

Gas Operations sets annual corporate Line of Sight (LoS) goals that cascade throughout the organization. Asset Family objectives are created using these LoS goals as a framework and developed both from a bottom-up and top-down approach. After analyzing asset risk and condition within the LoS framework, the 2016 C&P strategic asset objectives are:

1. Use Long-Term Compression Investment Plan information to inform 2019 GT&S Rate Case
2. Reduce total number of compressor unscheduled shutdowns by 10% per year
3. Evaluate 100% of Transmission Total Station Features by end of 2019
4. Implement corrosion monitoring programs to enhance existing programs by 2018
5. Apply Facility Integrity Management principles to all stations by 2025
6. Complete Physical Security Upgrades at Critical Facilities by 2021
7. Critical documents defined by TD-4551S are completed by 2019

1.3 Asset and Data Condition

During 2014 PG&E completed a condition assessment to quantify health of the C&P compressor stations and compression assets at the storage fields based on existing available data. The condition assessment was based on evaluating the major components in the C&P compressor stations against a set of scoring elements to determine a component health score. The components were then grouped by system and health was determined on a system level. The resultant health score for each system was compared to a target score for that system.

The results of the condition assessment identified three systems – compressors, control, and electrical – as having the highest health scores (which indicate the lowest health). Based on these results, the projects and programs proposed for the time period covered by this plan have been prioritized around these three systems. An observation in the assessment is the overall poor health of the Topock Compressor Station.

The condition assessment used data available from the following sources to assess the condition of the C&P station components:

- SAP (asset and work management tool)
- PLM (asset and work management tool – now retired)
- PSRS (project planning and tracking tool)
- Surveys and interviews
- Previous reports and assessments
- Site inspection information
- Operating diagrams
- Piping and Instrumentation Diagrams (P&ID's)
- Corrective Action Program (CAP) reports

There are still gaps in the data, but overall the information reviewed allowed for a reasonable determination of station and component condition. Data quality and availability still remains a focus for attention moving forward to ensure that decision-making is made on current and accurate information. The current data provides valuable information when leveraged by subject matter experts, knowledgeable in the facilities and systems, to define risks and mitigations. However, data for this asset family is limited in terms of quality, completeness, and accessibility to support a complete quantitative analysis of asset risk. Further, there are gaps in the available data which limit its reliability and use for monitoring program impact on risk reduction and tracking metrics. Enhancing data collection and quality is an area of focus in this plan to enable decision making going forward.

1.4 Key Risks

This and the other asset families within Gas Operations take a risk-informed approach to managing the assets to reduce risk. Proposed programs of work are risk scored with a process for prioritization across all asset families in an effort to implement investment plans that is driven by risk and considers constraints.

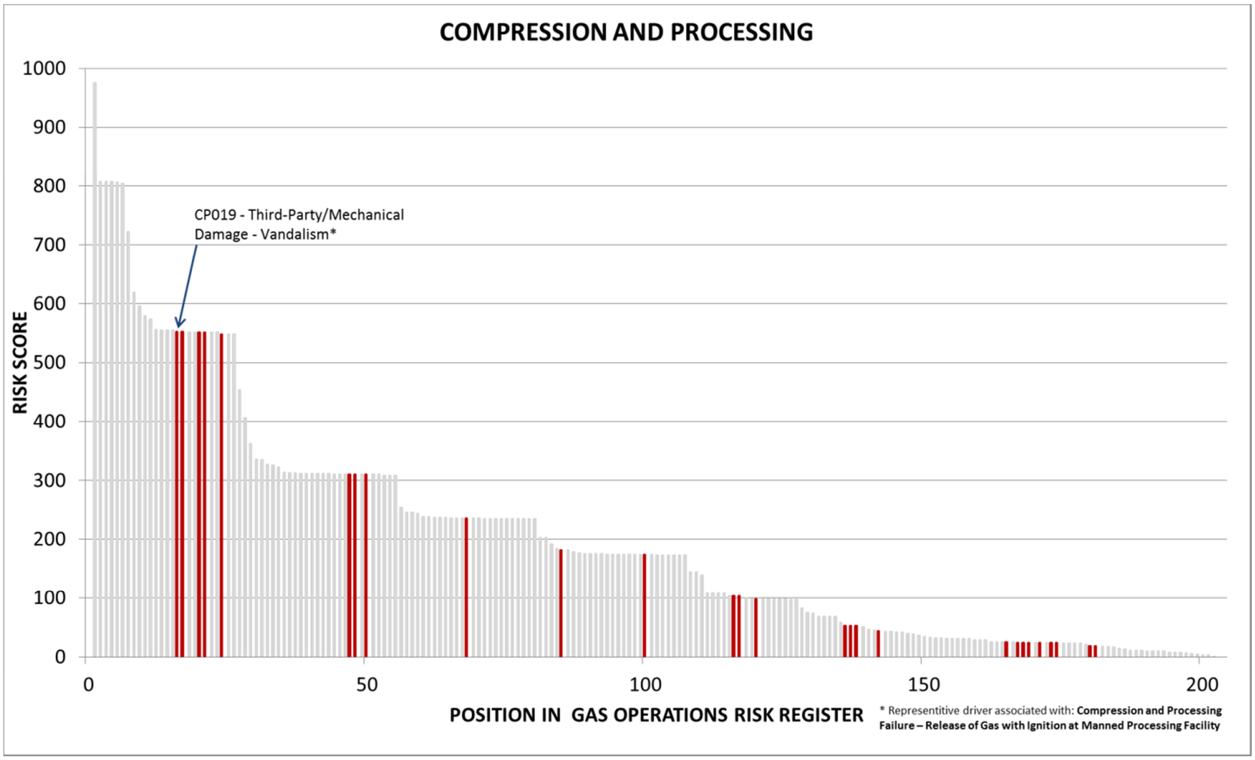
Gas Operations identifies risks for each asset family. For each threat (as defined in ASME B31.8S), risk drivers and risks are identified and assessed for each asset family based on available data and subject matter expert (SME) input. The result of this process is a set of several hundred Gas Operations risks with scores shown in Figure 1 below. (The risks are re-evaluated on an annual basis and the results of the 2016 refresh are included in Figure 1.) For this effort, risk is defined as the potential for an adverse event that can impact company's ability to achieve its objectives. Risk drivers for the Gas Operations level risks are defined as factors that could drive risk to occur. These risks are defined with a significant degree of granularity and are defined and discussed in each of the Gas Operations Asset Management Plans.

Enterprise Operational Risk Management (EORM) developed a criteria used to identify enterprise level risks. Furthermore, due to Gas Operations' level of granularity, the risk drivers were aggregated or "rolled up" to allow for consistent calibration with all PG&E lines of business. The rolled up risks incorporate multiple "risk drivers" from the Gas Operations risk register. Additional details regarding the roll up methodology can be found in the Strategic Asset Management Plan.

The highest scoring risk identified for the C&P asset family, and the risk that has been selected as the rolled up representative risk for the C&P asset family, is CP19, as shown on Figure 1 and as described in Table 1. CP19 captures the physical security risk of terrorism or vandalism on C&P assets.

This asset management plan is based on the risks developed for Gas Operations. Risks are derived based on a risk score that considers the likelihood and consequence of failure. The complete listing of C&P risks identified and evaluated is found in Appendix C.

Figure 1 - Gas Operations Risk Histogram



1.5 High Level Program Overview

In the near term, the asset management plan focuses on managing and reducing risk in the most cost efficient and effective manner possible. As the plan matures, focus on optimizing risks, performance, and costs will continue to be strengthened. For the time period covered by this asset management plan, several programs have been proposed to address risks that are not currently adequately mitigated and to advance achievement of the C&P strategic objectives. The proposed programs involve both capital and expense and in some cases address more than one area of risk or strategic objective. Detailed description of the scope of each program is found in Section 4. The pace, trajectory, scope and anticipated budgets for these proposed programs align with the submittals included in the 2015 Gas Transmission and Storage (GT&S) Rate Case and the proposed 2018 GT&S Rate Case.

Managing the risks and risk reduction involves identification and implementation of mitigation measures. Metrics are also defined to aid in monitoring the effectiveness of the mitigations. Multiple mitigation measures will often be required to adequately manage a risk. Table 1 below provides a brief description of the primary mitigation measures and metrics for the highest risks among multiple threats that have been identified across the C&P assets.

Table 1 – Key C&P Risks and Mitigations*

Threat	Risk ID	Risk Description	Primary Mitigation	Mitigation Metric
Third Party / Mechanical Damage	CP19**	The risk of vandalism or terrorist attack at facility may result in personal safety, loss of service, loss of containment, and/or equipment damage	5-Year Program to implement vulnerability assessment study recommendations	Progress of program to perform security upgrades at critical facilities
Weather Related/Outside Forces - Seismic [redacted]	CP22	The risk of a 6.7 earthquake may result in loss of service, loss entire compressor station (Hinkley and Los Medanos), and ignition	Pilot Seismic Assessment Program Condition Assessment Program	Progress of Pilot Seismic Assessment Program
Manufacturing Defects	CP12	The risk of equipment failures from poor design or manufacturing process may result in loss of service and possible loss of containment	Enforce requirements to obtain equipment from approved Suppliers	Number of CAP items related to design issues
Welding/Fabrication Related	CP8	The risk of poor construction practices may result in loss of containment and loss of service	Construction QC Program Borescope Procedure	Number of CAP items related to construction or fabrication issues
Incorrect Operations	CP6	The risk of incorrect operations causing failure or malfunction of critical pressure containing equipment at a [redacted] facility may result potential loss of containment	Critical Document Program Critical Equipment Training Operator Qualification Program	Number of unscheduled outages (incl. McDonald Island rental compressors)
External/Internal Corrosion	CP1	The risk of through wall leaks in storage facility piping from internal or external corrosion (discharge side) may result in loss of containment, loss of service and reliability.	Site Specific Corrosion Plans	Execution of execution of expense and capital programs to mitigate corrosion risks
External Corrosion - Under Pipe Insulation	CP2	The risk of through wall leaks from external corrosion forming beneath pipe insulation material may result in loss of service and loss of containment.	Revised and enhanced procedures for inspecting pipe under insulation	Execution of mitigative measures (inspection, evaluation of insulation removal

Threat	Risk ID	Risk Description	Primary Mitigation	Mitigation Metric
Internal Corrosion & Erosion	CP10	The risk of through wall leaks in storage processing, withdrawal piping and pressure vessels from internal corrosion or erosion may result in loss of containment, loss of service, and reliability.	Site Specific Corrosion Plans	Included in CP1
Equipment Related – Electrical Systems	CP13	The risk of aging electrical equipment at C&P stations may result in worker safety and loss of service	Full revision and roll out of Electrical Work Safety program Develop guidance for electric asset upgrade programs	Progress of roll out of revised Electrical Worker Safety program

* All risks with a score of 200 or higher as a result of the 2016 Session D process

** Enterprise Level Risk

1.6 Continuous Improvement since Revision 2 of C&P Asset Management Plan

The C&P asset family has made significant progress since the last version of the Asset Management Plan was published in August of 2015. Highlights of these improvements include the following items:

- Frame work for Facility Integrity Management Program (FIMP) has been established and associated Maturity Model has been developed (Section 4)
- First iteration of Long Term Compression Investment Plan has been published (Appendix N)
- Pilot Reliability Centered Maintenance Studies have been performed at Hinkley and Gerber Compressor Stations (Appendix K)
- Goal of performing 10% of proposed reliability projects per year was met and exceeded (Appendix K)
- Notable improvement made in reliability of chronic units at Los Medanos and Santa Rosa Compressor Station (Section 2)
- Overall condition assessment of Santa Rosa Compressor Station has been upgraded from “fair” to “good” largely as a result of the capital project to replace the electric switchgear and the motor control centers (Section 2)
- Reliability Principal Engineer has been hired to develop and implement reliability plans at C&P facilities
- Electrical Principal Engineer has been hired to develop electrical maintenance procedures at C&P facilities
- Implemented a program approach to mitigate risks to employees performing work on energized electrical equipment
- Created a standing Electrical Safe Work Practices team with a goal of developing, implementing and maintaining a comprehensive electrical work safety program
- Inventoried and corrected deficiencies related to insulated tools and appropriate Personal Protective Equipment (PPE) at all districts
- Developed and issued detailed electrical maintenance plans for all compression facilities
- Implemented program to install enhanced physical security upgrades at 8 C&P facilities (Section 4)
- Completed seismic assessments at McDonald Island, Hinkley Compressor Station and Gerber Compressor Station
- A comprehensive compressor dashboard has been implemented which is providing engineers and stakeholders with readily accessible and usable information to monitor and manage compressor performance
- Performed global benchmarking study with companies from Europe, North America, and South America to identify best practices for management of C&P assets
- Seeing more consistent year-to-year scoring of P95 and Enterprise C&P risks in Session D process

2. Asset Inventory and Condition Overview

2.1 Asset Overview

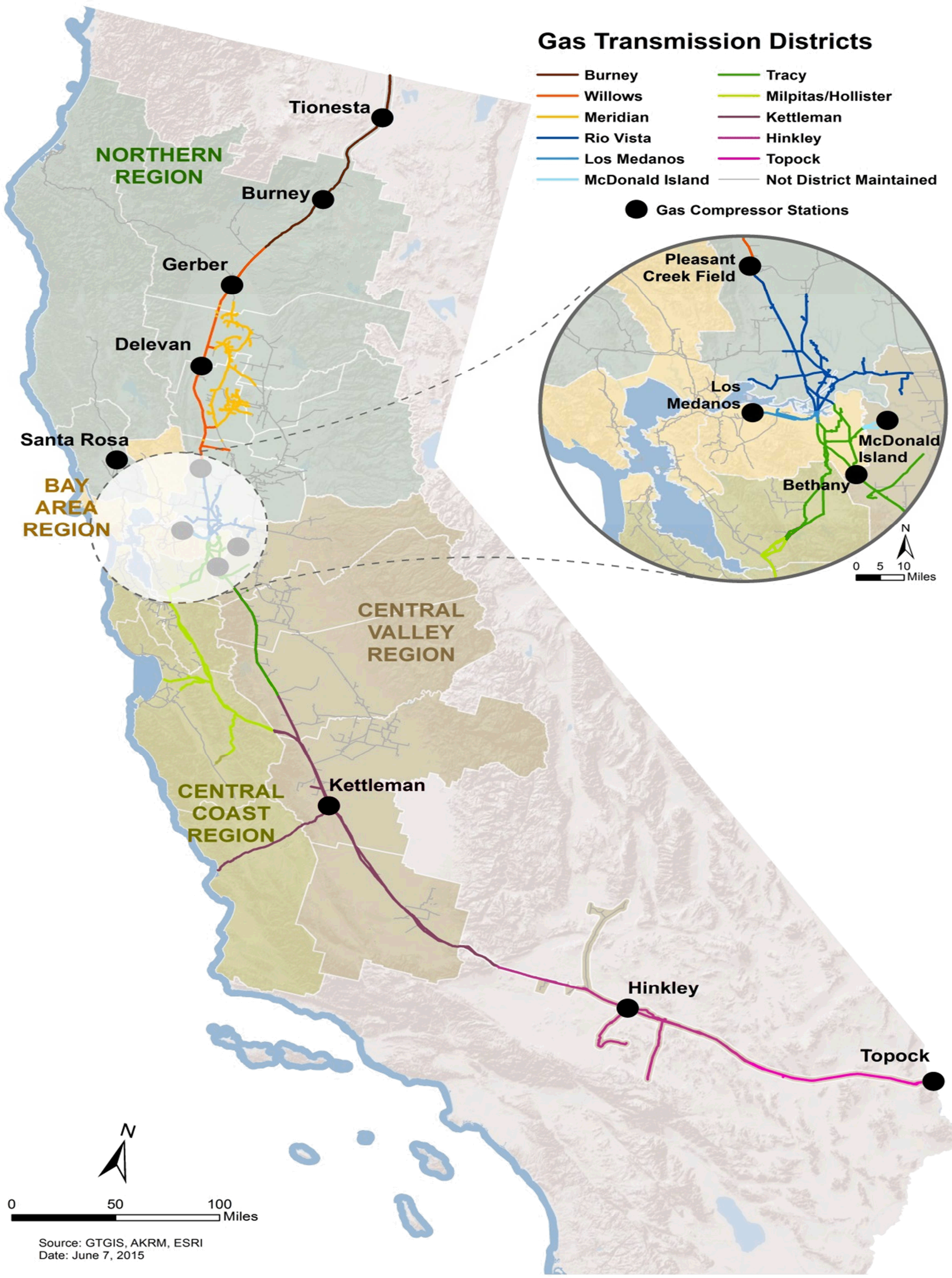
The physical assets in the Compression & Processing asset family include the nine compressor stations, compression and processing equipment at the three PG&E-owned and operated storage fields, and gas odorizers and associated equipment installed system-wide. Table 2 and accompanying Figure 2 which shows the locations of the assets present a high level overview of the facilities included in the Compression & Processing asset family.

Table 2 - Compressing and Processing Asset Overview

<table>
<tr><th>Asset</th><th>Transmission Line(s)</th><th>Description</th></tr>
<tr><td>Tionesta Compressor Station</td><td rowspan="4">L-400/L-401</td><td rowspan="9">Compressor units and associated equipment installed at the station</td></tr>
<tr><td>Burney Compressor Station</td></tr>
<tr><td>Gerber Compressor Station</td></tr>
<tr><td>Delevan Compressor Station</td></tr>
<tr><td>Bethany Compressor Station</td><td>L-401</td></tr>
<tr><td>Kettleman Compressor Station</td><td rowspan="3">L-300</td></tr>
<tr><td>Hinkley Compressor Station</td></tr>
<tr><td>Topock Compressor Station</td></tr>
<tr><td>Santa Rosa Compressor Station</td><td>L-21</td></tr>
<tr><td>McDonald Island</td><td>L-57</td><td rowspan="3">- PG&E-owned and rental compression equipment and associated equipment
- Gas processing and conditioning equipment</td></tr>
<tr><td>Los Medanos</td><td>L-65</td></tr>
<tr><td>Pleasant Creek</td><td>L-56, L-206</td></tr>
<tr><td>Gill Ranch</td><td>L-401</td><td>PG&E has a 25% interest stake and Gill Ranch Ltd owns the additional 75% and operates the field</td></tr>
<tr><td>Odorizers</td><td>System-wide, primarily at gas receipt points and strategic locations within the gas system to ensure gas is properly odorized</td><td>All injection and by-pass odorizers installed at stations, farm taps, or producer well sites</td></tr>
</table>

Figure 2 - Transmission Pipeline Map

Source: PG&E Critical Infrastructure Information



2.2 Asset Inventory and Condition

The inventory of the major asset components in the C&P asset family is provided in Table 3 – Compressors, Table 4 – Gas Processing Facilities, and Table 5 – Odorizers, below.

Table 3 - Compressors

Station	Station In-Service Date	Service	# Units	Type	Model	Total Site Horsepower	Fuel	Spare HP at Site?
Tionesta	1970	Transmission	1	Gas Turbine / Centrifugal	Rolls Royce Avon 1533-76G / Cooper Bessemer RFA 36	10,909	Gas	No
Burney	1969	Transmission	1	Gas Turbine / Centrifugal	GE LM1500GB101 (rental) / Cooper Bessemer FRA 36	11,359	Gas	No
Gerber	2002 (replaced after fire)	Transmission	1	Gas Turbine / Centrifugal	Solar Titan 130 SoLoNOx / Solar C652	17,240	Gas	No
Delevan	2010 & 2011 (Replaced original Gas Turbines)	Transmission	2	Motor / Centrifugal	Siemens Electric Motor / Solar C652	25,800	Electric	No
Delevan	1993	Transmission	1	Gas Turbine / Centrifugal	Solar Mars 100S SoLoNOx / Solar C601	12,860	Gas	
Bethany	1993	Transmission	2	Motor / Centrifugal	Ansaldo Electric Motor / Cooper Bessemer RF2B30	17,600	Electric	Yes
Kettleman	2001 (Replaced original reciprocating units)	Transmission	3	Gas Turbine / Centrifugal	Solar Taurus 60 SoLoNOx / Solar C402	23,100	Gas	No
Hinkley	1955	Transmission	5	Integral Reciprocating	Cooper Bessemer GMW	12,000	Gas	No
Hinkley	1955	Transmission	4	Integral Reciprocating	Cooper Bessemer GMW (retrofitted)	10,000	Gas	No
Hinkley	1968	Transmission	1	Integral Reciprocating	Cooper Bessemer GMWTC (retrofitted)	3,500	Gas	

Station	Station In-Service Date	Service	# Units	Type	Model	Total Site Horsepower	Fuel	Spare HP at Site?
Hinkley	1961	Transmission	2	Integral Reciprocating	Cooper Bessemer 16W-330 (retrofitted)	14,500	Gas	
Topock	1955	Transmission	8	Integral Reciprocating	Cooper Bessemer GMWTC	28,000	Gas	No
Topock	1970	Transmission	1	Integral Reciprocating	Cooper Bessemer GMWC	3,500	Gas	
Santa Rosa	1968	Transmission	2	Motor / Reciprocating	Electric Machinery Motor – Frame G72 / Clark CLRA-2	2,000	Electric	Yes
McDonald Island (on platform)	1961	Storage	1	Motor / Reciprocating	Electric Machinery Motor / Cooper Bessemer JM-6	3,067	Electric	Yes
McDonald Island (on platform)	1961	Storage	1	Motor / Reciprocating	GE Motor / Worthington BDC-1	4,869	Electric	
McDonald Island (Leased Units on ground)	N/A	Storage	3	Separable Reciprocating	Waukesha / Ariel (rentals)	7,387	Gas	Yes
Los Medanos	1981	Storage	8	Integral Reciprocating	Cooper Bessemer GMVM V-12 (Quad)	3,733	Gas	No
Pleasant Creek	2010	Storage	1	Integral Reciprocating	Waukesha F3514GSI / Ariel JGH-4	749	Gas	No
Gill Ranch	2010	Storage	5	Electric / Reciprocating	Ariel	45,000	Electric	

Table 4 - Gas Processing Facilities

Station	In-Service Date	Maximum Withdrawal Capacity (MMCFD)	Overall Condition	Comments
McDonald Island (Turner Cut Station)	1975	840	Good	• Platform rebuilt in 2005 • Glycol towers due for inspection • Long term plan needed to prevent future internal corrosion
McDonald Island (Whisky Slough Station)	1975 (Rebuilt in 2013)	840	Good (after completion of rebuild)	• Platform rebuilt in 2013 • Long term plan needed to prevent future internal corrosion
Los Medanos	1973	400	Good	• Major critical components have been replaced or upgraded
Pleasant Creek	1960	70	Fair	• Glycol dehydrator is original to the facility, and is limiting factor on withdrawal performance • Obsolete components
Gill Ranch	2010	650	Good	• Relatively Recent installation

Table 5 - Odorizers

Odorizer Type	No. of Units	Age	Upgrades/Replacements	Overall Condition
Injection	46	Various	Replaced on 10-year frequency	Good
Bypass	59	Various	As needed	Good

During 2014, PG&E completed a condition assessment to quantify health of the C&P stations based on existing available data. The condition assessment was based on evaluating the major components in the C&P stations against a set of scoring elements to determine a component health score. The components were then grouped by system and health was determined on a system level. The 15 systems listed below were identified for C&P assets.

- Civil/Structural
- Compressed Air
- Compressors
- Control
- Cooling Water
- Fuel Gas
- Main Gas
- Lube Oil
- Power Gas
- Processing

- Electrical
- Environmental
- Fire Detection
- Security
- Storage

Scoring on a system level rather than a station level allows for more granular scoring of the C&P stations and allows for comparison between systems of the various facilities. This method also keeps the system score equivalent to a Measurement and Control station asset, thus enabling prioritization of asset investment across asset families. See Appendix H for a detailed discussion of the condition health scoring model and approach.

The results of the condition assessment are documented in the Gas Transmission Condition Assessment Report. The condition data provides health scores for each component, an overall component health score, and a system level health score for the C&P stations.[1] The more significant results are summarized in Section 2.2.1 and Section 2.2.2. The information included in this section will change over time as projects and programs result in changes to component and system condition and risk. Therefore, the condition information contained in this section should be viewed as a snapshot of the condition through 2014.

2.2.1 Station Health

One observation in the assessment is the overall poor health of the Topock Compressor Station. The Topock facility has received reduced maintenance over the past years since the station was identified for replacement. However, the replacement has been delayed and the overall condition of the facility requires attention. The development of an overall investment strategy for this station is required and is part of the Long Term Compression Investment Plan that is included in Appendix N. Table 6 summarizes the overall condition for each station is based on the current condition assessment.

Table 6 – Station Condition Summary

Station	Overall Condition	Comments
Tionesta	Good	• Gas compressor replaced in 1990s • Recently upgraded electrical equipment and system, including standby generator
Burney	Fair	• Standby generator is obsolete, but operational • Parts for reaction turbine are available, but lead times are long • Engineering for K2 replacement is currently in progress
Gerber	Good	• None
Delevan	Good	• K-1 and K-2 replaced with new electric drive units in 2011 and 2010, respectively

[1] The condition data resides in the Station Equipment Database (SEDB) which is maintained on PG&E's T-Drive.

Station	Overall Condition	Comments
		• K-3 installed in 1993 • K3 unit control upgrades in 2009 • Cracking on exhaust stack for K-3
Bethany	Fair	• Vibration issues addressed, issues with motor rotor • Unit VFDs replaced in 2015
Kettleman	Good	• Liquids are getting past the filter-separator • Yard valves (original 1955 installation) are past design life • Utility power to the station is unreliable
Hinkley	Fair	• Gas compressors, station controls, and much of the associated equipment and systems, particularly electrical are aging and obsolete
Topock	Poor	• Minimal work was done at this facility for several years in anticipation of a change in the air emissions limit that would have required the station to be rebuilt. A change in the regulation is now not expected in the near term. In the meantime, the overall plant condition has declined. • External corrosion and coating issues found on main gas and fuel gas piping.
Santa Rosa	Good	• Reliability is a continuing issue • Older valves need replacement • Replacement of aging MCC and switchgear in progress
McDonald Island	Fair	• Compressor units nearing end of design life, significant expense investment needed in short term to maintain reliability • Units still supported, but lead time for parts is long
McDonald Island Rentals	Poor	• K3-K6 were removed late 2014 • K7-K9 are scheduled for removal in near term
Los Medanos	Fair	• Major critical components have been replaced or upgraded • Compressor unit (Quad) is no longer manufactured—lead time for parts is very long • Several major outages experienced with compressor piston cylinder failures • Replacement targeted for 2017 through 2019
Pleasant Creek	Good	• Compressor unit replaced in 2010

Additionally, several compressor units have been designated as chronic units to indicate that their reliability (condition and performance) has not met expectations. These units will receive additional attention and resources to improve overall reliability. The chronic units have been designated as:

- Hinkley retrofit units
- Bethany K-1 and K-2

- McDonald Island rental units (scheduled for near term removal)
- Los Medanos K-1 (notable increase in reliability over past year)
- Santa Rosa K-1 and K-2 (notable increase in reliability over past year)

These units will receive additional maintenance and project support during the next few years to improve the overall performance of these stations relative to number of outages and overall availability and reliability. A summary of the progress made in 2015 is included in Table 7 below.

Table 7 – Progress since July 2015 on Chronic Unites

Unit	Actions
Los Medanos K1	• One piston failure at the end of 2015 which was attributed to old age. One piston failure to date in 2016. The cause of the failure is being investigated. • Nitride power cylinders installed in 2015 still running well. Installed 3 more of these cylinders during the 2016 annual maintenance. • Remaining crack prone cylinders were replaced. GE (OEM) modified their cylinder casting design to eliminate the stress concentration causing the issue. • GE implemented proposed fixes for some parts quality issues. To date, no quality issues to report.
Bethany K1, K2	• K1 and K2 VFDs at Bethany were commissioned December 2015. • Unit controls upgrade project was completed its surge testing on 9/21/15.The new Petrotech program has been installed and with the help of Siemens, new surge lines for each unit have been created. Each unit runs efficiently when run separately; however, maximum efficiency of both units have not been utilized when run together due to load sharing logic. Load sharing program has been created by ICE group. Few tests on load sharing have been done but due to pipeline condition, both units have not been running beside the few initial hours.
Hinkley Retrofits	• Relocation of instrumentation off the compressor skids started and scheduled to be complete by mid-2017 • All retrofit PLC's have been replaced except for HK7 • K1 and K4 turbochargers and the spare HPO90 turbocharger have been replaced with upgraded turbochargers • Completed investigation of issues with the fuel ignition system on the units. Replaced or upgraded ignition systems on K3, K11 and K12
McDonald Island Rentals	• Notable improvements in flow performance. Flow performance has been near 90% for four months. • Reliability remains a concern; Archrock appears unable to break the trend of numerous minor breakdowns. • PG&E will likely begin operating the units this injection season. This is a contract requirement, and is not anticipated to increase flow performance. Outage hours may increase after PG&E begins operation due to less onsite Archrock presence, and Archrock call-outs originating from Bakersfield.
Santa Rosa K1, K2	• GSO has successfully been performing monthly starts remotely with no failed starts. • CROP was reversed, line is back to 610 Maximum Allowable Operating Pressure • Construction started in April on project to replace the station and unit electrical power systems and controls.

2.2.2 System / Component Health Scores

Directionally, we want to get to a state where Compression & Processing assets are routinely evaluated against condition targets specific to the facility. Resources are then preferentially applied to those assets that are below these targets. The chart in Figure 3 Average Health Scores by System provides an overall average health score for systems across all C&P facilities. (See Appendix H for information on the health scoring model and criteria). These health scores are based on currently available data that is incomplete and inconsistent. Therefore, subject matter expert review is required to validate the current health scores.

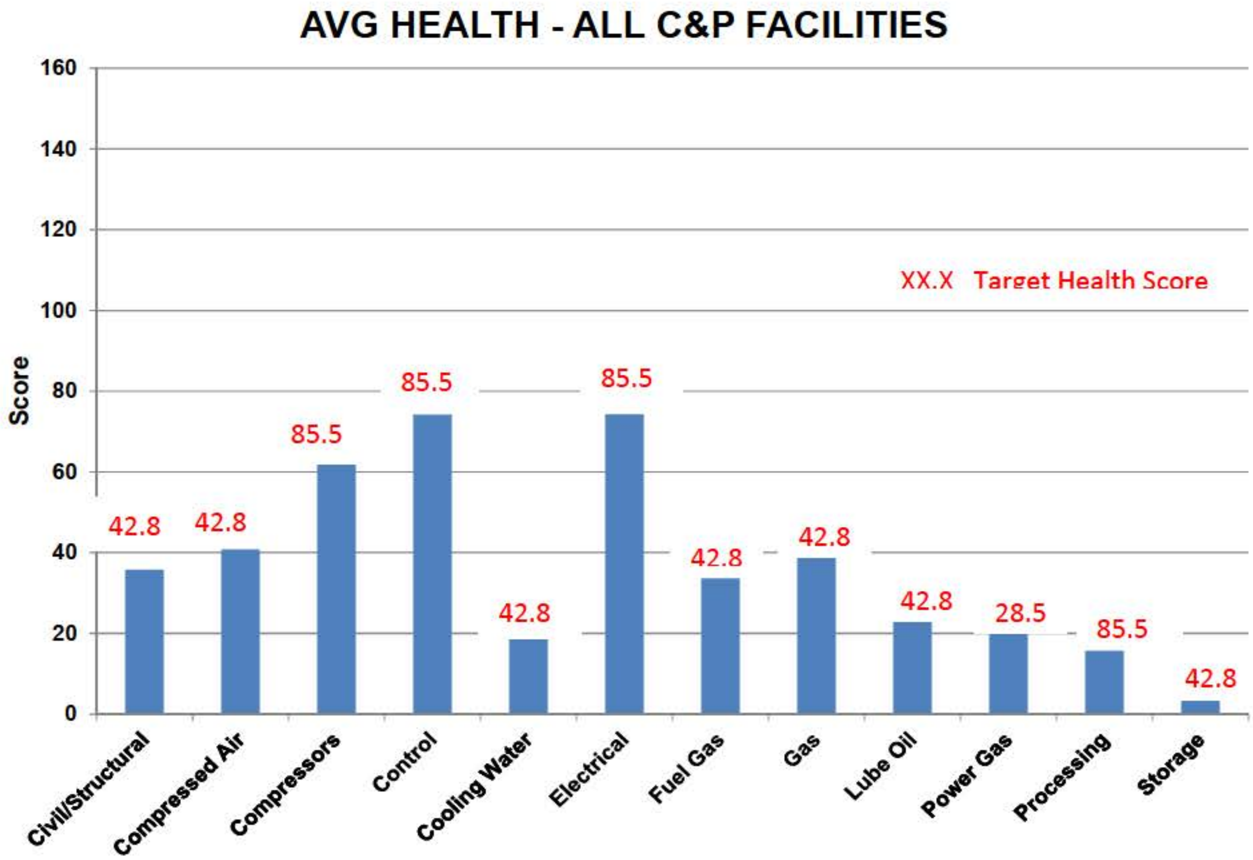
The last condition assessment of the C&P assets was performed in 2014 and the data shown in this section reflect that analysis. There is a plan in place to conduct a pilot condition assessment at one compressor station in 2016 to help further refine the condition assessment model to more closely align with Subject Matter Expert (i.e. Facility Engineers) assessments.

The score for each system is then compared to a target score for that system. The key assumptions and approach for setting the system targets is defined in Appendix J. The current system target health scores are shown in Table 8. It is anticipated that these targets will be modified over time.

Table 8 - C&P System Target Health Scores

System	Target System Health Score
Civil / Structural	42.8
Compressed Air	42.8
Compressors	85.5
Control	85.5
Cooling Water	42.8
Electrical	85.5
Environmental	42.8
Fire Detection / Suppression	42.8
Fuel Gas	42.8
Main Gas	42.8
Lube Oil	42.8
Power Gas	28.5
Processing	85.5
Security	42.8
Storage	42.8

Figure 3 – Average Health Score by System



The condition assessment identified three systems – compressors, control, and electrical – as having the highest health scores (which indicate the lowest health). Based on these results, the projects and programs proposed for the time period covered by this plan have been prioritized around these three systems.

Conversely, the scores for the processing and storage assets scored significantly better than their target scores. This can best be explained as a reflection of the investments made to these assets over the past several years (e.g. rebuilds of Whisky Slough and Turner Cut platforms).

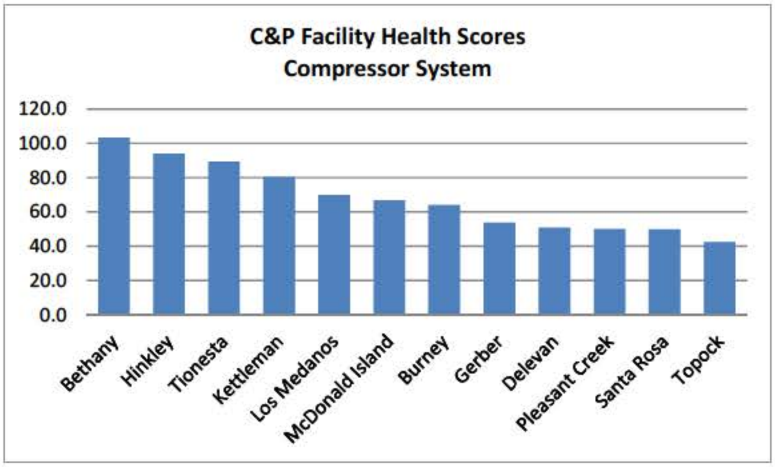
The three highest priority systems are described in the following paragraphs. See Appendix K for the assessment results of each of the systems. Information is provided on each system by facility to guide the need for projects or programs at specific facilities. Additionally, the target scores are included in the graphs within the appendix to provide further guidance into program and project needs.

Compressor System

The results of the condition assessment are provided in Figure 4 for the compressor system for the various facilities. Based on discussions with the facility engineers, there has been recent work on Delevan, Gerber and Kettleman so these stations should have relatively good condition scores compared with other units. Also, Bethany has recent and pending replacement work so this can be reduced in significance. The facility rankings for actions based on facility engineer feedback are:

- Burney (older system with limited spare parts and is scheduled for rebuild, scored high in the 2014 compressor assessment performed by Gulf Interstate Engineers)
- Los Medanos (recent major performance problems and limited availability of parts, scored high in the 2014 Gulf Interstate Engineers assessment)

Figure 4 – Compressor System Health Scores

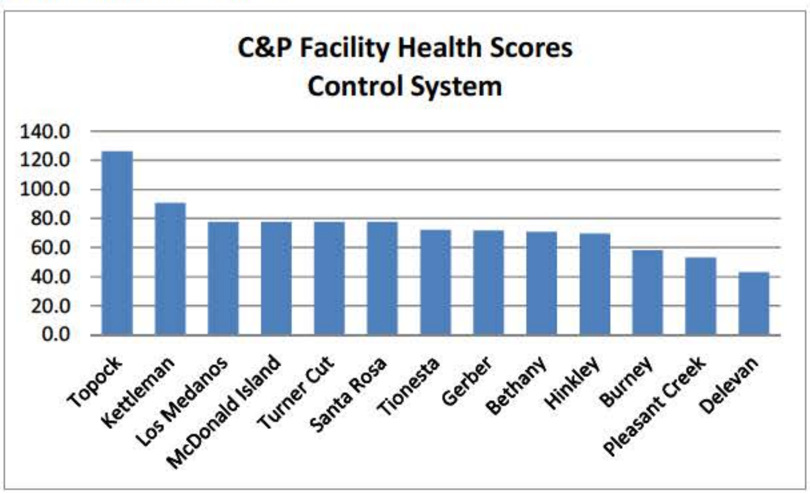


Control System

The results of the condition assessment are provided in Figure 5 for the control system for the various facilities. Based on discussions with the facility engineers, many of the stations have rebuilt or replaced control systems, including Los Medanos, Bethany, Tionesta, Hinkley, Pleasant Creek, Delevan, and Gerber. The facility rankings for actions based on facility engineer feedback are:

- Burney (included with compressor replacement project)
- Topock
- Santa Rosa

Figure 5 - Control System Health Scores



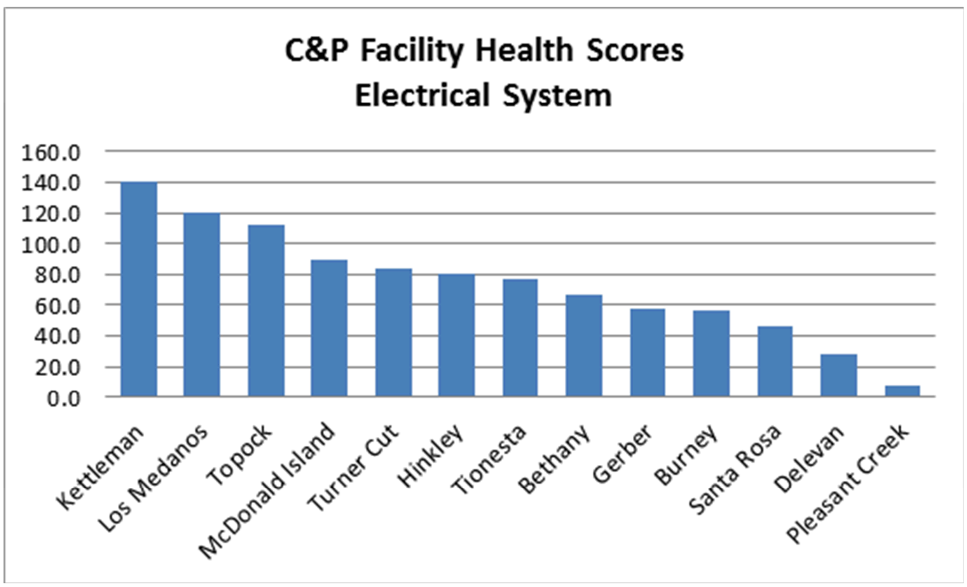
Electrical System

The results of the condition assessment are provided in Figure 6 for the electrical system for the various facilities. Based on discussions with the facility engineers, there is significant effort required to upgrade the electrical systems. The overall station scores for this system are high and indicate needed improvements in the electrical system health. Based on input from the facility engineers, the following stations have the biggest needs:

- Kettleman, Whisky Slough and Turner Cut have issues related to offsite power
- Santa Rosa and McDonald Island require transformer upgrades
- Topock has general electrical system aging and wear
- Pleasant Creek has issues with power supply and power quality

It should also be noted that Los Medanos has recent electrical system upgrades and that the Burney compressor replacement will include electrical system upgrades

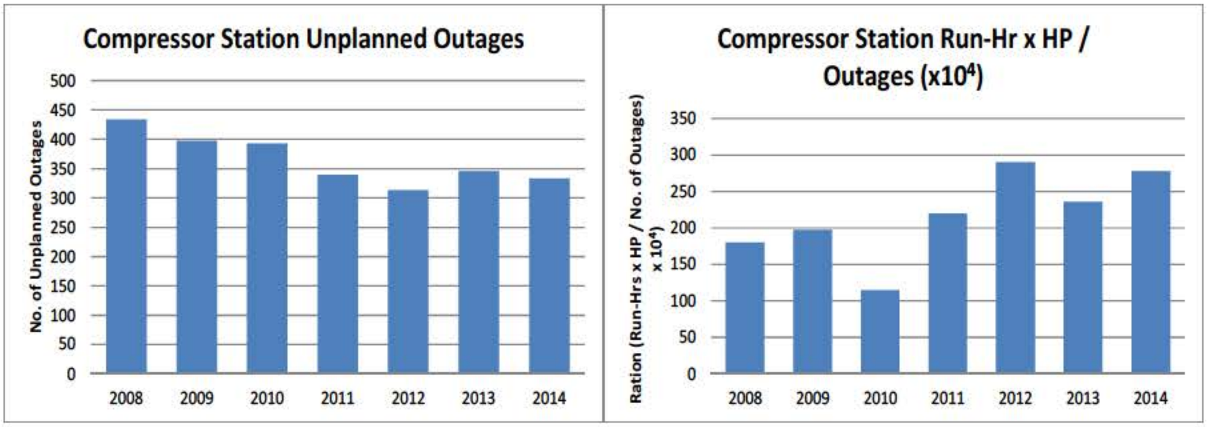
Figure 6 - Electrical System Health Scores



2.2.3 Current Asset Performance

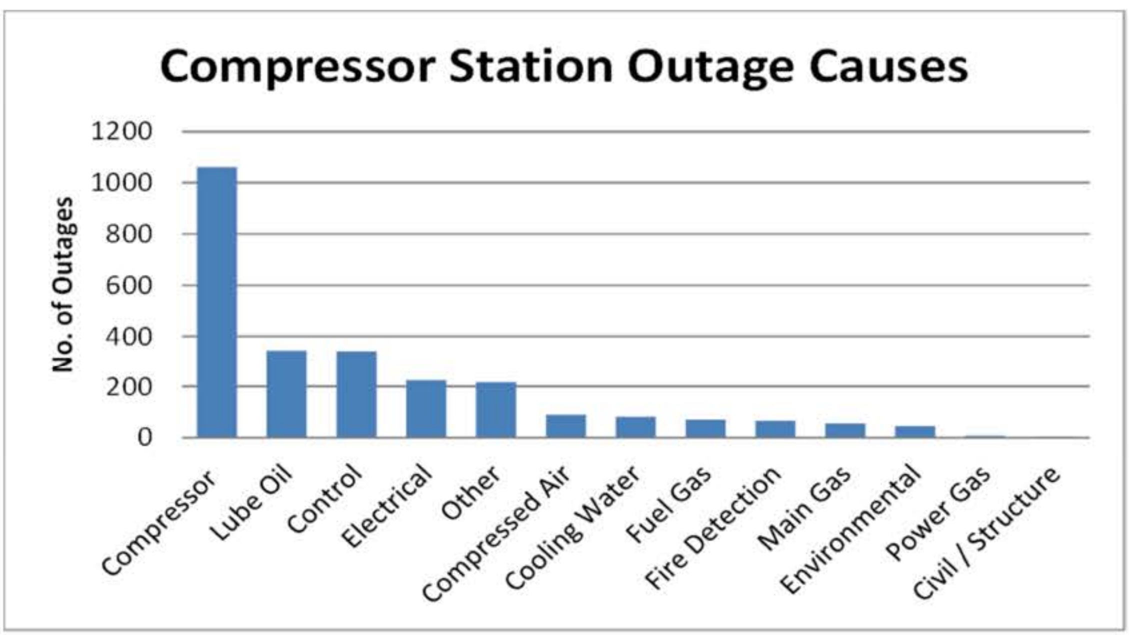
There was a specific review performed for outage performance at the compressor units since these represent the major components in the system. On a six-year view, the compressor performance is depicted system-wide in the following charts in Figure 7.

Figure 7 - Compressor Outage Data



The total number of compressor outages has shown an overall downward trend over the past 7 years although there was an increase in 2013. A measure of work between outage events is shown as the ratio of HP-Hours to unplanned outage. This metric also shows an overall improvement in the past three years, but again there was a decline in 2013. A more granular view of outage causes is shown in Figure 8. The total number of outages has been captured over the past six years and the causes are roughly grouped by system. The data available for the outage review was not specific so the outage causes were grouped based on some judgment in reviewing comments. However, the majority of outages were associated with compressor system and the compressor systems will be the focus for additional maintenance and replacement work. This category of "compressor" requires additional data and analysis to determine the specific problem subsystems. Also, the outage information was not specific enough to fully ascertain the cause so that assumptions were made when assigning outages to specific systems. The collection of this information will require improvement moving forward.

Figure 8 - Compressor Outage Causes

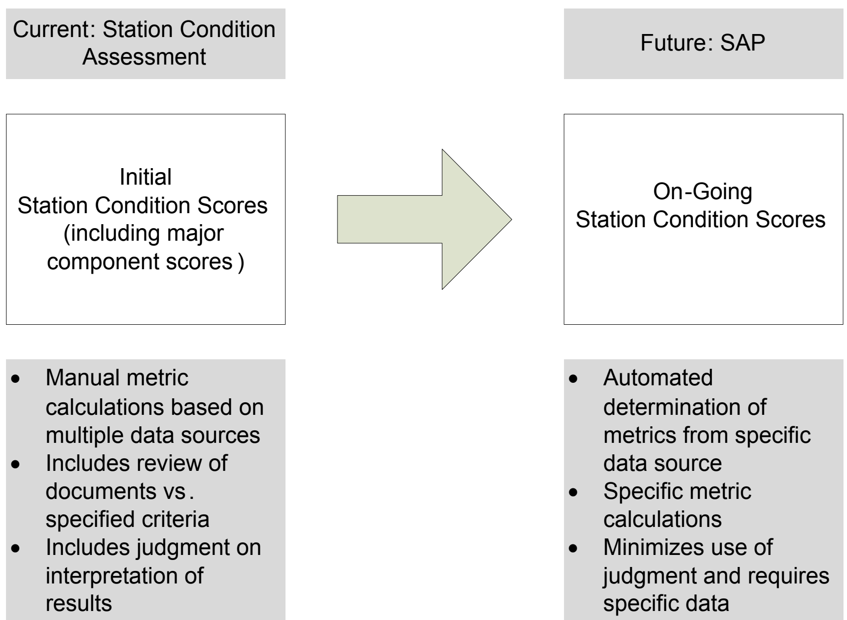


2.2.4 Asset Data for Health and Performance Monitoring

Asset Data
The condition assessment for gas transmission C&P facilities provides a determination of station condition (or health) by utilizing a set of metrics to score major components within a station and then to roll-up these component scores to a system level condition score. The overall goal of the component and system condition metrics and scores is to provide an on-going basis for evaluating station condition to assist the asset family owners in defining and prioritizing projects and programs for the gas transmission C&P facilities.

A roadmap or process for capturing the metrics and scoring approach is shown in Figure 9 – Metrics and Scoring Roadmap
.

Figure 9 - Metrics and Scoring Roadmap



There are still gaps in the data, but overall the information reviewed allowed for a reasonable determination of station and component condition. Data quality and availability still remains a focus for attention moving forward to ensure that decision-making is made on current and accurate information.

The current data provides valuable information when leveraged by subject matter experts, knowledgeable in the facilities and systems, to define risks and mitigations. However, data for this asset family is limited in terms of quality, completeness, and accessibility to support a complete quantitative analysis of asset risk. Further, there are gaps in the available data which limit its reliability and use for monitoring program impact on risk reduction and tracking metrics, but programs such as the Asset Health Scorecard (AHS) and Asset Management Backbone & Stations (AMBBS) / Gas Asset Management Enhancements (GAME) are addressing the gaps. Enhancing data collection and quality is an area of focus in this plan to enable decision making going forward. An assessment of the current data is provided in Appendix L. Data Assessment.

3. Threats and Risks

Risks are tracked in an enterprise-wide risk register, a central repository where risk names, descriptions, and scores as determined by utilization of Enterprise and Operational Risk Management's (EORM's) risk criteria along with other pertinent information are documented. The risk register is updated and refined as additional information is obtained and evaluated.

The risk management framework is fully integrated into PG&E's Integrated Planning Process (IPP). This framework complements risk assessment processes already in place via integrity management programs. Additional information about the Integrated Planning Process can be found in the Strategic Asset Management Plan, GP-1100.

Continuous Process
While the formal IPP (annual review cycle) is employed as described above, risks are also identified and addressed continuously as new information is discovered either from working with asset family assets, or from experience elsewhere in industry. Risks when discovered or when a potential change is observed are analyzed, prioritized, and mitigation plans are developed and implemented on a schedule that may fall within the annual cycle described above.

This continuous process can also result in revisions to the risk assessments that are already within the Gas Operations risk register and addressed in the annual refresh cycles, either on the annual cycle schedule, or more immediately if warranted.

3.1 Threat and Risk Identification

The Asset Family Owners (AFOs) work with their teams to identify the threats to the assets in their families. The AFO relies on American Society of Mechanical Engineers (ASME) Standard B31.8S and 49 Code of Federal Regulations (CFR) Part 192, Subpart O as the basis for categorizing and evaluating the threats. Table 9 below describes the threat categories from ASME B31.8S.

Table 9 – Threat Categories

Threat Category	Description	Specific Threats
Time-dependent	Potentially increase over time	• External Corrosion • Internal Corrosion • Stress Corrosion Cracking
Stable or "Resident"	Present, or potentially inherent in the pipeline, but do not grow over time or pose a threat unless influenced by another condition or failure mechanism	• Manufacturing • Construction/Fabrication • Equipment threats
Time-Independent	Not influenced by time	• Third Party Damage • Incorrect Operation • Weather and Outside Forces

In addition to these threat categories, PG&E evaluates threats related to its obligation to serve, both in terms of ensuring reliable delivery of natural gas and increasing capacity to meet demand, as well as threats posed by an inadequate response to and recovery from emergencies.

Threats are identified through the Corrective Action Program (CAP) and various on-going maintenance and assessment programs. Each AFO works with his/her team and other Subject Matter Experts (SMEs) to determine the relative risk associated with each threat. Risks are calibrated across both Gas Operations and enterprise-wide.

3.1.1 Primary Threats and Mitigations

The threat matrix in Appendix B lists the primary threats that are deemed applicable to the C&P asset family. The discussion below highlights the reason for the threat and primary mitigation measures. These threats guide the identification of the risks contained in the C&P Risk Register.

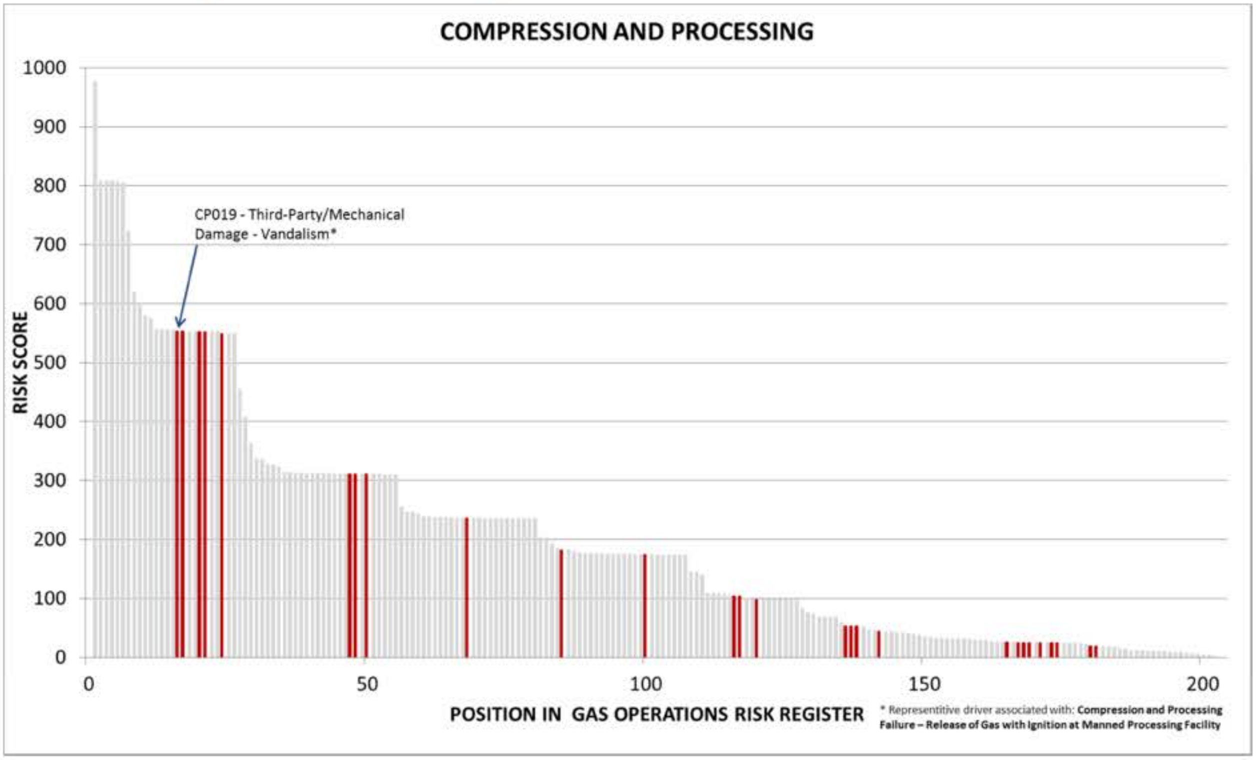
3.1.2 Key Compression & Processing Risks

Using the identified threats from the threat matrix, risks have been identified and annually updated for the C&P asset family, and prioritized for both Gas Operations (addressing risks across asset families) and within the asset family (as part of the risk and compliance process).

The EORM process addresses low likelihood, high impact risks. The C&P asset family identified 27 risk drivers in 2016. The top C&P risk driver (CP19) ranked 16th among the 204 risk drivers in Gas Operations with the ten highest scoring C&P asset family risk drivers in the top half of Gas Operations risk drivers.

Figure 10 below is a histogram that displays the position of the C&P asset family risks within the Gas Operations risk register, based on the analysis performed during 2016 Session D.

Figure 10 – Gas Operations Risk Histogram



The nine highest scoring risks for the C&P asset family are detailed in 10. See Appendix C for a complete listing of all C&P risks.

Table 10 – Key Compression and Processing Risk Drivers*

Risk ID	Risk Description	Threat
CP19**	The risk of vandalism or terrorist attack at facility may result in personal safety, loss of service, loss of containment, and/or equipment damage	Third Party / Mechanical Damage
CP22	The risk of a 6.7 earthquake may result in loss of service, loss entire compressor station (Hinkley and Los Medanos), and ignition	Weather Related/Outside Forces – Seismic [redacted]
CP12	The risk of equipment failures from poor design or manufacturing process may result in loss of service and possible loss of containment	Manufacturing Defects
CP8	The risk of poor construction practices may result in loss of containment and loss of service	Welding/Fabrication Related
CP6	The risk of incorrect operations causing failure or malfunction of critical pressure containing equipment at a	Incorrect Operations

Risk ID	Risk Description	Threat
	[redacted] facility may result potential loss of containment	
CP1	The risk of through wall leaks in storage facility piping from internal or external corrosion (discharge side) may result in loss of containment, loss of service and reliability.	External/Internal Corrosion
CP2	The risk of through wall leaks from external corrosion forming beneath pipe insulation material may result in loss of service and loss of containment.	External Corrosion – Under Pipe Insulation
CP10	The risk of through wall leaks in storage processing, withdrawal piping and pressure vessels from internal corrosion or erosion may result in loss of containment, loss of service, and reliability.	Internal Corrosion & Erosion
CP13	The risk of aging electrical equipment at C&P stations may result in worker safety and loss of service	Equipment Related

* All risks with a score of 200 or higher as a result of the 2016 Session D process
** Enterprise Level Risk

3.2 Integrity Management Programs

C&P assets will be operated under the principles of the Facility Integrity Management Program (FIMP) and will interface with the Transmission Integrity Management Program (TIMP) at the station boundaries. In addition, the C&P asset family leverages information from TIMP to identify asset risks. These integrity management programs are described below.

Facility Integrity Management Program (FIMP)

PG&E's Facility Integrity Management Program (FIMP), identifies, assesses, and mitigates risks in order to reduce both the likelihood and consequences of gas transmission facility incidents. This includes facilities within the Measurement & Control and Compression & Processing asset families. While the approach for assessing risk within FIMP has similarities to TIMP/DIMP, it should be noted that an integrity management program for facilities is, by definition, quite different from an integrity management program (IMP) for a pipeline. These differences are driven by the nature of the assets to be managed (scope) and the resulting objectives (program purpose) for those assets as well as vastly differing life cycles. The table below highlights the differences between pipeline integrity management programs and FIMP.

Table 11 – Comparison of Integrity Management Programs

Element	Pipeline Integrity Management Programs	FIMP
Scope	Assets are relatively uniform (i.e., pipelines of varying grades, wall thickness, and diameter)	Disparate asset types
Program Goal	The safe environmentally responsible and reliable service of pipelines by working towards minimizing loss of containment	The safe environmentally responsible and reliable service of all pipeline system facilities, exclusive of pipeline, by ensuring

Element	Pipeline Integrity Management Programs	FIMP
	events	control and containment of service fluids (e.g., gas, lube oil), and equipment meets or exceed design life given its intended purpose and actual operating conditions
Asset Life Cycle	Long life cycle	Life cycles vary significantly and assets with long life cycles often contain numerous components with short life cycles

Source: Canadian Energy Pipeline Association, Facility Integrity Management Program Recommended Practice, 1st Edition, May 2013

Transmission Integrity Management Program (TIMP)

The TIMP program is a mature, well-defined program for assessing the risk related to different segments of pipe on the system and taking action to prevent or mitigate these risks. The approach for assessing risk is based on an assessment of likelihood and consequence of a leak or rupture, and uses the nine threats listed in the threat matrix to identify high-risk segments. While the TIMP risk management process contains many elements that overlap with risk assessment processes within the risk register, it is a separate process that considers threats to individual segments of pipe as opposed to the system as a whole. *Please refer to document GP-1101: Transmission Pipe Asset Management Plan for more details.*

4. Desired State, Strategic Objectives, Programs and Risk Mitigations

The long term vision for the Compression & Processing asset family is to improve the overall reliability of the assets through a combination of infrastructure improvements and promotion of a culture that focuses on long term reliability of the assets. While infrastructure improvement is a key element in improving reliability, having a culture that is focused on the long term health and reliability of the assets is necessary for sustained improvement. Goals supporting this vision include:

- Improve asset reliability over time via incremental change driven by data and metrics
- Shift focus and culture of engineers and maintenance and operations personnel from being purely reactive to planned long term reliability
- Take a broader view of reliability – include systems, not only individual compressor units
- Perform Reliability – Centered Maintenance studies on C&P facilities and implement recommendations related to maintenance, operational, and spare parts practices
- Utilize the results of the condition assessment effort to give visibility to the systems at greatest risk to prioritize and sequence capital investments for Compression & Processing assets
- Foster an improved culture of accountability by local crew and leadership for station reliability.

The strategic objectives of the C&P asset family align with PG&E's corporate vision to be the safest most reliable gas company in the US. A world class asset management program includes the following key elements:

- Risk-based maintenance and inspection plan that defines preventive and condition-based maintenance tasks that address major system and operating threats and risks
- Data and records that provide for continual trending, monitoring, and prioritization
- Procedures and on-going personnel training that reflect the overall inspection and maintenance programs.

A key program to ensure that the long-term vision for the C&P assets is carried out is the development and implementation of a robust Facility Integrity Management Program (FIMP). The FIMP defines the long-term desired state for the condition and the management of the C&P assets.

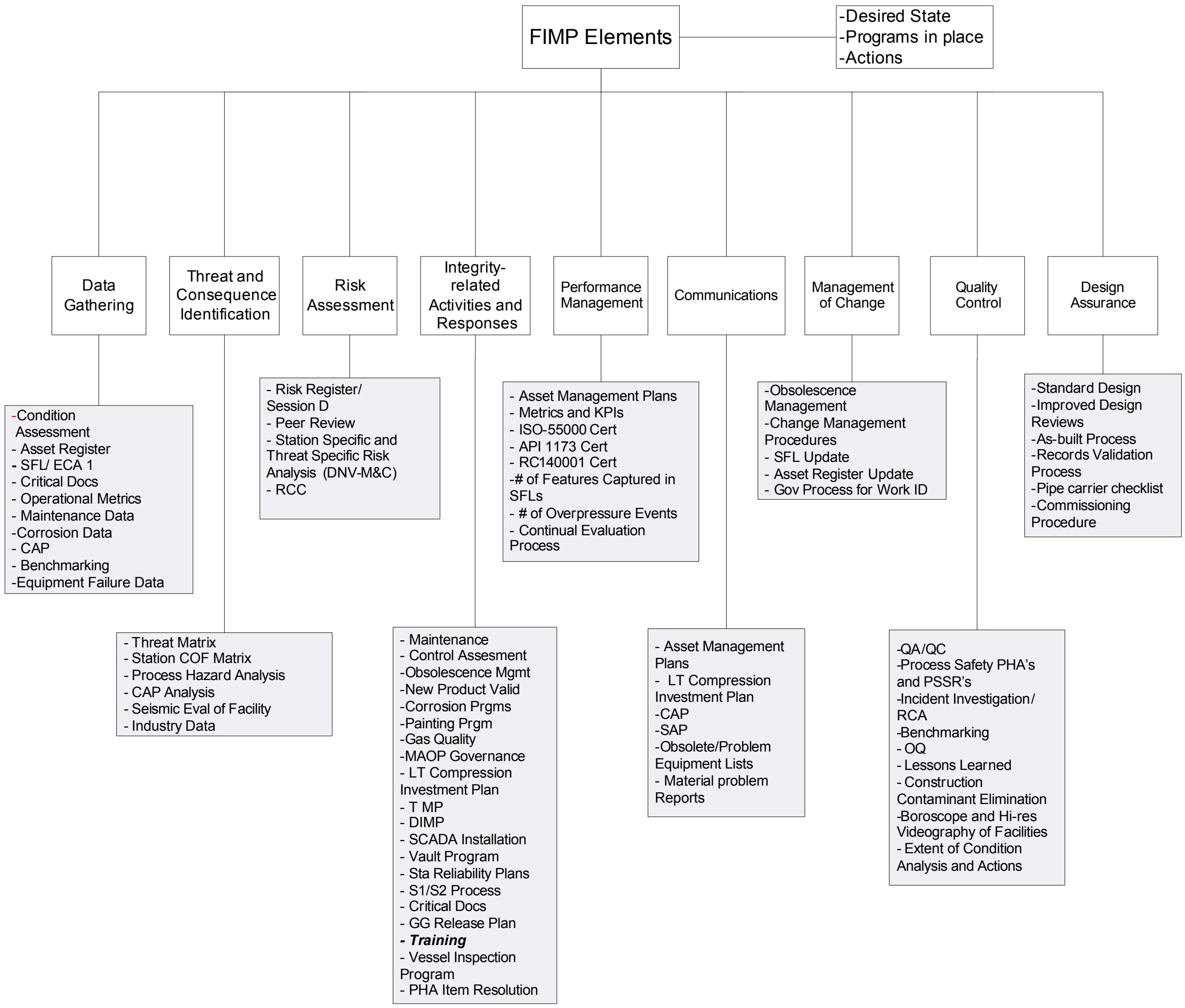
Facilities Integrity Management Plan (FIMP)
One of the strategic objectives is to Apply Facility Integrity Management principles to all transmission and distribution stations by 2025. PG&E's goal is to develop a world-class facility integrity management program. This task consists of preparing the roadmap and FIMP plan to guide the development and implementation of various program elements. This task includes working with PG&E stakeholders to prepare and review the plan and to define implementation actions. The FIMP plan has been prepared to address the following issues as well as recommendations from the station condition assessment program. The plan will focus on the integration of current activities along with newly identified actions.

1. Data gathering (including storage and retrieval)
2. Threat identification and consequences
3. Risk assessment and prioritization

4. Integrity-related activities (including the specification of maintenance and inspection activities to address compliance and reliability needs)
5. Response actions for inspection and maintenance findings
6. FIMP performance management
7. Reporting and communication of FIMP issues
8. Facility change management (how to address changes to facilities so that appropriate asset management information is updated and tracked)
9. Quality control requirements to ensure FIMP requirements are being met and lessons learned are incorporated into the program
10. Design-related activities to ensure that FIMP requirements are included in design of facilities

The C&P Asset Management plan will become a part of the FIMP, which is shown in Figure 11 below.

Figure 11 – FIMP Elements



FIMP Maturity Model

In order to evaluate whether 2025 represents the right pace for FIMP development, each of the elements is evaluated against a FIMP maturity model. The strategic objective will be reached when each of the elements is deemed to score a ten (10), which means that it has reached its desired state. Intermediate States are also defined and given a score (e.g., 4, 5, 8, etc.). The element score is determined by evaluating the status of each of the programs that make up that element as to where they are on their path to their desired state. The model and scoring criteria are shown in Figure 12 below. As shown in that Figure, the current state of maturity at the end of CY 2015 was shown to be 24% of the desired state. Scores for each element are shown highlighted in yellow in the figure.

Once the current level of maturity was determined, an attempt was made to predict how where the FIMP would be at the end of 2016. This was calculated by analyzing the various specific actions that are planned for 2016 for their potential impact to improve the score in their respective elements. Based on that assessment, it is expected that the state of maturity at the end of 2016 will be 32% along the path to the desired state. This projection is highly dependent on the planned actions actually being accomplished and their having the desired effect.

Beyond 2016 the process described above will be repeated and the current status of the maturity of each element as well as a forecast for improvement in the following year will be established. This evaluation will include an analysis of how successful the actions planned for that year had been as well as the development of a specific set of actions for the following year with a forecast of the expected improvements they will bring.

A forecast has been made of expected progress through the year 2025 is shown in both tabular and graphical format in Figure 13. This forecast was highly dependent on the forecast completion dates of the major programs shown under each element in Figure 14. As large projects such as SFL/ECA 1 and Critical Documents are completed and their results become a routine part of normal business, it is expected that the maturity score of their element will improve. This longer term forecast will also be revisited each year as part of the continual evaluation process

Figure 12– FIMP Maturity Score

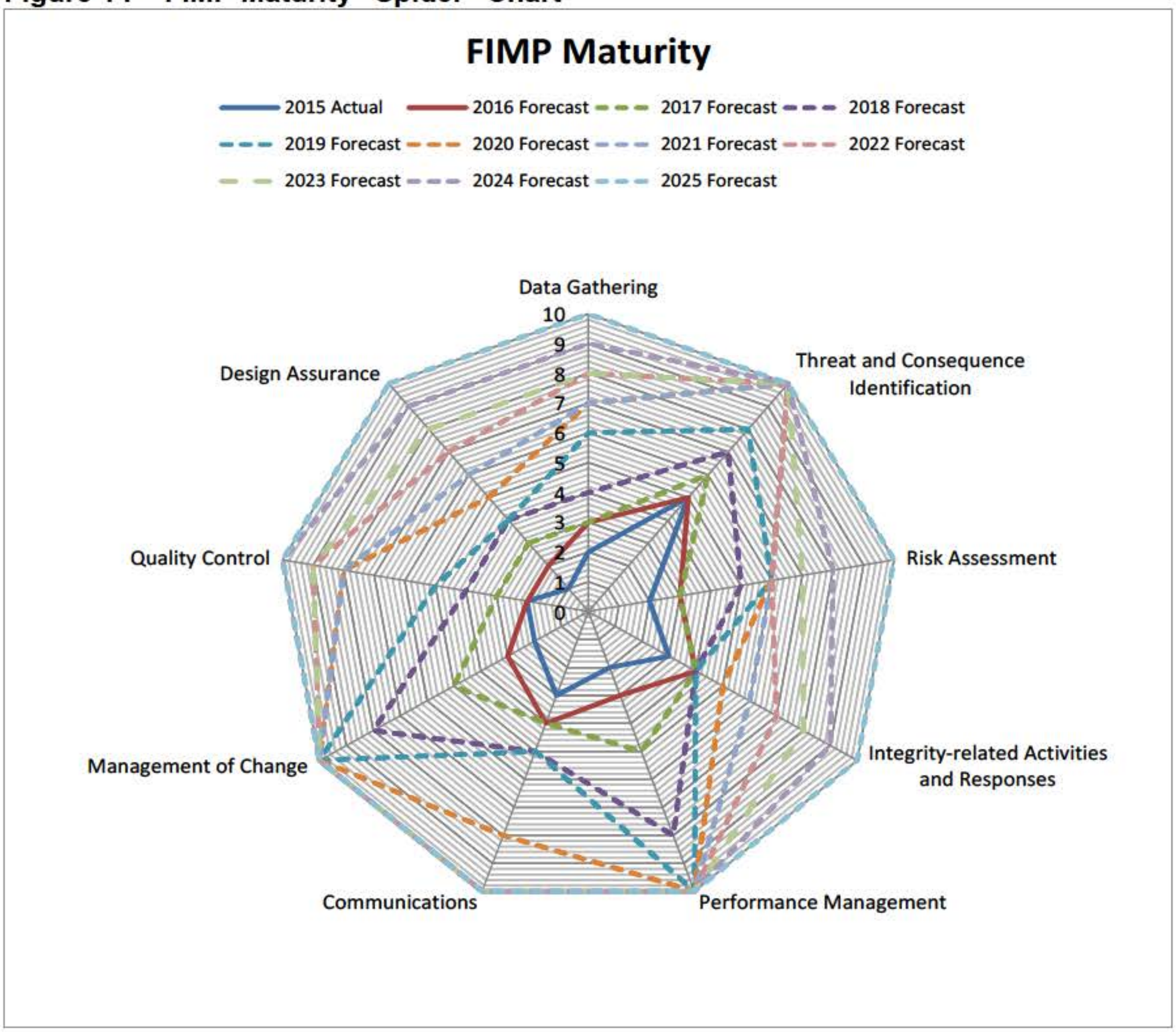
FIMP Maturity Score

Maturity Score	Data Gathering	Threat and Consequence Identification	Risk Assessment	Integrity-related Activities and Responses	Performance Management	Communications	Management of Change	Quality Control	Design Assurance	Overall Score
0	No data collection	No threat or consequence identification	No risk assessment	Reactive programs and projects	No asset management plan or metrics	No data collection	No data collection	Limited QC / no benchmarking	No standard designs / process safety	24%
1									**(2016 same as 2015)**	32%
2	Limited data collected; limited accessibility for analysis		General risk assessment; industry data		Asset management plan; limited metrics		Limited data collected; limited accessibility for analysis	Limited QC and benchmarking **(2016 same as 2015)**	Standard designs for Distribution	
3	All assets within SAP (T&D)		Risk models exist (T)	Condition informed programs and projects	Asset management plan; key metrics updated and available	Limited data collected; limited accessibility for analysis	SFL and Obsolescence Project Pilots are in place	PHA's, PSSR's and Incident Investigations are a normal part of business	Commissioning procedure in place for Distribution	
4	Ops diagrams updated			RCM studies for 2 locations; control assessments and training implemented; condition assessment snapshots		Condition data available for informing program and projects		Construction contamination elimination and boroscoping/ hi-res video inspections in place	PHA's and PSSR's are a normal part of business	
5	Maint and corrosion programs in place for T&D and included in SAP	Identify threats at P95 level annually at a fleet level (CAP, SME, Ops data, Benchmark)	Risk models exist (D)	RCM expanded; condition assessment automated; corrosion activities implemented	Asset management plan; key metrics updated and available. Data is easily accessible	Integrity management and condition information available for informing program and projects	MOC process rolled out to the entire FIMP Organization in accordance with Standard	Extent of Condition analysis and actions complete; mitigations in place	Standard designs for Transmission	
6	Data and assets from P&IDs in SAP (T)	Add seismic risk threat	S-Map models (fleet level)							
7	SFL/ECA1 (records) complete (T)	COF T complete on station basis	Risk models (T) at station level w/ data							
8	SFL/ECA1 (records) complete (D); Data and assets from P&IDs in SAP (D)	COF D complete on station basis	Risk models (D) at station level w/ data	Facility integrity management activities in place, updated regularly.	Asset management plan; metrics defined for all elements and available for informing programs and projects	Integrity management and condition information available for informing program and projects; automated updates	Asset Register update process in place	Lessons Learned and Benchmarking are incorporated into the normal business		
9	Integrated data in SAP (incl. SFL)									
10	Data is collected on a regular basis as part of a normal business process; data is stored where it is accessible for trending and analysis; and data is complete and accurate.	Complete and on-going identification and modification of threats and consequences at station level.	Risk assessment updated on a regular basis at a station or facility level.	Facility integrity management activities in place, updated regularly and risk-informed.	Asset management plans and programs driven by regularly updated metrics.	Integrity management activities underway; risk assessment and investment plan by station available and accessible; Regular updates of information based on data-driven information and analysis	Full implementation of mature, well-documented business processes	Full implementation of mature, well-documented business processes	Full implementation of mature, well-documented business processes	
NOTES	2015									
	2016									
2015 Score Basis	There are significant data collection programs underway to complete data sets; to migrate data sets; and to make data more assessable for analysis. However, the current information is not easily assessable for use.	Significant work has been done to identify and quantify risks at a P95 level. Less information has been prepared to address the lower consequence / more frequent events that represent most of everyday work.	Risk assessments are performed using industry data, but there is limited PG&E specific failure data available for use. Risk assessment is currently at a station level and less equipment specific.	There are many integrity related activities being performed and many are condition based. There is limited risk based specific equipment and system based risk analysis.	Asset management plans are developed, but limited use of metrics is being performed.	There are many tools being used to communicate asset information and problem information. However, there is no on-going approach to integrating and evaluating this information.	Significant work is underway for programs affecting this category, but there is still substantial effort required for data to support change management. There is a pilot being performed for FIMP MOC in the ECA1 program.	QC issues have been identified for recent projects and this item has been tagged "red" in the threat matrix.	Limited standard design standards for transmission. Recent issues with as-built process and OC.	Score is a percent based on total score of the 9 categories divided by 90 (maximum score)

Figure 13 – Forecast of FIMP Maturity

Year	Data Gathering	Threat and Consequence Identification	Risk Assessment	Integrity-related Activities and Responses	Performance Management	Communications	Management of Change	Quality Control	Design Assurance	Score	
2015 Actual	2	5	2	3	2	3	2	2	1	24%	
2016 Forecast	3	5	3	4	3	4	3	2	2	32%	Forecast
2017 Forecast	3	6	3	4	5	4	5	3	3	40%	Forecast
2018 Forecast	4	7	5	4	8	5	8	4	4	54%	Forecast
2019 Forecast	6	8	6	4	10	5	10	5	4	64%	Forecast
2020 Forecast	7	10	6	5	10	8	10	8	5	77%	Forecast
2021 Forecast	7	10	6	6	10	10	10	8	6	81%	Forecast
2022 Forecast	8	10	6	7	10	10	10	9	7	86%	Forecast
2023 Forecast	8	10	7	8	10	10	10	9	8	89%	Forecast
2024 Forecast	9	10	8	9	10	10	10	10	9	94%	Forecast
2025 Forecast	10	10	10	10	10	10	10	10	10	100%	Forecast

Figure 14 – FIMP Maturity "Spider" Chart



C&P Strategic Objectives

The C&P asset family's strategic objectives are defined both top-down, from corporate line-of-sight objectives and goals, and bottoms-up, based on the condition and risks to the assets. Using these inputs, a 5-year program plan has been defined to meet C&P, Asset Management and corporate objectives. These objectives also align with PG&E's vision to be the "safest and most reliable gas utility in the United States".

The Gas Operations objectives are as follows:

- Safe: Safety First / Find It and Fix It
- Reliable: Do the Right Work in the Right Way
- Compliance: Do the Right Thing
- Affordable: One Company, One Way
- Customer: Do Say Ratio = 1
- People: Build Unity and Trust

The C&P strategic objectives and associated metrics are mapped to the Gas Operations objectives as shown in Table 12 below.

Table 12 – C&P Strategic Objectives

Gas Operations Objective	Strategic Objective	Metric
Public, Employee & Contractor Safety / Reliability /Affordability	Use Long-Term Compression Investment Plan information to inform 2019 GT&S Rate Case	Percentage of plan development milestones met
Reliability	Reduce total number of compressor unscheduled shutdowns by 10% per year	Number of unscheduled outages compared to target
Public, Employee & Contractor Safety	Evaluate 100% of Transmission Total Station Features by end of 2019	Number of features evaluated each year compared to target
Public Safety	Implement site-specific corrosion monitoring programs to enhance existing programs by 2018	Number of stations with fully implemented monitoring programs
Public Safety / Reliability	Apply Facility Integrity Management principles to (T and/or D) all stations by 2025	Percentage of FIMP elements implemented at each station
Public, Employee & Contractor Safety / Reliability	Complete Physical Security Upgrades at Critical Facilities by 2021	Percentage of milestones completed versus plan
Employee & Contractor Safety/Reliability	Critical documents defined by TD-4551S are completed by 2019	Percent complete of Critical Documents program

4.1 Strategic Objectives, Programs and Mitigations Alignment

The following programs have been identified and developed to meet the strategic objectives using the aforementioned risk-based investment strategy to address both enterprise and asset level risks, meet compliance requirements and maintain asset condition.

Table 13 – Programs, Mitigation and Strategic Objectives

Programs & Mitigations	Asset Family Strategic Objectives						
	Use Long-Term Compression Investment Plan information to inform 2019 GT&S Rate Case	Reduce total number of compressor unscheduled shutdowns by 10% per year	Evaluate 100% of Transmission Total Station Features by end of 2019	Implement site-specific corrosion monitoring programs to enhance existing programs by 2018	Apply Facility Integrity Management principles to (T and/or D) all stations by 2025	Complete Physical Security Upgrades at Critical Facilities by 2021	Critical documents defined by TD-4551S are completed by 2019
Engineering Critical Assessment (ECA) Phase 1			X		X		
Engineering Critical Assessment (ECA) Phase 2			X		X		
Hydrostatic Testing Station Facilities C&P			X		X		
Critical Documents					X		X
Physical Security (expense work)	X				X	X	
Routine Expense Spending	X	X	X	X	X	X	X
Burney K-2 Compressor Replacement	X	X			X		
Los Medanos K-1 Compressor Replacement	X	X			X		
Compressor Unit Control Replacements	X	X			X		
Compressor Unit Control Replacements	X	X			X		
Upgrade Station Controls	X	X			X		
Emergency Shutdown (ESD) System Upgrades	X	X			X		
Rebuild Santa Rosa Compressor Station Electrical Substation	X	X			X		
Upgrade Pleasant Creek Processing Facilities	X	X			X		
Gas Transmission Electrical Upgrades – Hinkley & Topock	X	X			X		

Programs & Mitigations	Asset Family Strategic Objectives						
	Use Long-Term Compression Investment Plan information to inform 2019 GT&S Rate Case	Reduce total number of compressor unscheduled shutdowns by 10% per year	Evaluate 100% of Transmission Total Station Features by end of 2019	Implement site-specific corrosion monitoring programs to enhance existing programs by 2018	Apply Facility Integrity Management principles to (T and/or D) all stations by 2025	Complete Physical Security Upgrades at Critical Facilities by 2021	Critical documents defined by TD-4551S are completed by 2019
Compressor Stations							
Gas Transmission Electrical Upgrades – Compressor Stations (Excludes Hinkley, Topock, Santa Rosa)	X	X			X		
Physical Security (capital work)	X				X	X	
Hinkley Compressor Unit Retrofit Project	X	X			X		
Install Active Fire Suppression Systems	X				X		
Routine Capital Spending	X	X			X	X	
Hard-to Turn Valve Replacement Program	X	X			X		
Preventive Maintenance Program	X	X			X		
Condition Metrics and Operating Data	X	X			X		
Cybersecurity Measures	X				X	X	
Guidance Documents	X	X		X	X	X	X
Station Design Standardization	X	X			X	X	
Training		X			X	X	
External Corrosion Control (Coatings, CP, ECDA)	X			X	X		
Process Safety	X	X			X	X	

4.2 Programs and Mitigations Overview

The timeframes for the programs and mitigations shown in Table 14 are based on the proposed 2018 GT&S Rate Case targets as of the publish date of this Asset Management Plan.

Table 14 – Program Summary, C&P Assets*

<table>
<tr><td>Program:</td><td>Engineering Critical Assessment (ECA) Phase 1</td></tr>
<tr><td colspan="2">Scope:
PG&E began performing an ECA – Phase 1 for its station facilities at the start of 2015. This work is preceded by a record retrieval and document research project that was completed late 2014. The work carried out under ECA – Phase 1 reviews and identifies the issues that may compromise station asset integrity. ECA – Phase 1 represents a comprehensive and fundamental element of improving asset knowledge. This project also helps identify situations that require additional risk mitigation, or changes to equipment or operations to achieve compliance, and will help prioritize downstream projects of ECA – Phase 2 and Hydrostatic Testing.</td></tr>
<tr><td>Desired State:</td><td>Identification of discrepancies that require mitigation</td></tr>
<tr><td>Risks Addressed:</td><td>CP5, Gas Operations Records Risk</td></tr>
<tr><td>Timeframe:</td><td>2014 – 2019</td></tr>
<tr><td>Responsibilities:</td><td>FIMP</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Program:</td><td>Engineering Critical Assessment (ECA) Phase 2</td></tr>
<tr><td colspan="2">Scope:
The scope of this program will mitigate discrepancies identified during the ECA Phase 1 program. This program will begin in 2015 and continue through 2019. ECA Phase 2 will use techniques such as determination of material property via non-destructive and destructive testing, fatigue life calculations and other evaluations that can substitute for a pressure test. The program may include small scale pipe or component replacement when the cost and/or operational impact of replacement are more favorable than the cost and/or operational impact created by station hydrostatic testing.</td></tr>
<tr><td>Desired State:</td><td>Minimize the number of discrepancies that must be mitigated through pressure testing</td></tr>
<tr><td>Risks Addressed:</td><td>CP5</td></tr>
<tr><td>Timeframe:</td><td>2015 – 2019</td></tr>
<tr><td>Responsibilities:</td><td>Gas Operations</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Program:</td><td>Hydrostatic Testing Station Facilities C&P</td></tr>
<tr><td colspan="2">Scope:
This program provides for the hydrotest of sections of pipe within C&P facilities that require it. The full scope potentially includes up to the 3 gas storage facilities, [redacted] compressor stations, and [redacted] compressor stations, but will be limited to stations/sections that require testing after ECA Phase 1 identifies risks that cannot be successfully mitigated by ECA Phase 2. This program will extend beyond the 5-year period.</td></tr>
<tr><td>Desired State:</td><td>Mitigate discrepancies remaining after completion of ECA Phase 1 and Phase 2 work</td></tr>
</table>

Risks Addressed:	CP5
Timeframe:	2018 – 2037
Responsibilities:	Gas Operations
Program:	Critical Documents
Scope: PG&E has developed and implemented a Utility Standard (TD-4551S) for the critical drawings that are required for each individual station based on the complexity of the operations at the station. Beginning in 2012, this program is expected to be completed by 2019.	
Desired State:	Compliance with the requirements of TD-4551S
Risks Addressed:	CP6, CP30, Gas Operations Records Risk
Timeframe:	2012 – 2019
Responsibilities:	Gas Operations
Program:	Physical Security (Expense and Capital)
Scope: This program has been developed in order to implement physical security measures at large station facilities. Many of the critical defined Transportation Security Agency (TSA) facilities have been outfitted with security technology, including alarms, access systems and cameras. However, even with these security enhancements, additional security measures will be required in the future to meet a changing threat/risk. Projects moving forward would include a Security Vulnerability Assessment, performed by Lawrence Livermore National Lab, similar to the assessment being conducted at Metcalf substation, to clearly identify mitigation measures to address small arms, Improvised Explosive Devices and protection of other critical components associated with gas delivery. Security enhancements would include dedicating easement for a buffer zone, utilizing barriers to prevent vehicle attacks, including Vehicular Improvised Explosive Devices (VIEDs), deploying new radar/thermal imaging technology to identify threats outside the fence line, measures to protect communication/operating systems from physical attacks and utilizing ballistic protection around critical components. Also, the security enhancement would be deployed outside the facilities to improve protection of exposed transmission pipe, valves, and related communication systems.	
Desired State:	Reduced vulnerability of critical infrastructure to terrorist-type attacks
Risks Addressed:	CP19
Timeframe:	2015 – 2020
Responsibilities:	Gas Operations
Program:	Routine Expense and Routine Capital Spending
Scope: These programs have been established to capture routine expense and capital projects that arise in the course of normal operation of C&P assets and that must be performed to maintain current levels of service and reliability.	
Desired State:	Current levels of service and reliability are maintained
Risks Addressed:	All

Timeframe:	On-going
Responsibilities:	Gas Operations
Program:	Compressor Unit Replacements
Scope: This program has been established to manage the replacement of aging compressor units and associated equipment. A White Paper prepared by Gulf Interstate Engineering provides a basis for performing a feasibility study on the units that are most likely candidates for replacement, prioritizing those units that are deemed to be feasible for replacement, and then selecting and executing the replacement of two of those units. The preliminary list of candidates includes Los Medanos K1, McDonald Island K1 and K2, Burney K2, and Delevan K3. The current plan is to replace the Burney K2 unit in 2017 and then the Los Medanos K1 unit in 2019. Assume that project scope is for a single unit; replacement units will be turbines; erect on same location as existing. This program will continue beyond the 5-year period.	
Desired State:	Obsolete unit and equipment no longer supported by the manufacturer are replaced and improved compressor unit reliability. Please refer to Long Term Compression Investment Plan in Appendix N for unit replacement strategy over the next 30 years.
Risks Addressed:	CP9, CP27
Timeframe:	2014 – 2018 (Burney K-2); 2016 – 2019 (Los Medanos K-1) and then on-going
Responsibilities:	Gas Operations
Program:	Compressor Unit Controls Replacements
Scope: This program has been developed to replace the unit control for a single compressor at one location per year over the life of the program. The scope of work includes PLC programming and system integration.	
Desired State:	Obsolete equipment no longer supported by the manufacturer is replaced
Risks Addressed:	CP33
Timeframe:	2015 – 2020
Responsibilities:	Gas Operations
Program:	Upgrade Station Controls
Scope: This program has been specifically developed to replace the station Programmable Logic Controls (PLC) at Hinkley Compressor Station, Kettleman Compressor Stations, and Gerber Compressor Station. Hinkley and Kettleman: Remove existing control systems; install new PLC-based controllers; re-write control philosophy; additional computer/terminal stations required; rebuild existing panels in control room. Gerber: add new PLC system, edit control philosophy, and add dedicated control station.	
Desired State:	Obsolete PLCs no longer supported by the manufacturer are replaced
Risks Addressed:	CP23, CP24, CP28
Timeframe:	2016 – 2020
Responsibilities:	Gas Operations

Program:	Emergency Shutdown (ESD) System Upgrades
Scope: It is anticipated that 1 ESD System will be replaced per year; new ESD system will be integrated with a new fire and gas detection system; new system will consist of 15 UVIR fire detectors, 8 gas detection sensors, 2 local control panels, and a main PLC in control building; all new conduit will be required; existing ESD valves do not need replacement except for replacement of solenoids. This program will continue beyond the 5-year period.	
Desired State:	Faster response to fires to minimize damage and facility outage time
Risks Addressed:	CP23, CP24, CP25, CP26, CP27, CP28, CP31, CP32, CP33
Timeframe:	2015 – 2025
Responsibilities:	Gas Operations
Program:	Rebuild Santa Rosa Compressor Station Electrical Substation
Scope: This project has been established to replace the antiquated substation at the Santa Rosa Compressor Station. Assume 2016 operational date; new transformer, switchgear, MCCs will be required; foundation modifications required, conduit and cable added as needed.	
Desired State:	Improved safety for employees and station reliability
Risks Addressed:	CP17, CP32
Timeframe:	2013 – 2016
Responsibilities:	Gas Operations
Program:	Upgrade Pleasant Creek Processing Facilities
Scope: This project has been created to upgrade the processing equipment at the facility. It is anticipated that the new facilities will be operational in 2015. Restore reliability & integrity while keeping the withdrawal rate at 60MMSCFD; perform following: install reboiler burner & controls upgrade; install bidirectional US flowmeter; install 500 gallon odorizer; install glycol separator; add fire detection for reboiler; replace regulator – monitor valves & controls; inspect contactor; install gas sampler; and install 100 KVA electrical power, compressor building enclosure & blowers, and yard lighting.	
Desired State:	Obsolete equipment is replaced
Risks Addressed:	Equipment Related due to obsolescence
Timeframe:	2016 – 2018
Responsibilities:	Gas Operations
Program:	Gas Transmission Electrical Upgrades – Hinkley & Topock Compressor Stations

Scope: This program has been established in order to upgrade the 480VAC electrical equipment at both the Hinkley and Topock Compressor Stations. Assume 2017 operational date; upgrade 480 VAC electrical systems including 2 SWGR sections, 2 MCC sections; 2500 LF of conduit and cable; 125 HP motor; minimal station downtime.	
Desired State:	Improved safety for employees and station reliability
Risks Addressed:	CP13, CP24, CP33
Timeframe:	2016 – 2019
Responsibilities:	Gas Operations
Program:	Gas Transmission Electrical Upgrades – Compressor Stations (Excludes Hinkley, Topock, Santa Rosa)
Scope: This program has been established in order to upgrade the 480VAC electrical equipment at large stations other than Hinkley or Topock. Assume 2 total – every other year; upgrade 480 VAC electrical systems including 4 SWGR sections, 4 MCC sections; 5000 LF of conduit and cable; 125 HP motor; minimal station downtime.	
Desired State:	Improved safety for employees and station reliability
Risks Addressed:	CP13
Timeframe:	2016 – 2020
Responsibilities:	Gas Operations
Program:	Hinkley Compressor Unit Retrofit Project
Scope: This project has been developed to include a complete engine and compressor overhaul, foundation and alignment work, auxiliary equipment modifications and High Pressure Fuel Injection NOx Retrofit. The retrofitted units (K1, K3, K4, K7, K11 & K12) are permitted to operate 24 hours a day, 365 days per year. The non-retrofitted units (K2, K5, K6, K8, & K9) cannot exceed 1,500 run hours per year. Hours return on a rolling calendar basis and are calculated separately for each unit. If we run out of non-retrofitted hours and continue to operate the non-retrofitted units, we will violate our air permit. High Pressure Fuel Injection (HPFi) is the latest development in lean burn retrofit technology. HPFi was installed on Hinkley K-1 and K-4 (2,500 BHP) in 2001 and has successfully been in operation for 28,000 hours+. HPFi is the recommend conversion for any unit at Hinkley.	
Desired State:	Additional retrofitted unit having unlimited run hours to improve station reliability
Risks Addressed:	CP9, CP24
Timeframe:	2016 – 2018
Responsibilities:	Gas Operations
Program:	Install Active Fire Suppression Systems

Scope:

This program has been established to install active fire suppression units in compressor and control buildings. Assume fire suppression system will be water in 1 gas compressor building; inert gas in 3 electrical and controls buildings; system will include firewater tank, firewater pumps, controllers, backup generator, piping, valves and nozzles.

Desired State:	Improve safety of personnel at [redacted] facilities and mitigate spread of fire, reducing damage and outage time
Risks Addressed:	CP21, CP22, CP23, CP24, CP25, CP26, CP27, CP28, CP31, CP32, CP33
Timeframe:	2016 – 2025
Responsibilities:	Gas Operations

Program:	Hard to Turn Valve Replacement Program

Scope:

This program has been established to identify valves that are hard-to-turn and systematically remove and replace. It is anticipated that we will replace 10 six-inch diameter valves per year; valves are ANSI CL600, carbon steel ball valves; valves are buried and weld-end; and x-ray inspection is required. The costs for this program are captured in the Transmission Pipe program and will continue beyond the 5-year period.

Desired State:	Improved operability
Risks Addressed:	CP23, CP24, CP25, CP26, CP27, CP28, CP31, CP32, CP33
Timeframe:	On-going
Responsibilities:	Gas Operations

Program:	Preventive Maintenance

Scope:

This program has been established to ensure that our preventative maintenance programs continue to meet or exceed code requirements and are consistent with best industry practices. The costs for this program are included in the District / Division maintenance budgets. This is an on-going program and will continue beyond the 5-year period.

Desired State:	Minimize corrective maintenance backlog and deferred maintenance
Risks Addressed:	CP17
Timeframe:	On-going
Responsibilities:	Gas Operations

Program:	Condition Metrics and Operating Data

Scope:

This program has been established to develop metrics to track and ensure optimal operating performance of C&P facilities. This program has also been developed to establish and prioritize categories of operating data to be captured, evaluated, reported, and retained. The costs for this program will be captured in the operating plans of the Gas System Planning and Asset Knowledge Management groups. The development of this program will be completed within the 5-year period. However, on-going maintenance of the metrics will continue beyond the 5-year period.

Desired State:	Improved visibility into operating condition of the assets
Risks Addressed:	All
Timeframe:	2014 – 2019 for system development, On-going upkeep of data
Responsibilities:	Gas Operations
Program:	Cyber Security Measures
Scope: Implement cyber security for all GT assets. Cyber security standards have been created because sensitive information is stored on computers that are attached to the Internet. Also, many tasks that were once done by hand are carried out by computer; therefore there is a need for Information Assurance (IA) and security. Applicable security management practice standards will be utilized in the development and implementation of this program. This program is on-going to address 3rd party threats and will continue past the 5-year period.	
Desired State:	Recommended actions for protecting critical data and systems
Risks Addressed:	Enterprise Cyber Security Risk
Timeframe:	On-going
Responsibilities:	Enterprise Cyber Security organization
Program:	Guidance Documents
Scope: This program has been developed to ensure that comprehensive reference and guidance documentation is available or specifically prepared for all applicable processes that encompass the work performed by the C&P asset family. This includes applicable Utility Standards; methodology for compliance with federal and state codes and standards; applicable API, ASME, ANSI and other trade association and industry standards; engineering and design standards; recommended equipment operation and maintenance reference documents; and all other applicable documentation. Costs for this program will be captured in the operating plan of the Codes and Standards group.	
Desired State:	Guidance documents that have sufficient detail to ensure safe operation and maintenance of C&P asset components
Risks Addressed:	CP6, CP8, CP12, CP30, Gas Operations Records Risk
Timeframe:	On-going
Responsibilities:	Gas Operations
Program:	Station Design Standardization
Scope: This program has been developed to ensure consistency between C&P engineering and design work; to ensure that designs comply with applicable regulations and employ best safety practices; to ensure cost-effective design methodology; to provide uniformity in selection of equipment; and to streamline required training and operation & maintenance of installed systems. The Gas Transmission Engineering & Design Manual is being developed to accomplish these objectives. The costs for development of this manual are captured in the operating plan for the Engineering & Design Group.	
Desired State:	Published set of station design standards and guides

Risks Addressed:	CP6, CP7, CP30, Gas Operations Records Risk
Timeframe:	2018
Responsibilities:	Gas Operations
Program:	Training
Scope: This program has been established to ensure that the training regimens for District / Division and engineering personnel are comprehensive, cover operation and maintenance requirements of all applicable equipment, and reflect best industry practices. The costs for this program are included in the individual PCC Standard Rates. This program is developed to ensure training of personnel and will be on-going past the 5-year period.	
Desired State:	Maintenance personnel have the necessary training to safely operate and maintain compression and processing assets
Risks Addressed:	CP6, CP7, CP30, Gas Operations Records Risk
Timeframe:	On-going
Responsibilities:	Gas Operations
Program:	External Corrosion Control (Coatings, CP, ECDA)
Scope: This program has been established to ensure that adequate coatings are present on equipment at C&P facilities. This program provides a methodology to inspect coatings on aboveground equipment, vessels and piping and provides for recoating these facilities as warranted. These costs are captured in the Integrity Management plan.	
Desired State:	Implementation of structured corrosion monitoring program for stations
Risks Addressed:	CP1, CP2, CP10, CP18
Timeframe:	2016 to establish site specific programs, On-going
Responsibilities:	Gas Operations
Program:	Process Safety
Scope: This program is designed to ensure that safety is incorporated in all of the engineering and design work performed by the C&P asset family. This will include measures such as performing HAZOP reviews on process designs. A pilot program to ensure that safety is embedded in our designs has been established for the McDonald Island Whisky Slough Station Rebuild project. The costs of these process safety improvements are typically captured at the project level. This program is on-going and processes will be continually updated to meet regulatory and technology changes. This program will extend beyond the 5-year period.	
Desired State:	Process safety elements integrated into facility designs
Risks Addressed:	CP23, CP24, CP25, CP26, CP27, CP28, CP31, CP32, CP33
Timeframe:	2016 for baseline PHAs, On-going
Responsibilities:	Gas Operations

* Stakeholders for these programs are as shown in Appendix D

5. Areas for Continuous Improvement

The C&P asset family has made significant progress since the last version of the Asset Management Plan was published in August of 2015. Highlights of these improvements include the following items:

- Frame work for Facility Integrity Management Program (FIMP) has been established and associated Maturity Model has been developed (Section 4)
- First iteration of Long Term Compression Investment Plan has been published (Appendix N)
- Pilot Reliability Centered Maintenance Studies have been performed at Hinkley and Gerber Compressor Stations (Appendix K)
- Goal of performing 10% of proposed reliability projects per year was met and exceeded (Appendix K)
- Notable improvement made in reliability of chronic units at Los Medanos and Santa Rosa Compressor Station (Section 2)
- Overall condition assessment of Santa Rosa Compressor Station has been upgraded from “fair” to “good” largely as a result of the capital project to replace the electric switchgear and the motor control centers (Section 2)
- Reliability Principal Engineer has been hired to develop and implement reliability plans at C&P facilities
- Electrical Principal Engineer has been hired to develop electrical maintenance procedures at C&P facilities
- Implemented a program approach to mitigate risks to employees performing work on energized electrical equipment
- Created a standing Electrical Safe Work Practices team with a goal of developing, implementing and maintaining a comprehensive electrical work safety program
- Inventoried and corrected deficiencies related to insulated tools and appropriate Personal Protective Equipment (PPE) at all districts
- Developed and issued detailed electrical maintenance plans for all compression facilities
- Implemented program to install enhanced physical security upgrades at 8 C&P facilities (Section 4)
- Completed seismic assessments at McDonald Island, Hinkley Compressor Station and Gerber Compressor Station
- A comprehensive compressor dashboard has been implemented which is providing engineers and stakeholders with readily accessible and usable information to monitor and manage compressor performance
- Performed global benchmarking study with companies from Europe, North America, and South America to identify best practices for management of C&P assets
- Seeing more consistent year-to-year scoring of P95 and Enterprise C&P risks in Session D process

There are some areas in the asset management plans that have not been fully built out at this stage; these are highlighted in Table 15 below. These are areas that will continue to evolve and improve as more thorough data sets and understanding of asset condition are developed over time.

Table 15 – Areas for Continuous Improvement

Areas for Continuous Improvement
Performance Metrics • Refine leading and lagging performance indicators in order to measure, monitor and report on asset performance and condition
Repair vs. Replace • Documented criteria and decision-making when repairing vs. replacing a component
Asset Health Scorecard • Develop a new LOB-wide tool that will be used by all asset families; will be a "single source" of information based on data from multiple systems; and will help establish, implement and maintain process(es) and/or procedure(s) to monitor and measure the performance of the asset management system and the performance and/or condition of assets and/or asset systems. • Replace the one-time, snapshot C&P asset health scorecards developed as part of the site visit condition assessments with a living tool that will be developed based on the metric requirements in Appendix M. Key Performance Indicators (KPIs).
Asset Criticality • Improved understanding of critical component assets – To be developed as part of the Reliability Centered Maintenance Study • Gill Ranch may fall under the C&P asset management umbrella and a plan for including PG&E programs at Gill Ranch may be developed.

Data Collection / Structure / Validation Areas of Need

- Development of credible asset register and development of asset hierarchy with taxonomy in accordance with ISO 14224 guidelines
- More comprehensive data assessment and identification of gaps in existing data
- Develop programs/processes to address data gaps
- Coordinate more with the TIMP organization. This organization routinely gathers and retains information related to C&P assets
- Refresh of current asset register information to validate existing asset information in SAP
- Update of maintenance processes to ensure that maintenance data is captured in a consistent and meaningful way for analysis
- Increased use of the material problem reporting system to collect data on equipment to improve analysis and mitigation for problem equipment
- Need for on-going identification of obsolete equipment to inform the need for replacement programs
- Review of the design and construction processes to ensure that new equipment is consistently identified and captured into the asset register and maintenance management system of SAP
- Need to establish a means to automate capture of functional performance data for use in defining “functional performance” health metric
- Need to establish a means to capture component physical condition information for use in defining “physical condition” health metric
- This information was identified during the condition assessment as required to define component, system, and station health and risk. The data collection activities will be a key element of attention moving forward.
- The update of key documents is also required and this program is already included as the “critical documents”, “ECA Phase 1 and Phase 2”, and “Hydrostatic Testing Station Facilities C&P” programs defined in Section 4.1. Table 12 – Programs, Mitigation and Strategic Objectives

Personnel Implications

- Additional personnel/hours will be needed to develop and implement data quality issues resolution process
- Identify development plans for subject matter experts to ensure their skills/expertise remain current
- Identify succession plans for subject matter experts and begin skill/expertise development for successor

Long Term Compression Investment Plan

- Work began in 2015 to develop a long term investment plan for compression assets and the first iteration of this plan was completed in May of 2016.
- The plan has a 30-year outlook and provides input on programs to be included in future Gas Transmission and Storage rate case proceedings.

- The scope includes transmission line and storage compressor units and associated equipment.
- The current plan is to review the plan on an annual basis and refresh the plan as warranted.
- A copy of this plan is included in Appendix N.

Compressor Station Reliability Plan

- Compressor station reliability improvements have been developed by the facility engineers to improve overall availability and reliability of the compressor stations.
- A reliability plan for the compressor stations is being developed to provide for a systematic review and prioritization of actions to maintain and improve overall system and individual unit performance.
- Further evaluate the establishment of a reliability-centered maintenance program for C&P assets
- The compressor station reliability plan is provided in Appendix K.

Condition Assessment

- Conduct pilot program at one compressor station to refine condition assessment model for C&P facilities

Risk Analysis

- The initiation of a quantitative risk analysis process will be developed to build on the condition health scoring model.
- The risk analysis is intended to be performed at a system and station level so that improved information will be available to populate the risk register.

Management of Change (MOC) Process

- A management of change process is required to identify, capture, and update key asset data from changes due to construction and maintenance. This change process will affect multiple organizations that manage and communicate the asset information. The management of change process will be developed and implemented for the C&P asset family through the reliability plan described in Appendix L and the risk mitigation programs described in Section 4.
- As part the Facility Integrity Management Program, a pilot program is under development using the MoC procedure that has been developed by the Station Assessment group. The pilot program will consist of the development of an obsolescence management program using this MOC protocol.

APPENDICES

Appendix	Title
A	Related Documents
B	Threat Matrix and Key Threats
C	Asset Family Risks
D	Stakeholder Roles and Responsibilities Matrix
E	Summary of Integrated Programs
F	Glossary of Acronyms and Abbreviations
G	Change Log
H	Condition Health Scoring Model and Criteria
I	C&P System Target Score Criteria
J	C&P System Health Scores
K	Proposed C&P Reliability Plan
L	Data Assessment
M	Key Performance Indicators (KPIs)
N	Long Term Compression Investment Plan

A. Related Documents

The following table lists documents associated with this asset management plan.

Table 16 – Related Documents

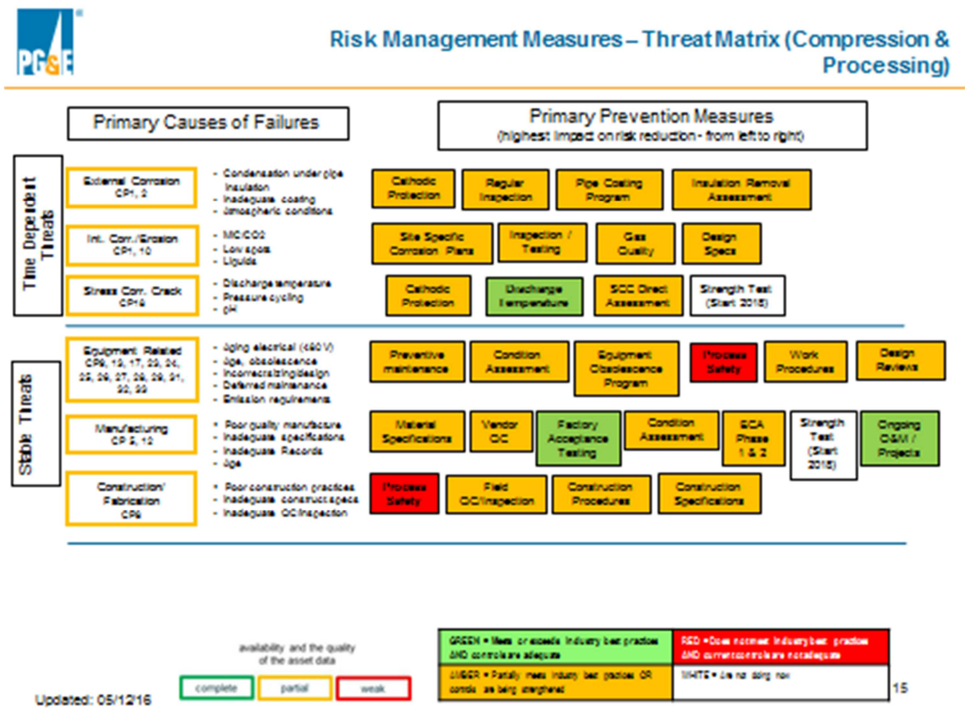
Related document	Document Number / Description	Link
Compression & Processing Risk Register	The risk register captures all risks outlined in this plan at the data of publish	http://gasrisk/
Asset family investment planning forecast	Retained by investment planning for S1 and S2 planning purposes.	Contact Investment Planning
Enterprise and Operational Risk Management Standard and Procedures	RISK-5001S, RISK-5001P-01, RISK-5001P-02, RISK-5001P-03	http://pgeatwork/Guidance/RiskCompliance/Pages/default.aspx
Gas Asset Management Policy	TD-01	TD-01
Gas Operations Asset Management System Risk Management Standard and Procedure	TD-4011S, TD-4011P-01	TD-4011S and TD-4011P-01
Gas Operations Risk and Compliance Committee Charter	GOV-1021S	http://pgeatwork/Guidance/Governance/Pages/default.aspx
Asset Management Strategy and Objectives	GP-1100	Gas Safety Plans / Asset Management
Transmission Asset Management Plan	GP-1101	
Distribution Mains and Services Asset Management Plan	GP-1102	
Customer Connected Equipment Asset Management Plan	GP-1103	
Measurement and Control Asset Management Plan	GP-1104	
LNG/CNG Portable Supplies Asset Management Plan	GP-1106	
CNG Station Asset Management Plan	GP-1107	
Gas Storage Asset Management Plan	GP-1108	

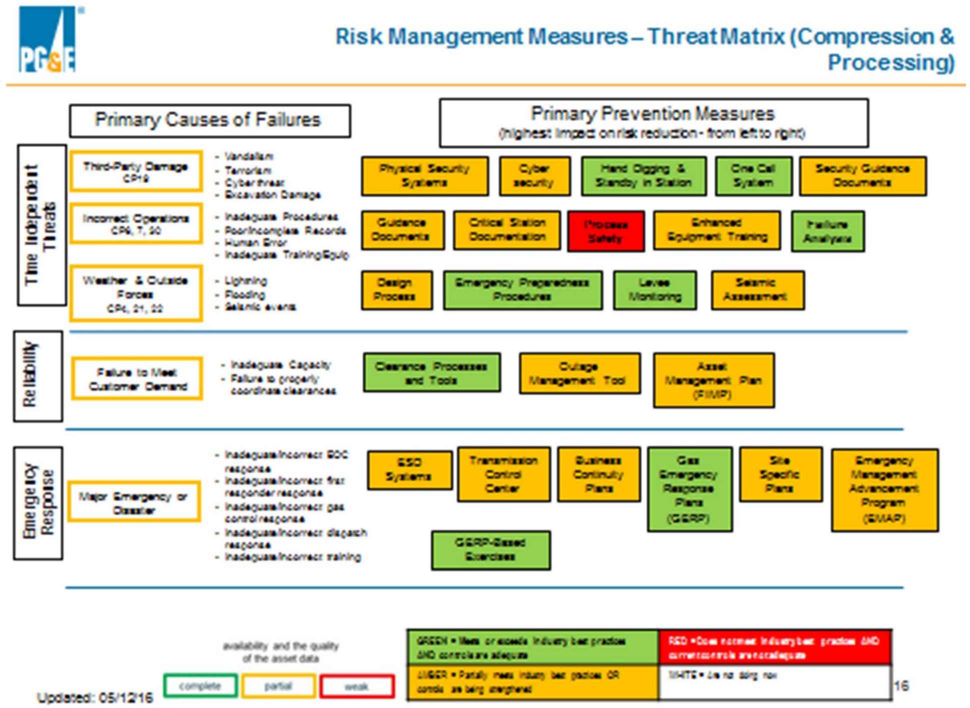
B. Threat Matrix and Key Threats

Threat Matrix

The threat matrix below displays threats, drivers, and mitigations associated with this asset family. The threats are outlined with a red, amber, or green status denoting the current availability and quality of asset data. The mitigations are color coded with white, red, amber, or green status to display how it currently compares to industry best practices as well as the strength of the controls.

Figure 15 – Compression and Processing




Risk Management Measures – Threat Matrix (Compression & Processing)
Primary Causes of Failures
Primary Prevention Measures
(highest impact on risk reduction - from left to right)
Time Independent Threats
Third-Party Damage CP19
- Vandalism
- Terrorism
- Cyber threat
- Excavation Damage
Physical Security Systems
Cyber security
Hand Digging & Standby in Station
One Call System
Security Guidance Documents
Incorrect Operations CP6, 7, 30
- Inadequate Procedures
- Poor/Incomplete Records
- Human Error
- Inadequate Training/Equip
Guidance Documents
Critical Station Documentation
Process Safety
Enhanced Equipment Training
Failure Analyses
Weather & Outside Forces CP4, 21, 22
- Lightning
- Flooding
- Seismic events
Design Process
Emergency Preparedness Procedures
Levee Monitoring
Seismic Assessment
Reliability
Failure to Meet Customer Demand
- Inadequate Capacity
- Failure to properly coordinate clearances
Clearance Processes and Tools
Outage Management Tool
Asset Management Plan (FIMP)
Emergency Response
Major Emergency or Disaster
- Inadequate/Incorrect EOC response
- Inadequate/Incorrect first responder response
- Inadequate/Incorrect gas control response
- Inadequate/Incorrect dispatch response
- Inadequate/Incorrect training
ESD Systems
Transmission Control Center
Business Continuity Plans
Gas Emergency Response Plans (GERP)
Site Specific Plans
Emergency Management Advancement Program (EMAP)
GERP-Based Exercises
availability and the quality of the asset data
complete
partial
weak
GREEN = Meets or exceeds industry best practice AND controls are adequate
RED = Does not meet industry best practice AND current controls are not adequate
AMBER = Partially meets industry best practices OR controls are being strengthened
WHITE = Are not doing now
Updated: 05/12/16
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External Corrosion and Internal Corrosion
External and internal corrosion and erosion of piping is a key threat affecting piping, tanks, and vessels at processing facilities, especially at McDonald Island. There have been instances of through-wall corrosion and detectable loss of pipe wall thickness attributed to erosion from entrained sand produced by the gas wells. This presents a risk of loss of containment leading to loss of service and safety impacts. This risk is managed by 1) performing targeted ad hoc inspections and analysis for internal corrosion and wall loss, 2) implementing major capital projects to remediate specific problems; e.g. Whisky Slough Station Rebuild, and 3) including capital and expense projects each year to address inadequate external coatings.

Stress Corrosion Cracking
Material deterioration from corrosion may cause leaks and potential failure of piping downstream of compressor stations. Stress corrosion risks are produced by deterioration of material over time due to a combination of factors from pressure cycling, chemicals, stress, and material types.

Equipment – Age and Obsolescence
Equipment obsolescence is defined as the state where equipment may be difficult to maintain, the vendor no longer supports the product, spares parts are no longer available, or equipment parts become incompatible (e.g., new actuators installed on older valves). Although remedial work and upgrades have been done at compression and processing facilities, much of the equipment and controls system-wide is over 40 years old, obsolete or no longer supported by the manufacturer, and is showing signs of wear and deterioration. Additionally, some equipment will eventually be non-compliant with current and emerging environmental regulations; e.g. compressor air emissions rules and AB 32 requirements for Green House Gas emissions. If not replaced, there is risk of failure or restricted operation of critical components or systems that could result in a loss of compression services at multiple locations. This risk is currently managed by 1) including a number of capital and expense projects each year to systematically replace aging and obsolete equipment, and 2) to recommend projects to specifically upgrade or retrofit equipment to meet current environmental regulations.

Manufacturing Related Defects
There is increased focus on identifying and addressing possible manufacturing related threats affecting piping in gas transmission stations, including compressor stations and processing facilities. The extent of the threat is currently unknown, but specific initiatives to scope and mitigate the threat and attendant risk are included as part of this asset management plan. By the end of 2014, PG&E will have completed its preliminary research of facility documentation to consolidate and review its traceable, verifiable, and complete records. This systemic review of all C&P stations will generate detailed asset lists that will enable the following downstream programs to begin after 2014:

- Engineering Critical Assessment (ECA) Phase 1: Review station assets in an attempt to identify particular safety or compliance risks that require mitigation.

- ECA Phase 2: Mitigation of the risks identified by ECA Phase 1 without the need for hydrostatic testing. These methods will offer viable, yet-low risk alternatives that may include non-destructive or destructive testing, fatigue life calculations, and other evaluations that can substitute for a pressure test.
- Hydrostatic Testing (HST): For risks that remain post-ECA Phase 2 that were unsuccessfully mitigated.

Welding / Fabrication Related
Risks due to construction or fabrication are related to inadequate installation of the station resulting in potential premature equipment failure or operational difficulties. Additional risks are associated with the documentation and construction records not being sufficient or properly maintained to demonstrate regulatory requirements. This impact is similar to the manufacturing record risks and includes the ECA Phase 1, ECA Phase 2, and Hydrostatic Testing projects listed earlier in this subsection.

3rd Party / Mechanical Damage – Cyber Threats
The potential for cyber security breaches and vandalism pose additional risks on the system. PG&E has historically implemented mitigation measures to improve physical security at critical gas transmission facilities. Upgrades have been made in compliance with internal PG&E standards based on TSA guidelines. With convergence of information technology and control systems such as SCADA and process control, the threat of third party damage is necessarily expanded to include risk of unauthorized operation along with loss of service and reliability due to cyber security. This risk is currently managed through established IT processes governing design and access of databases and systems critical to operations.

Incorrect Operations
Incorrect operations pose a serious threat to this asset family. The systems and equipment installed in compressor stations and processing facilities are complex, requiring specialized training. Risks associated with incorrect operations include overpressure of the gas system, loss of service, and safety impacts due to malfunction or failure of critical assets. There is also risk of increased operating costs as a result of shortened equipment life. Underlying causes include human error, failure to follow procedures, the lack of or inadequate training, inadequate work procedures, and out-of-date drawings and records. This risk is currently managed by designing in fail safes to minimize risk of incorrect operation and to provide specific training on new equipment or systems that is unfamiliar to operating and maintenance personnel.

Weather Related & Outside Force
McDonald Island Gas Storage Facility is PG&E's largest gas storage field and supplies up to one-third of PG&E's total gas system demand during winter peak periods. The reservoir is located in a flood plain in the Delta region and is highly vulnerable to flooding. The levees protecting the facility are fragile and there have been historic incidences of flooding. The PG&E-owned compression and processing equipment are installed on platforms that elevate the piping and equipment above the flood plain and enable the facility to operate in the event of a levee break. However, there is significant injection capacity provided by leased compression installed on the ground that would be impacted. Also, a prolonged flood would increase risk of failure of gas gathering lines from the gas wells due to corrosion.

Additionally, subsidence (lower land level) due to peat soils and agricultural practices is evident on McDonald Island. Ground settlement puts stress on the platform supports and on the gathering line piping running from the well heads to the flow meter runs. There is a risk of loss of service and safety impacts due to possible loss of containment. While there is physical evidence of subsidence, there is currently no data to determine the extent of the threat.

Risks associated with the levees are managed through PG&E's participation on the local reclamation board. Risk associated with subsidence is currently managed by including specific capital or expense projects as needed to monitor and address stresses caused by settling of buried piping.

The proximity of Santa Rosa and Hinkley compressor stations to active seismic zones poses a risk of damage and loss of service in the event of a magnitude 6.7 or greater earthquake.

People and Processes

The unavailability of district and Instrumentation and Regulation (I&R) resources due to higher priority work has had significant impact on discretionary maintenance for reliability and support for projects. Because compliance and safety driven work has priority, scheduled preventive maintenance for some at-risk equipment has not been performed due to the lack of resources and time. Lack of resources for discretionary maintenance results in deferred maintenance and increases the risk of unscheduled outages. In 2012 the lack of district and I&R resources resulted for the first time in deferral of capital projects. In view of the required availability and reliability expected of these assets, and cost of the assets, the current maintenance approach should be reviewed as part of the reliability plan (see Attachment I). Benchmarking the current approach with peer companies will provide additional data and perspective.

From a design perspective, during the past few years there has been significant loss of expertise in the station design group with key individuals taking on responsibilities outside of the project design function and many new engineers joining the group. The lack of a formal engineering design manual for Gas Transmission Stations makes it difficult to train new engineers and ensure consistent design practices. Work towards creating a design manual is in progress and should provide a good basis for training and design consistency.

C. Asset Family Risks

Table 17 – Compression and Processing Risks and Interdependencies

Risk ID	Threat	Risk	Interdependencies with Other Risks
CP19	Third Party / Mechanical Damage	The risk of vandalism or terrorist attack at facility may result in personal safety, loss of service, loss of containment, and/or equipment damage	NA
CP22	Weather Related/Outside Forces – Seismic [redacted]	The risk of a 6.7 earthquake may result in loss of service, loss entire compressor station (Hinkley and Los Medanos), and ignition	NA
CP12	Manufacturing Defects	The risk of equipment failures from poor design or manufacturing process may result in loss of service and possible loss of containment	NA
CP8	Welding/Fabrication Related	The risk of poor construction practices may result in loss of containment and loss of service	NA
CP6	Incorrect Operations	The risk of incorrect operations causing failure or malfunction of critical pressure containing equipment at a [redacted] facility may result potential loss of containment	NA
CP1	External/Internal Corrosion	The risk of through wall leaks in storage facility piping from internal or external corrosion (discharge side) may result in loss of containment, loss of service and reliability.	NA
CP2	External Corrosion – Under Pipe Insulation	The risk of through wall leaks from external corrosion forming beneath pipe insulation material may result in loss of service and loss of containment.	NA
CP10	Internal Corrosion & Erosion	The risk of through wall leaks in storage processing, withdrawal piping and pressure vessels from internal corrosion or erosion may result in loss of containment, loss of service, and reliability.	NA
CP18	Stress Cracking Corrosion	The risk of stress corrosion cracking on piping downstream of compressor stations may result in potential safety impacts, loss of service and reliability.	NA

Risk ID	Threat	Risk	Interdependencies with Other Risks
CP5	Manufacturing Defects – Pipe Quality	Loss of containment or reduction in operating pressure due to pipe of unknown or suspect quality (Topock, Hinkley, and station side of Kettleman) or defect resulting from poor manufacture or design practices. The risk of suspect pipe (manufacturing defects or unknown quality) may result in rupture of pipe from overpressure	NA
CP7	Incorrect Operations – Odorization	The risk of incorrect operation or maintenance of odorizers may result in over/under-odorization of the gas system, possible equipment damage/failure, and emergency gas leaks calls.	CP6.1
CP13	Equipment Related – Electrical Systems	The risk of aging electrical equipment at C&P stations may result in worker safety and loss of service	NA
CP21	Weather Related/Outside Forces – Seismic [redacted]	The risk of a 6.7 earthquake may result in loss of service, loss entire compressor station (Santa Rosa), and ignition on a CWD.	NA
CP29	Equipment Related – Hinkley Non-Retrofit compressor Reciprocating Engine	The risk of over pressurization of crankcase and subsequent activation of crankcase pressure relief device resulting in spraying hot oil (approx. 140 degF) may result in employee injury and loss of service (single unit). – (Hinkley PHA results Ref #2)	NA
CP24	Hinkley Station Non-Retrofitted compressor outage due to any cause	The risk of outage at Hinkley Station due to any cause on CWD may result in loss of service	NA
CP25	Delevan Station compressor outage due to any cause	The risk of outage at Delevan Station due to any cause on CWD may result in loss of service	NA
CP32	Santa Rosa Station compressor outage due to any cause	The risk of outage at Santa Rosa Station due to any cause on CWD may result in loss of service	NA

Risk ID	Threat	Risk	Interdependencies with Other Risks
CP4	Weather Related/Outside Forces – Flooding (System Safety)	The risk of failure of the levees at McDonald Island protecting compression or storage assets may result in flooding.	NA
CP9	Equipment Related – Air Emission Regulation	The risk of existing equipment or technology not being able to be upgraded enough to comply with stricter air emission regulations may result in loss of service and non-compliance.	NA
CP23	Kettleman Station compressor outage due to any cause (System Safety)	The risk of outage at Kettleman Station due to any cause on CWD may result in loss of service	NA
CP26	Tionesta Station compressor outage due to any cause (System Safety)	The risk of outage at Tionesta Station due to any cause on CWD may result in loss of service	NA
CP27	Burney Station compressor outage due to any cause (System Safety)	The risk of outage at Burney Station due to any cause on CWD may result in loss of service	NA
CP28	Gerber Station compressor outage due to any cause	The risk of outage at Gerber Station due to any cause on CWD may result in loss of service	NA
CP31	Bethany Station compressor outage due to any cause	The risk of outage at Bethany Station due to any cause on CWD may result in loss of service	NA
CP33	Topock Station compressor outage due to any cause	The risk of outage at Topock Station due to any cause on CWD may result in loss of service	NA

Risk ID	Threat	Risk	Interdependencies with Other Risks
CP30	Incorrect Operations	The risk of incorrect operation of critical compression or storage processing equipment may result in reduced transmission capacity or storage withdrawal capacity on CWD and causing core customer outage	NA
CP17	Equipment Related – Deferred maintenance	The risk of deferred preventive or corrective work on equipment (excludes compliance work) may result in potential safety impacts and loss of service.	NA

D. Stakeholder Roles and Responsibilities Matrix

The key contacts are stakeholders who are involved in each phase of the asset life cycle, managing and operating the assets to operate as planned.

Table 18 – Stakeholder Roles and Responsibility Matrix

		Creation / Enhancement						
Stakeholder Group	**Primary Contact**	**Conception**	**Design**	**Procure**	**Construct / Start-up**	**Utilization**	**Maintenance**	**Decommission / Dispose**
Facility Integrity Management & Technical Services	Director	X	X	X	X	X	X	X
Reservoir Engineering	Director	X	X		X	X		X
Compliance	Director	X	X	X	X	X	X	X
Transmission Engineering & Design	Director	X	X	X	X			X
Transmission Project Management	Director	X	X	X	X			X
Backbone Planning	Manager	X	X			X		X
Local Transmission Planning	Senior Manager	X	X			X		X
Gas Transmission Control Center	Manager	X			X	X	X	X
Gas Control Strategy & Support	Director	X	X					X
Gas Pipeline Operations & Maintenance	Director		X		X		X	X

		Creation / Enhancement						
Stakeholder Group	**Primary Contact**	**Conception**	**Design**	**Procure**	**Construct / Start-up**	**Utilization**	**Maintenance**	**Decommission / Dispose**
Wholesale Marketing & Business Development	Director	X						X
General Construction	Senior Director				X			X

E. Summary of Integrated Programs

The table below summarizes the programs of work contained within this asset management plan that are relevant to and documented in other asset family asset management plans. The table highlights which programs are applicable to multiple asset families and which plan has included forecast costs. This also ensures there is no duplication in forecasted program costs.

Table 19 – Programs Relevant to Multiple Asset Families

Programs of Work	Transmission Pipe	Gas Storage	M&C	C&P	Other
Locate & Mark	X	X			
Gas transmission routine pipeline maintenance & monitoring	X	X			
Gas transmission routine pipeline reliability & expense projects	X	X			
Corrosion control	X	X	X	X	
ILI assessments	X	X			
ILI upgrades	X	X			
ILI anomalies rectification	X	X			
ILI inspected by other means	X	X			
ECDA	X	X			
ICDA	X	X			
SCCDA	X	X			
Close Interval Surveys (CIS)	X	X			
Stress corrosion cracking	X	X			
Pressure testing	X	X			
Shallow pipe	X	X			
Class location program	X	X			

Programs of Work	Transmission Pipe	Gas Storage	M&C	C&P	Other
Valve automation	X	X	X		
Public awareness	X	X			
Inoperable & Hard-to-Turn Valves	X	X	X	X	
Preventative maintenance program	X	X	X	X	X
Guidance documents	X	X	X	X	X
Training	X	X	X	X	X
Process safety	X	X	X	X	X
Cyber security	X	X	X	X	X
Physical security	X	X	X	X	
Locate & Mark	X	X			
Gas transmission routine pipeline maintenance & monitoring	X	X			
Gas transmission routine pipeline reliability & expense projects	X	X			
Corrosion control	X	X	X	X	
ILI assessments	X	X			
ILI upgrades	X	X			
ILI anomalies rectification	X	X			
ILI inspected by other means	X	X			
ECDA	X	X			
ICDA	X	X			
SCCDA	X	X			
Close Interval Surveys (CIS)	X	X			
Stress corrosion cracking	X	X			

Programs of Work	Transmission Pipe	Gas Storage	M&C	C&P	Other
Pressure testing	X	X			
Shallow pipe	X	X			
Class location program	X	X			
Valve automation	X	X			
Public awareness	X	X			
Inoperable & Hard-to-Turn Valves	X	X	X	X	
Preventative maintenance program	X	X	X	X	X
Guidance documents	X	X	X	X	X
Training	X	X	X	X	X
Process safety	X	X	X	X	X
Cyber security	X	X	X	X	X
Physical security	X	X	X	X	

F. Glossary of Acronyms and Abbreviations

Table 20 – Abbreviations and Acronyms

Acronym	Meaning
AC	Alternating Current
AC	Atmospheric Corrosion
AF	Asset Family
AFO	Asset Family Owner
AHS	Asset Health Scorecard
AMP	Asset Management Plan
AMR	Automated Meter Reading
ANSI	American National Standards Institute
APD	Abnormal Peak Day
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
Bcf	Billion cubic feet
BHP	Brake Horsepower
BTU	British Thermal Unit
C&P	Compression & Processing
CAP	Corrective Action Program
CC&B	Customer Care and Billing
CCE	Customer-Connected Equipment
CCR	California Code of Regulations
CDD	Critical Document Database
CFH	Cubic Feet per Hour
CFR	Code of Federal Regulations
CIS	Close Interval Survey
CM	Corrective Maintenance
CNG	Compressed Natural Gas
CNL	Compensated Neutron Log
CoF	Consequence of Failure
CP	Cathodic Protection
CPP	Casing Potential Profile

Acronym	Meaning
CPUC	California Public Utilities Commission
CSRP	Copper Service Replacement Program
CWD	Cold Winter Day
DC	Direct Current
DCVG	Direct Current Voltage Gradient
DHSV	Downhole Safety Valve
DIMP	Distribution Integrity Management Program
DOGGR	Division of Oil, Gas and Geothermal Resources
DOT	Department of Transportation
ECA	Engineering Critical Assessment
ECDA	External Corrosion Direct Assessment
EORM	Enterprise and Operational Risk Management
ERM	Enterprise Risk Management
ERW	Electric Resistance Welded
ESD	Emergency Shut Down
ESZ	Emergency Shut-down Zone
ETS	Electrolysis Test Station
FIMP	Facility Integrity Management Program
FM	Facility Maintenance
FPI	Future Performance Indicator
GC	Gas Chromatograph
GDCC	Gas Distribution Control Center
GGE	Gas Gallon Equivalents
GHG	Greenhouse Gas
GIS	Geographic Information System
GMPCP	Gas Meter Performance Control Program

Acronym	Meaning
GPRP	Gas Pipeline Replacement Program
GRC	General Rate Case
GRN	Gamma Ray Neutron
GSDB	Gas Storage Database
GSE	Gas Safety Excellence
GSR	Gas Service Representative
GT	Gas Transmission
GTI	Gas Technology Institute
GT&S	Gas Transmission and Storage
HAZOP	Hazard and Operability
HCA	High Consequence Area
HP	High Pressure
HP	Horsepower
HPR	High Pressure Regulator
I/O	Input/Output
I/W	Injection/Withdrawal
IA	Information Assurance
IC	Internal Corrosion
ICDA	Internal Corrosion Direct Assessment
IGIS	Integrated Gas Information System
IJ	Injection
ILI	In-Line Inspection
IM	Integrity Management
IMLAP	Internal Metal Loss Action Plan
INGAA	Interstate Natural Gas Association of America
I&R	Instrument & Regulation
IRV	Internal Relief Valve
KPI	Key Performance Indicator
LUAF	Lost and Unaccounted For
LNG	Liquefied Natural Gas
LOB	Line of Business
LoF	Likelihood of Failure
LP	Low Pressure

Acronym	Meaning
LRCV	Line Rupture Control Valve
M&C	Measurement and Control
M&O	Maintenance and Operations
MAME	Meter Asset Management and Engineering
MAOP	Maximum Allowable Operating Pressure
MASCP	Maximum Allowable Surface Casing Pressure
MAT	Major Activity Type
MCC	Motor Control Center
Mcf	Thousand cubic feet
MFL	Magnetic Flux Leakage
MMcf	Million cubic feet
MIC	Microbiologically Induced Corrosion
MIT	Mechanical Integrity Test
ML	Microlog
MMCFD	Millions of Cubic Feet per Day
MOP	Maximum Operating Pressure
MPP	Meter Protection Program
MPR	Material Problem Reporting
MSA	Meter Set Assembly
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
MTU	Meter Transmitting Units
MWC	Major Work Category
NDE	Non-Destructive Examination
NFPA	National Fire Protection Association
NOV	Notice of Violation
NOx	Nitrogen Oxides
OBS	Observation
OEM	Original Equipment Manufacturer
OPF	Over-Pressure Frequency
OPP	Over-Pressure Protection

Acronym	Meaning
OSHA	Occupational Safety and Health Administration
PAP	Public Awareness Plan
PCC	Provider Cost Center
PCM	Pipeline Current Mapper
PG&E	Pacific Gas and Electric
PHA	Process Hazard Analysis
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIR	Potential Impact Radius
PLC	Programmable Logic Controller
PLM	Pipeline Maintenance
PM	Preventive Maintenance
PMC	Periodic Meter Change
PRCI	Pipeline Research Council International
PS	Portable Supply
psig	Pounds per Square Inch Gauge
PSRS	Project Status Reporting System
PSSR	Pre-Startup Safety Review
QRA	Quantitative Risk Assessment
RCC	Risk and Compliance Committee
RCV	Remote Control Valves
RIM	Records Integrity Management
RMP	Risk Management Procedure
RTU	Remote Terminal Unit
SAP	Systems, Applications, Products
SCADA	Supervisory Control and Data Acquisition
SCC	Stress Corrosion Cracking
SCCDA	Stress Corrosion Cracking Direct Assessment
SLA	Service Level Agreement
SMC	Statistical Meter Control
SME	Subject Matter Expert

Acronym	Meaning
SMYS	Specified Minimum Yield Strength
SP	Spontaneous Potential
STPR	Strength Test Pressure Report
SWD	Salt Water Disposal
SWGR	Switchgear
T&R	Transmission & Regulation
TCS	Turner Cut Station
TIMP	Transmission Integrity Management Program
TOX	Thermal Oxidizers
TPL	Tangible Property List
TSA	Transportation Security Administration
UPSV	Uphole Safety Valve
USA	Underground Service Alert
USGS	United States Geological Survey
UVIR	UltraViolet InfraRed
VAC	Volts Alternating Current
VFD	Variable Frequency Drives
VIED	Vehicular Improvised Explosive Device
WD	Withdrawal
WELL	Well Integrity Management Program
WRO	Work Requested by Others
WSS	Whisky Slough Station

G. Change Log

The following table summarizes revisions since the previous publication of GP-1105: Compression & Processing Asset Management Plan, Revision 2, 8/12/2015.

Table 21 – Asset Management Plan Change Log

Section	Change	Reason for Change	Implication of Change
Entire Asset Management Plan	Update to previous version of Asset Management plan dated August 12, 2015; no major changes to format of document	Provided updated information regarding fleet of C&P assets; condition of C&P assets; risks associated with C&P assets; mitigations associated with risks to C&P assets; and continuous improvement activities associated with C&P assets	Updated Information
Executive Summary and Section 4.1	Change to Strategic Objectives: Delete Strategic Objective related to Standardized Designs and add Strategic Objective related to Physical Security	Upon further review, standardized designs for C&P facilities are not appropriate because of unique design of each individual facility. Conversely, a Physical Security strategic objective ties directly to the greatest C&P risk identified in Session D.	More closely aligns strategic objectives to top C&P risk
Section 5	Changes / Updates to areas of continuous improvement	Updated continuous improvements list to more closely align with current thinking	Activities identified are more achievable and less aspirational
Appendix K	Description of Reliability Program components and updated list of proposed and completed reliability projects	Incorporates results of pilot Reliability Centered Maintenance Studies along with capturing completed reliability projects	Further progress in developing reliability program and meeting goal of completing 10% of reliability projects per year
Appendix M	Addition of Long Term Compression Investment Plan	First iteration of plan was completed since last update of the Asset Management Plan	First glimpse of planned investments over a 30-year period

H. Condition Health Scoring Model and Criteria

This appendix describes the calculation basis for the metrics and the data required to support the metrics. The following topics are addressed in this section:

- Component metrics definitions and data requirements
- Component scoring approach
- C&P station scoring approach

H.1. Component Level Health Scoring Elements

The condition assessment for C&P facilities defines the evaluation of health for the components of a station. The condition assessment employs a set of component-level scoring elements that are utilized to provide an indication of the component health. These metrics, which include both leading and lagging indicators, are defined in Table 22 – Component Condition Health Metrics, below.

Table 22 – Component Condition Health Metrics

Metric No.	Indicator	Scoring Element	Definition
1	Leading	Component Age	Percent of component age vs. expected life of component
2	Leading	Obsolete Equipment	Component make and model matches equipment on obsolescence list Equipment obsolescence is defined as the state where equipment may be difficult to maintain, the vendor no longer supports the product, spare parts are no longer available, or equipment parts become incompatible.
3	Leading	Problem Equipment	Component make and model matches equipment on problem equipment list This metric represents the identification of equipment where undesirable functional or operational issues have been detected which is suspected to be or is a direct result of a manufacturing defect or in-service configuration with system-wide implications.
4	Leading	Physical Condition	Assessment of component from visual inspection based on site inspection criteria
5	Lagging	Functional Performance	Assessment of component performance based on review of maintenance and operations history against performance criteria
6	Leading	Operational Efficiency	Measure of operational efficiency based on review of maintenance hours spent on component over past three years against efficiency criteria
7	Leading	Engineered Maintenance Strategy	Component included in maintenance database (PLM or SAP) with defined maintenance strategy (preventive maintenance or maintenance for cause)
8	Lagging	Corrective Maintenance Tasks	Number of corrective maintenance tags against equipment with defined maintenance strategy, excluding maintenance for cause strategy
9	Lagging	Planned Maintenance Tasks Overdue	Occurrence of preventive maintenance tasks overdue greater than 30 days
10	Lagging	Percent Corrective Maintenance vs. Total Maintenance	Percent of work hours associated with corrective maintenance against the total work hours on the component

The metrics defined in Table 22 – Component Condition Health Metrics, have been used in the component condition assessment. However, the use of these metrics to assess component condition requires that the information needed to define these metrics is collected and evaluated on an on-going basis. The data sources for these metrics and the on-going data collection and update activities required to continue to score the components are based on the assumption that the data is available to support calculation of the metrics.

The information for each metric includes:

1. Scoring criteria for the metric
2. Current information which is the basis for the uploaded information from the critical documents (asset register information) and health scoring information
3. Recommended future source for updating this information.

H.1.1. Component Age

Scoring Criteria: The component age metric represents the ratio of component age to its intended life expectancy. The metric is measured as shown below in Table 23.

Table 23 – Component Age Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Component Age	Percent of component age vs. expected life of component	0-20%	21-40%	41-60%	61-80%	>80%

Current Information: The information on component age as well as make and model number is not readily available in the various databases, such as PLM, SAP or PSRS. The current quality of this information is low due to uncertainty in the reliability and accuracy of the data. To the extent possible, data with the highest perceived accuracy was used according to the following priority:

- Site inspection information from the Critical Documents project
- PSRS project description records
- PLM or SAP
- Operating Diagrams initial drawing date (proxy for commissioning date)

The information on expected life has been developed based on the experience of various stakeholders and experts for various component types. The expected life definitions have been included for categories of equipment and have not been based on component-specific make or model number. Table 24 – Component Expected Life – provides the list of expected life by component for the various components included in the condition assessment.

Table 24 – Component Expected Life

Component	Expected Life (Years)	Component	Expected Life (Years)
AIR RECEIVER	50	METER – INSERTION	60
ANALYZER	10	METER – ORIFICE	30
ATS	20	METER – ROTARY	20
BATTERY	10	METER – TURBINE	20
BLOWER	30	METER – ULTRASONIC	20
BOILER	30	METHANOL SYS	40
BOTTLE	60	MONITOR	30
BURNER	15	MOTOR	60
CIVIL-BUILDING	60	ODORIZER	20
CIVIL-OTHER	60	OXIDIZER	50
COMPRESSOR	60	PIPING	60

COOLER	50	PUMP	40
COOLING TOWER	50	PWR GAS SYS	50
DEHYDRATOR	50	REGENERATOR SYS	30
DETECTOR	20	REGULATOR	30
DRYER	20	RELAY	10
ENGINE	60	RTU / PLC	15
ESD	20	SAMPLER	10
EXTINGUISHER	40	SEPARATOR	30
FAN – COMPRESSOR	30	SUPPORTS	60
FAN – CIVIL-BUILDING	60	SUPPRESSOR – NOISE	60
FENCE	30	SWITCH	20
FILTER	30	SWITCHGEAR / MCC	30
FOAM	40	TANK	60
FOUNDATION	60	TRANSFORMER	30
GATE	30	TRANSMITTER	15
GENERATOR	40	TURBINE – COMPRESSOR	40
HEAT EXCHANGER	50	UPS	10
HEATER – FUEL GAS	30	VALVE	60
HEATER – GAS	40	VALVE – ACTUATED	30
HEATER – LUBE OIL	30	VALVE – CHECK	60
HVAC	30	VALVE – RELIEF	30
HYDRAULIC SYS	40	VFD	20
LUBE SYS	40	WIRING	60

Future Needs: The information for future metric evaluation will come from:

- The equipment asset register
- Annual updates to the table for expected component life to be included in the health scoring database (currently identified as SAP)

H.1.2. Obsolete Equipment

Scoring Criteria: The obsolete equipment metric represents the identification of equipment as components identified as obsolete, where obsolescence refers to a component being out of the market place (original equipment offer or availability of spare parts). This metric can be automatically updated as changes are made to the asset register changing the age of the assets (either existing asset age updated annually or new components added). The metric is measured as shown below in Table 25 – Obsolete Equipment Metric Criteria.

Table 25 – Obsolete Equipment Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Obsolete Equipment	Component make and model matches equipment on obsolescence list	Equipment currently available in market (not on the list)	N/A	Equipment with component age metric equal to 10 (not on the list)	N/A	Equipment no longer available; spare parts limited (on the list)

Current Information: The information on equipment obsolescence is based by comparing known equipment make and model information to a list of identified obsolete make and models. Currently, the sources of equipment make and model is often incomplete, unreliable/inaccurate, and not readily accessible. As a temporary mitigation measure, this information was supplemented by the following sources:

- Site inspection information from Critical Documents project
- PSRS project description records

A list of obsolete components will be maintained in the Facilities Integrity Management SharePoint site.

Future Needs: The information for future metric evaluation will come from:

- The equipment asset register (which will include make and model number)
- A centrally maintained database of obsolete equipment

A list of obsolete equipment needs to be defined and updated by the facility engineers (or other identified personnel) on an on-going basis. It is also recommended that the obsolete equipment database be stored in a central location and be easily integrated into the Asset Management Information System so the health and condition monitoring systems can be automatically updated when new information is available.

H.1.3. Problem Equipment

Scoring Criteria: The problem equipment metric represents the identification of equipment where undesirable functional or operational issues have been detected which is suspected to be or is a direct result of a manufacturing defect or in-service configuration with system-wide implications. The metric is measured as shown below in Table 26.

Table 26 – Problem Equipment Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Problem Equipment	Component make and model matches equipment on problem equipment list	No reported issues with equipment (not on list)	N/A	N/A	N/A	System wide issues with equipment (on list)

Current Information: The information on problem equipment is based on comparing known equipment make and model information to a list of identified problem equipment. As was previously mentioned, currently the information on make and model number is often incomplete, unreliable/inaccurate, and not readily accessible. As a temporary mitigation measure, this information was supplemented by the following sources:

- Site inspection information from Critical Documents project
- PSRS project description records

Problem equipment should be identifiable through review of information stored in the Material Problem Report (MPR) computer program. This information can be used to report, evaluate, and document defective material and equipment among other things.

Future Needs: The information for future metric evaluation will come from:

- The equipment asset register
- Utilization of Material Problem Reporting (or similar) as specified under SCM-2106S and integrated into the enterprise Asset Management Information System (e.g., SAP)

A list of problem equipment needs to be defined and updated by the facility engineers (or other identified personnel) on an on-going basis. This information can be updated in the health scoring database and the component metric can be updated automatically based on changes to the problem equipment database.

H.1.4. Physical Condition

Scoring Criteria: The physical condition metric represents an assessment of the physical condition of a component from a visual inspection. The inspection is focused on observable issues with material condition (rust and corrosion), excessive grease or oil, and support configuration (or physical configuration). The metric is measured as shown below in Table 27.

Table 27 – Physical Condition Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Physical Condition	Assessment of component from annual visual inspection based on site inspection criteria	Condition "good" from inspection document	N.A.	Condition "medium" from inspection document	N.A.	Condition "poor" from inspection document

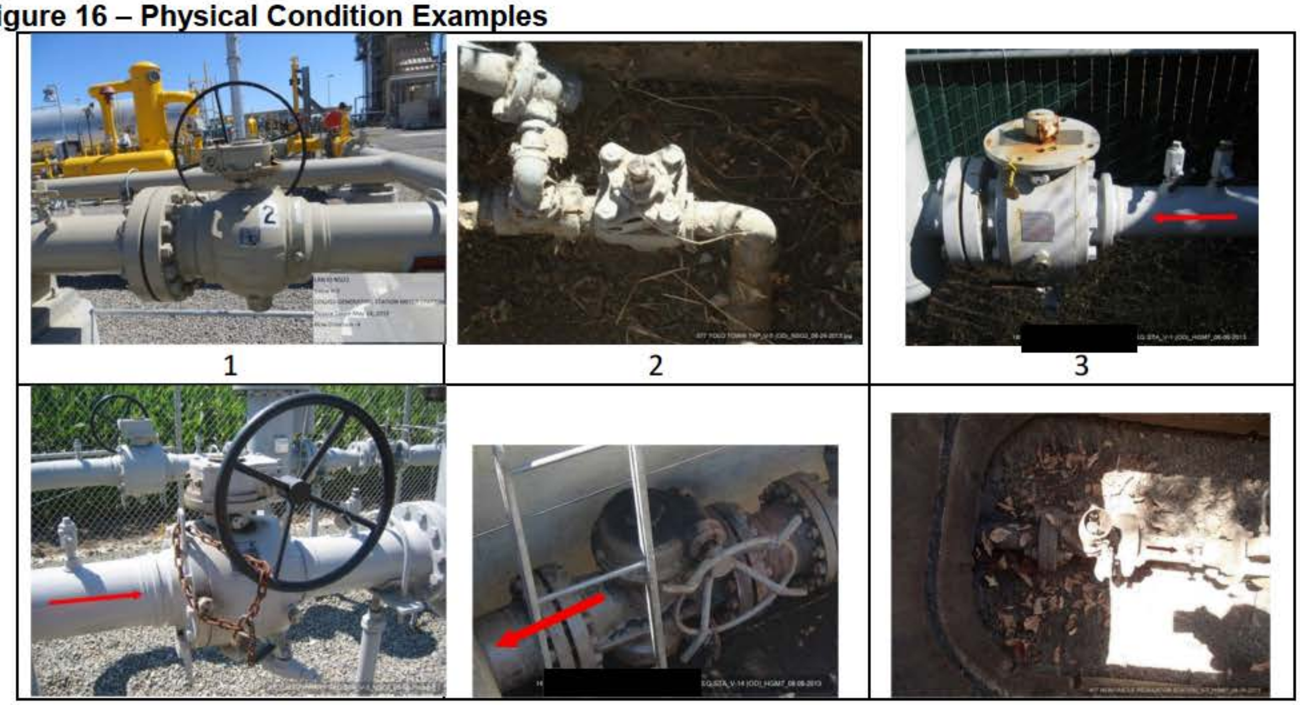
Current Information: The information on physical condition is based on the information from the site inspection checklists (visual inspection) performed during the condition assessment and critical document projects as well as on photographs taken of the components during the site visits. If a component has a "poor" score for any criteria in the checklist, then it is scored a "10". If there are no "poor" scores, but a "medium" score for any criteria, then it is scored a "5". If there are no "poor or medium" scores for all criteria, then the item is scored a "1". A review of available photographs is also performed to assist in determining the score. The photograph review is used to help ensure that consistent scoring is used for this metric. Table 28 below provides information to guide the physical condition metric.

Table 28 – Physical Condition Metric Characteristics

Condition	Characteristic	Description and Explanation
Good	Fully painted	Atmospheric corrosion protection (photo 1)
	Little to some dirt	Able to spot residue leaks, rust, and other physical health characteristics Does not threaten the operation of the equipment (photo 2)
	Minor rust	Little to no rust (photo 3)
	No or minor grease / residue	Periodically cleaning equipment is a good maintenance practice (detect minor issues before they develop into major problems). Studies have also shown that it improves morale and work performance (encourages ownership). (photo 4)
Medium	Some grease or other residue	Grease or other residue generally not wiped off following maintenance or equipment seal(s) have deteriorated. When excessive, tends to mask early warning signs of more significant problems (photo 5)
	Excessive dirt where not buried (e.g., vaulted)	Has potential to inhibit operability Has potential to mask early warning signs of more significant problems (photo 6)
	Some rust	Spotty rust (< 10% of surface area) usually due to chipped/flaking paint (Includes non-pressure containing elements of equipment)
	Chipped/flaking paint	Inadequate corrosion protection Unsightly (photo 7)
	Poor paint job	Typically involves failing to strip equipment surface prior to painting in accordance with PG&E standards. This can lead to disbondment in the future and corrosion/pitting to occur (photo 8)
	Unanchored or missing supports	Support not in contact with piping Support base plate not anchored/fastened to concrete footing (photo 9)
	Combination of issues	Less severe combination of above characteristics which when taken together is determined to be more significant than a 'Good' designation but not so severe as to be designated as 'Poor' (photos 10 & 11)
Poor	Excessive grease or other residue	Visible residue on the ground Potential operability issues (inadequate lubrication) Unsightly (photo 12)
	Excessive rust	Not spotty; broad areas of equipment impacted Higher potential for pitting / integrity failure Unsightly (photo 13)
	Excessive chipping/flaking paint	Not spotty; broad areas of equipment impacted Higher potential for pitting / integrity failure Unsightly (photo 14)

Condition	Characteristic	Description and Explanation
	Flooded vault	Higher potential for corrosion Inhibits inspections (accessibility) Masks early warning signs of more significant problems (photo 15)
Unknown	Underground	Valve is underground and the operator/stem is the only part visible (photo 16)
	Vaulted	Equipment in a vault that could not be opened at the time of visit
	Photo not available	Photo not taken during site inspection
Low Confidence	Underground	Buried equipment that is not visible
	Vaulted	Vaulted equipment that is inaccessible
	Poor photograph	Photograph cannot be evaluated (or poor quality)

Figure 16 – Physical Condition Examples



4	5	6
		
7	8	9
		
10	11	12
		
13	14	15
		
16		

Future Needs: The information for future metric evaluation will need to come from information gained in the scheduled atmospheric corrosion inspections. The criteria for assessing the overall condition of a station include review of material conditions, housekeeping, structural supports, and other factors.

The atmospheric corrosion assessment contains a checklist that incorporates the above criteria. The information needs to be captured at the equipment level so that it is can be readily integrated into the Asset Information Management System to support health and condition assessments and other asset management activities. This metric can then be automatically updated as information on the visual inspections are entered into the appropriate database.

H.1.5. Functional Performance

Scoring Criteria: The functional performance metric represents an indication of current operational performance. The specific criteria for these metrics are different for various equipment categories. However, the score is based on the following general criteria as shown below in Table 29 – Functional Performance Metric Criteria.

Table 29 – Functional Performance Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Functional Performance	Assessment of component performance based on review of maintenance and operations history over past three years against performance criteria	No performance issues identified	N/A	Minor performance issues identified	N/A	Significant performance degradation

Current Information: The criteria for scoring functional performance are the most subjective of those used in the condition assessment. To the extent information is available, functional performance considers the frequency and impact(s) of the issue(s) documented. Table 30 below includes, but is not limited to, examples of common characteristics of the various levels of work history issues encountered.

Table 30 – Functional Performance Metric Characteristics

Issue(s) Extent	Characteristic(s) / Examples
None	small/minor leak (e.g., on a fitting, active grade 3)
	TLA leaks (tighten, lubrication, or adjustment required to fix; non-reportable)
	equipment degradation problems reported and corrective action taken where sufficient time has passed to determine effectiveness (e.g., issue detected in 2011, no issues reported in 2012)
Minor	at most 1 CM of moderate significance
	Grade 2/2+ leaks, and there has not been sufficient time to determine its effectiveness (e.g., issue detected in 2012 for a 2013 assessment)
	Leaks of unknown Grade or Cause where there has not been sufficient time to determine its effectiveness
	Multiple leaks
Significant	major problem reported with corrective action taken, but not sufficient time to determine its effectiveness (e.g., issue detected in 2012 for a 2013 assessment)
	Repeated major operability issues
	assets were identified as having performance problems during the control assessments and there is no evidence of corrective action taken
	Asset not in use (abandoned in place or inoperable)

For the current assessment, corrective work is only considered to have resolved the problem when documented evidence of the corrective work was found or at least one maintenance cycle had gone by, indicating the problem no longer existed.

Future Needs: The information for future metric evaluation will need to be determined based on one or two specific functional tests of a component. This metric is different for each component type and the specific measures for collecting and evaluating data for this metric still need to be defined during the completion of the condition assessment project.

There are several alternatives available for developing this metric:

- This metric may not be easily automated such that information can be queried from some database and calculated in the metric algorithm. It is possible that this metric will require entry by the responsible facility engineer on an annual basis or when there is some issue raised on the component performance.
- This metric may be based on specific failure codes that can be included in SAP and that are updated based on maintenance, material problem reports, or events.

The final definition of this metric will require future work.

H.1.6. Operational Efficiency

Scoring Criteria: The operational efficiency metric represents the measure of maintenance hours spent on a component from one year to the next. The metric is intended to identify potential component issues through the annual hours spent on maintenance. The metric is measured as shown below in Table 31.

Table 31 – Operational Efficiency Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Operational Efficiency	Measure of operational efficiency based on review of maintenance hours spent on component over past three years against efficiency criteria	Similar hours spent each year over 3 year period	N.A.	Hours spent in one year >5 times other years	N.A.	Hours spent in one year >10 times other years

Current Information: The information on maintenance man-hours for this metric is taken from man-hours shown for total maintenance hours identified in PLM or SAP for a given component. The metric is based on using 3 years of total maintenance hours. Key definitions are:

- H_3= PM + CM hours of year health is being assessed (for an evaluation taking place in 2013, this is 2012)
- H_i =PM + CM hours of year i, where i is the number of years prior to the current evaluation year (e.g., for an evaluation taking place in 2013, i = 1 corresponds to 2010, i = 2 corresponds to 2011, and i = 3 corresponds to 2012)
- WT = proxy for current wrench time trend
- OE = operational efficiency score

The equation used to determine this metric is:

If $WT = \begin{bmatrix} \leq 1.5 \\ > 1.5 \; and \leq 2.5 \\ > 2.5 \\ no \; infomration \end{bmatrix}$, then the metric for operational efficiency is $OE = \begin{bmatrix} 1 \\ 5 \\ 10 \\ 1 \end{bmatrix}$

where,

$$WT = \frac{3 \times H_3}{\sum_{i=1}^{3} H_i}$$

Note that the definition for *WT* is the last year (2012 in the example) divided by the average of the 3 years (2010, 2011 and 2012).

The man-hour information is captured by SAP for work management and this metric can be automatically determined based on this information.

Future Needs: The information for future metric evaluation will come from the total man-hours in SAP. The future information will come from the same source as the current information. The major data issue to be resolved for the future needs is that corrective maintenance must be identified against a specific component and not the station.

H.1.7. Engineering Maintenance Strategy

Scoring Criteria: The component age metric represents the ratio of component age to its intended life expectancy. The metric is measured as shown below in Table 32.

Table 32 – Engineering Maintenance Strategy Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Engineered Maintenance Strategy	Component included in maintenance database (PLM or SAP) with defined maintenance strategy (preventive maintenance or maintenance for cause)	N/A	Strategy defined and specific equipment tasks included in work management system	N/A	Strategy not defined or included in work management system	N/A

Current Information: The information on the engineered maintenance strategy metric is based on whether the component is included in PLM or SAP; and that a planned maintenance task is included for the component.

Future Needs: The information for future metric evaluation will come from SAP similar to the current approach. The major data issue to be resolved for the future needs is that components that have only "no maintenance required" need to be included in SAP. This requirement will ensure that all components are accounted for in the strategy and that corrective maintenance against these items can be reviewed for the potential need for planned maintenance.

The information for this metric is captured by SAP for work management and this metric can be automatically determined based on this information.

H.1.8. Corrective Maintenance Tasks

Scoring Criteria: The corrective maintenance task metric represents the number of corrective maintenance tags against a component on a yearly basis. Since the components included here have defined planned maintenance tasks, a corrective maintenance task violates the goal of preventing failure of these components. The metric is measured as shown below in Table 33.

Table 33 – Corrective Maintenance Task Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Corrective Maintenance Tasks	Number of corrective maintenance tags against equipment with defined maintenance strategy, excluding maintenance for cause strategy	0	N/A	1	N/A	>1

Current Information: The information on corrective maintenance tasks is taken directly from data in PLM and SAP.

Future Needs: The information for future metric evaluation will come directly from data in PLM and SAP similar to the current approach. The major issue is to ensure that all corrective maintenance tasks are identified and captured as corrective maintenance. Current review of data indicates that some corrective maintenance is performed under planned maintenance; that some corrective maintenance is entered against the station and not the component; and that some corrective tasks are performed with no entry into PLM or SAP.Table 33.

Table 33 should be used for all components that require a PM task. If a component does not require a defined maintenance task (such that it is a "fix when broke" strategy), then the component should have a default score of "1".

The information for this metric is captured by SAP for work management and this metric can be automatically determined based on this information.

H.1.9. Planned Maintenance Tasks Overdue

Scoring Criteria: The overdue planned maintenance metric represents the occurrence of planned maintenance tasks against a component that are greater than 30 days overdue. The metric is measured as shown below in Table 34.

Table 34 – Overdue Planned Maintenance Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Percent Planned Maintenance Tasks Overdue	Percent of preventive maintenance tasks overdue greater than 30 days	All on schedule	N/A	N/A	N/A	Maintenance strategy defined and any overdue for past year or Undefined maintenance strategy

Current Information: The information on overdue planned maintenance tasks is taken directly from data in PLM and SAP. This metric is calculated by using the percent maintenance overdue for the year being evaluated. The following criteria may be used:

- PM task overdue by 30 days: Score "10"
- PM task on time (within 30 days): Score "1"
- If no PM is assigned and is required, then default to Score "10"

Future Needs: The information for future metric evaluation will come directly from data in SAP similar to the current approach. A potential issue is that planned maintenance tasks are generally entered for compliance maintenance only, and not for reliability maintenance. There is a high priority on compliance maintenance so that if other maintenance tasks are not identified, then this metric may not prove to be useful for monitoring schedule compliance. Since schedule compliance is a key maintenance metric, future review of maintenance tasks identified against equipment may be required.

H.1.10. Percent Corrective Maintenance vs. Total Maintenance

Scoring Criteria: The ratio of corrective maintenance man-hours to total maintenance man-hours represents the effectiveness of the maintenance program to prevent equipment failures that require corrective maintenance. The metric is measured as shown below in Table 35.

Table 35 – Condition Age Metric Criteria

Metric	Definition	Metric Score (1=good; 10= poor)				
		1	3	5	7	10
Percent Corrective Maintenance vs. Total Maintenance	Percent of work hours associated with corrective maintenance against the total work hours on the component	<30%	N/A	30%-50%	N/A	>50%

Current Information: The information on the ratio of corrective to total maintenance man-hours is based on information taken directly from PLM and SAP. The future metric may be automated by using the percent corrective maintenance hours to total maintenance hours for the year being evaluated. The following criteria may be used:

If a PM is defined: Score based on criteria in Table 33.

- Table 33
- If no PM is defined:
  - Score "1" if no CM exists
  - Score "10" if CM exists
- If component is defined to require "no maintenance", then default to Score "1"

The information for this metric is captured by PLM and SAP for work management and this metric can be automatically determined based on this information.

Future Needs: The information for future metric evaluation will come directly from SAP similar to the current approach. The major issue is to ensure that all corrective maintenance tasks are identified and captured as corrective maintenance. Current review of data indicates that some corrective maintenance is performed under planned maintenance; that some corrective maintenance is entered against the station and not the component; and that some corrective tasks are performed with no entry into PLM or SAP.

H.2. Component Level Health Model

The component level score is based on the ten metrics listed in Table 36 below using the weighting factors shown. The component level score is based on summation of the metric score times the weighting factors:

$$Component\ score = \sum_{i=1}^{10} (metric\ score)_i \times (weighting\ factor)_i$$

The component scoring basis is the same for all components in all station types (M&C and C&P).

Table 36 – Component Metric Weighting Factors

Metric	Metric Weighting Factor
Component Age	10%
Obsolete Equipment	15%
Problem Equipment	15%
Physical Condition	15%
Functional Performance	25%
Operational Efficiency	4%
Engineered Maintenance Strategy	4%
Corrective Maintenance Tasks	4%
Percent Planned Maintenance Tasks Overdue	4%
Percent Corrective Maintenance vs. Total Maintenance	4%

The metric weighting factors reflect the importance of the metric relative to component condition and the current confidence level in the data and data sources. The weighting factors above put 25% on age and obsolescence, 55% on current condition, and 20% on maintenance-related items. Since the data related to maintenance appears to be incomplete in the PLM and SAP systems, the maintenance related items were relied on less heavily. An alternate view shows that the weighting factors are 63% leading indicators and 37% lagging indicators.
In the future, consideration should be given to adjustments to the weighting factors as importance or data confidence changes.

H.3. C&P Level Health Model

The C&P score is based on a systems level score rather than a station level score. This allows for more granular scoring of the C&P stations and allows for comparison between systems of the various stations. Also, this keeps the system score equivalent to an M&C station score. The 15 systems listed below have been identified for C&P assets.

- Civil / Structural
- Compressed Air
- Compressors
- Control
- Cooling Water
- Electrical
- Environmental
- Fire Detection
- Fuel Gas
- Main Gas
- Lube Oil
- Power Gas
- Processing
- Security

- Storage

Each system component is assigned a component type that is used to tie the component to an equipment class. The weighting factors are then assigned to the equipment class. The current equipment types and classes are shown in Table 37 below.

Table 37 – Equipment Type, Class and Weighting Factor

System	Component Type	Class Large	System Factor
Civil/Structural	BOILER	3	50%
	CIVIL-BUILDING	3	50%
	FAN – CIVIL-BUILDING	3	50%
	FOUNDATION	2	100%
	HVAC	3	50%
	SUPPORTS	3	50%
Compressed Air	AIR RECEIVER	3	50%
	COMPRESSOR	2	100%
	DRYER	2	100%
	FILTER	3	50%
	SWITCH	2	100%
Compressors	ANALYZER	1	150%
	BLOWER	2	100%
	COMPRESSOR	1	150%
	COOLER	3	50%
	ENGINE	1	150%
	FAN	3	50%
	FILTER	3	50%
	MOTOR	1	150%
	TURBINE	1	150%
	TURBINE – PWR	2	100%
	VFD	1	150%
Control	ESD	2	100%
	RTU / PLC	1	150%
	SWITCH	2	100%
	TRANSMITTER	3	50%
Cooling System	COOLER	3	50%
	COOLING TOWER	3	50%
	FILTER	3	50%

System	Component Type	Class Large	System Factor
	HEAT EXCHANGER	3	50%
	PUMP	2	100%
	TANK	4	0%
	VALVE – ACTUATED	3	50%
Electrical	ATS	2	100%
	BATTERY	2	100%
	COOLER	3	50%
	GENERATOR	1	150%
	RELAY	1	150%
	SWITCHGEAR / MCC	2	100%
	TRANSFORMER	2	100%
	UPS	2	100%
	WIRING	3	50%
Environmental	CIVIL-BUILDING	1	0%
	CIVIL-OTHER	1	0%
	HAZMAT-LABEL	1	0%
	HAZMAT-STORAGE	1	0%
Fire Detection/Suppression	DETECTOR	1	0%
	EXTINGUISHER	1	0%
	FOAM	1	0%
	PUMP	1	0%
	TANK	1	0%
Fuel Gas	DEHYDRATOR	3	50%
	FILTER	3	50%
	HEATER	3	50%
	METER – ORIFICE	3	50%
	METER – TURBINE	3	50%
	REGULATOR	2	100%
	SEPARATOR	3	50%
	VALVE	3	50%
	VALVE – ACTUATED	2	100%
	VALVE – RELIEF	3	50%
Gas	ANALYZER	4	0%

System	Component Type	Class Large	System Factor
	BOTTLE	4	0%
	COOLER	3	50%
	DEHYDRATOR	3	50%
	FAN	3	50%
	FILTER	3	50%
	HEATER	4	0%
	METER	3	50%
	METER – INSERTION	3	50%
	METER – ORIFICE	3	50%
	METER – ROTARY	3	50%
	METER – TURBINE	3	50%
	METER – ULTRASONIC	3	50%
	MONITOR	2	100%
	ODORIZER	2	100%
	PIPING	4	0%
	REGULATOR	2	100%
	SAMPLER	4	0%
	SEPARATOR	3	50%
	SUPPRESSOR – NOISE	4	0%
	VALVE	4	0%
	VALVE – ACTUATED	2	100%
	VALVE – CHECK	4	0%
	VALVE – RELIEF	3	50%
Lube Oil	COOLER	2	100%
	FILTER	2	100%
	HEATER	2	100%
	LUBE SYS	2	100%
	PUMP	2	100%
	TANK	3	50%
Power Gas	PWR GAS SYS	2	100%
Processing	BLOWER	2	100%
	BOILER	2	100%
	BURNER	2	100%
	COOLER	1	150%

System	Component Type	Class Large	System Factor
	DEHYDRATOR	1	150%
	FILTER	1	150%
	HEAT EXCHANGER	3	50%
	METER – ORIFICE	3	50%
	METER – ULTRASONIC	3	50%
	OXIDIZER	2	100%
	PUMP	1	150%
	REGENERATOR SYS	1	150%
	SEPARATOR	3	50%
	TANK	4	0%
	VALVE	4	0%
	VALVE – ACTUATED	1	150%
	VALVE – RELIEF	1	150%
	VFD	1	150%
Security	DETECTOR	1	0%
	FENCE	1	0%
	GATE	1	0%
	SIGN	1	0%
Storage	HYDRAULIC SYS	2	100%
	METER – ORIFICE	3	50%
	METHANOL SYS	2	100%
	REGULATOR	2	100%
	VALVE	4	0%
	VALVE – ACTUATED	2	100%

The system level score is based on component scores based on the following formula:

$$System\ Score = \left[\begin{array}{c} \frac{\sum(Class\ 1\ Scores) * class\ 1\ weighting\ factor}{No.of\ class\ 1\ comp'ts} + \\ \frac{\sum(Class\ 2\ Scores) * class\ 2\ weighting\ factor}{No.of\ class\ 2\ comp'ts} + \\ \frac{\sum(Class\ 3\ Scores) * class\ 3\ weighting\ factor}{No.of\ class\ 3\ comp'ts} + \\ \frac{\sum(Class\ 4\ Scores) * class\ 4\ weightig\ factor}{No.of\ class\ 4\ comp'ts} \end{array}\right] \times 10$$

The system score is normalized to allow for more weighting on the class 1 components, which have an active function to perform. The remaining components are divided into class 2 or 3 secondary components, which support the functionality of the class 1 components; and class 4 or passive components, which typically have no active function.

Finally, an assessment is performed to determine the consequence of failure (COF) at a station level for the six major risk categories listed below.

- Health and Safety
- Reliability
- Environmental
- Regulatory
- Financial
- Reputation

The criteria used to define the COF for each station is provided in Table 38 below.

Table 38 – COF Criteria for Gas Transmission Stations

Risk Category	COF Rating	Comment
Health & Safety	If [redacted] processing facility, COF = 7 If [redacted] or [redacted] compressor station, COF = 6	C&P stations based on compatibility with risk register.
Regulatory & Compliance	For all stations, COF = 4	COF calibrated with maximum risk register score of 4 for C&P stations. Most risks score as 3, but 4 is maximum.
Environmental Impact	Hinkley, Topock COF = 6 (legacy issues). McDonald Island, COF = 4 (flooding risk) All other stations, COF = 3	Based on calibration with risk register.
Reliability	Stations identified as critical, COF = 5 Other stations, COF = 4	Based on calibration with risk register. Critical stations include the following: Delevan, McDonald Island, Los Medanos, Kettleman, Hinkley, and Topock.
Reputation	For all stations, COF = 4	Based on calibration with risk register. For 3rd party security risk, COF = 5; however, for all other risks, COF = 4.
Financial Impact	For all stations, COF = 5	Based on calibration with risk register.

This COF information was not utilized in the current condition assessment as the risk model for the C&P facilities has not yet been developed; however, this information along with the condition information is available for use in future risk analysis.

D. C&P System Target Score Criteria

The target score criteria for C&P facilities are based on the following:

- Average component score based on metric scores between good and medium (similar to M&C stations based on high health & safety and reliability COF)
- System score based on all components being at the average component score
- Targets adjusted for types of class components in each system

The component and system score are shown below:

Table 39 – C&P Facility

C&P Facility

Component Score					
			Category 1 Targets (Note 1)		
No.	Metric	Weighting	Target Score	Metric Score (Wtd)	Target Score Basis
1	Age	10%	8	0.80	Assume average age
2	Obsolescence	15%	1	0.15	Assume no obsolescence
3	Problem Equipment	15%	2.5	0.38	Assume between good and medium.
4	Physical Condition	15%	2.5	0.38	Assume between good and medium.
5	Functional Performance	25%	2.5	0.63	Assume between good and medium.
6	Operational Efficiency	4%	2.5	0.10	Assume between good and medium.
7	Engineered Maintenance Basis	4%	3	0.12	Assume maintenance strategy defined
8	Number of CM's	4%	2.5	0.10	Assume between good and medium.
9	Number of PM's Overdue	4%	2.5	0.10	Assume between good and medium.
10	Ratio of CM / PM Man-Hours	4%	2.5	0.10	Assume between good and medium.
	Component Score	100%		2.85	Based on scale of 1 (good) to 10 (poor)

Station Score					
			Category 1 Targets (Note 1)		
No.	Component Type	Weighting	Target Score	Metric Score (Wtd)	Target Score Basis
1	Class 1	150%	2.85	42.75	Assume all category 1 are same component score or the average is the same.
2	Class 2	100%	2.85	28.50	Assume all category 2 are same component score or the average is the same.
3	Class 3	50%	2.85	14.25	
4	Class 4	0%	2.85	0.00	
	Station Score			85.5	

The scoring is based on the class of components as shown in the Table 40 below.

Table 40 – Equipment Type, Class and Weighting Factor

System	Component Type	Class Large	System Factor
Civil/Structural	BOILER	3	50%
	CIVIL-BUILDING	3	50%
	FAN – CIVIL-BUILDING	3	50%
	FOUNDATION	2	100%

System	Component Type	Class Large	System Factor
	HVAC	3	50%
	SUPPORTS	3	50%
Compressed Air	AIR RECEIVER	3	50%
	COMPRESSOR	2	100%
	DRYER	2	100%
	FILTER	3	50%
	SWITCH	2	100%
Compressors	ANALYZER	1	150%
	BLOWER	2	100%
	COMPRESSOR	1	150%
	COOLER	3	50%
	ENGINE	1	150%
	FAN	3	50%
	FILTER	3	50%
	MOTOR	1	150%
	TURBINE	1	150%
	TURBINE – PWR	2	100%
	VFD	1	150%
Control	ESD	2	100%
	RTU / PLC	1	150%
	SWITCH	2	100%
	TRANSMITTER	3	50%
Cooling Water	COOLER	3	50%
	COOLING TOWER	3	50%
	FILTER	3	50%
	HEAT EXCHANGER	3	50%
	PUMP	2	100%
	TANK	4	0%
	VALVE – ACTUATED	3	50%

System	Component Type	Class Large	System Factor
Electrical	ATS	2	100%
	BATTERY	2	100%
	COOLER	3	50%
	GENERATOR	1	150%
	RELAY	1	150%
	SWITCHGEAR / MCC	2	100%
	TRANSFORMER	2	100%
	UPS	2	100%
	WIRING	3	50%
Environmental	CIVIL-BUILDING	1	0%
	CIVIL-OTHER	1	0%
	HAZMAT-LABEL	1	0%
	HAZMAT-STORAGE	1	0%
Fire Detection/Suppression	DETECTOR	1	0%
	EXTINGUISHER	1	0%
	FOAM	1	0%
	PUMP	1	0%
	TANK	1	0%
Fuel Gas	DEHYDRATOR	3	50%
	FILTER	3	50%
	HEATER	3	50%
	METER – ORIFICE	3	50%
	METER – TURBINE	3	50%
	REGULATOR	2	100%
	SEPARATOR	3	50%
	VALVE	3	50%
	VALVE – ACTUATED	2	100%
	VALVE – RELIEF	3	50%
Main Gas	ANALYZER	4	0%

System	Component Type	Class Large	System Factor
	BOTTLE	4	0%
	COOLER	3	50%
	DEHYDRATOR	3	50%
	FAN	3	50%
	FILTER	3	50%
	HEATER	4	0%
	METER	3	50%
	METER – INSERTION	3	50%
	METER – ORIFICE	3	50%
	METER – ROTARY	3	50%
	METER – TURBINE	3	50%
	METER – ULTRASONIC	3	50%
	MONITOR	2	100%
	ODORIZER	2	100%
	PIPING	4	0%
	REGULATOR	2	100%
	SAMPLER	4	0%
	SEPARATOR	3	50%
	SUPPRESSOR – NOISE	4	0%
	VALVE	4	0%
	VALVE – ACTUATED	2	100%
	VALVE – CHECK	4	0%
	VALVE – RELIEF	3	50%
Lube Oil	COOLER	2	100%
	FILTER	2	100%
	HEATER	2	100%
	LUBE SYS	2	100%
	PUMP	2	100%
	TANK	3	50%
Power Gas	PWR GAS SYS	2	100%

System	Component Type	Class Large	System Factor
Processing	BLOWER	2	100%
	BOILER	2	100%
	BURNER	2	100%
	COOLER	1	150%
	DEHYDRATOR	1	150%
	FILTER	1	150%
	HEAT EXCHANGER	3	50%
	METER – ORIFICE	3	50%
	METER – ULTRASONIC	3	50%
	OXIDIZER	2	100%
	PUMP	1	150%
	REGENERATOR SYS	1	150%
	SEPARATOR	3	50%
	TANK	4	0%
	VALVE	4	0%
	VALVE – ACTUATED	1	150%
	VALVE – RELIEF	1	150%
	VFD	1	150%
Security	DETECTOR	1	0%
	FENCE	1	0%
	GATE	1	0%
	SIGN	1	0%
Storage	HYDRAULIC SYS	2	100%
	METER – ORIFICE	3	50%
	METHANOL SYS	2	100%
	REGULATOR	2	100%
	VALVE	4	0%
	VALVE – ACTUATED	2	100%

Based on the classes within each system, the following are the system targets:

Table 41 – C&P System Target Health Scores

System	Target System Health Score
Civil / Structural	42.8
Compressed Air	42.8
Compressors	85.5
Control	85.5
Cooling Water	42.8
Electrical	85.5
Environmental	42.8
Fire Detection / Suppression	42.8
Fuel Gas	42.8
Main Gas	42.8
Lube Oil	42.8
Power Gas	28.5
Processing	85.5
Security	42.8
Storage	42.8

These target scores are then used to assist in prioritizing work at the C&P stations.

J. C&P System Health Scores

This appendix captures the system level health scores and provides the current condition health score and the target score on a system basis. The information in the work management system is incomplete and not precise in many cases so that the system scores require validation from the subject matter experts (facility engineers) to confirm or modify the system rankings. The results and discussion presented here include the raw system scores (based on Appendix E criteria) and on discussions with the facility engineers. Each of the compressor systems is presented.

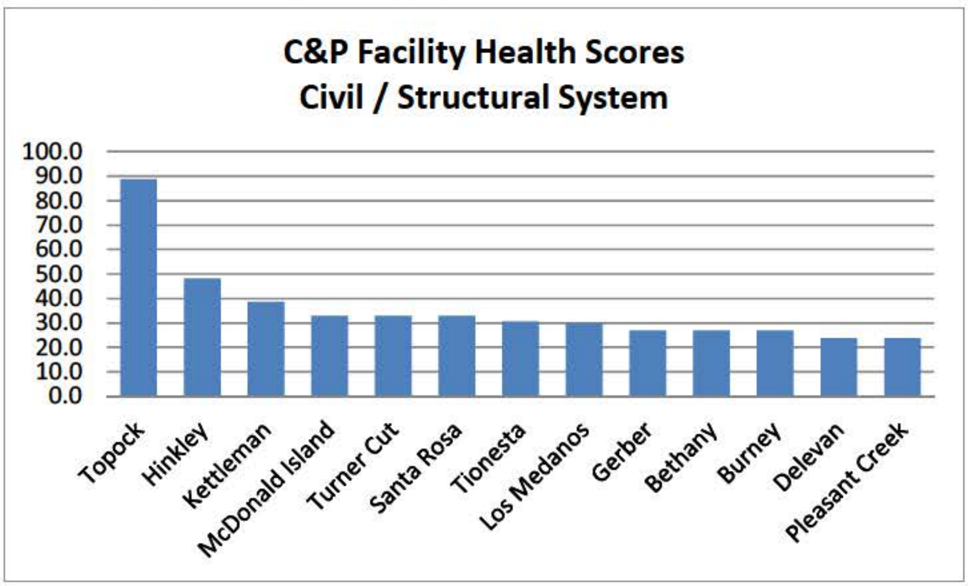
1. Civil / Structural System

The results of the condition assessment are provided in the figure below for the civil / structural system for the various facilities. Based on the assessment, the scores are generally less than 30, which indicate that these systems are in good health. Based on discussions with the facility engineers, there are issues related to foundations and buildings at Topock and Hinkley and these facilities should be at the top of the list. It was also indicated that the McDonald Island platform has some issues and should be considered as third on the list.

Therefore, for the civil / structural systems, the top three facilities for actions are:

- Topock
- Hinkley
- McDonald Island

Figure 17 – Civil/ Structural System Health Scores



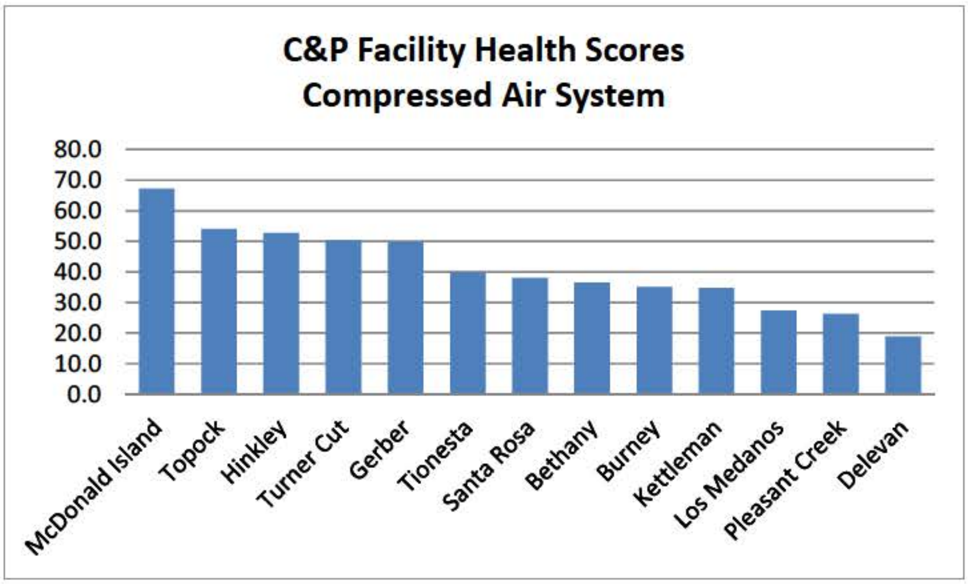
2. Compressed Air System

The results of the condition assessment are provided in the figure below for the compressed air system for the various facilities. Based on discussions with the facility engineers, many of the stations have rebuilt or replaced compressed air systems, including Hinkley, Kettleman, Whisky

Slough and Gerber. Also, it was indicated that Turner Creek should be reduced in significance. The facility rankings for actions based on facility engineer feedback are:

- Pleasant Creek (new system but functionally inadequate)
- Bethany
- McDonald Island
- Burney (old system and requires significant maintenance; however, rebuild included in the Burney rebuild project)
- Tionesta (old system and requires significant maintenance)

Figure 18 – Compressed Air System Health Scores

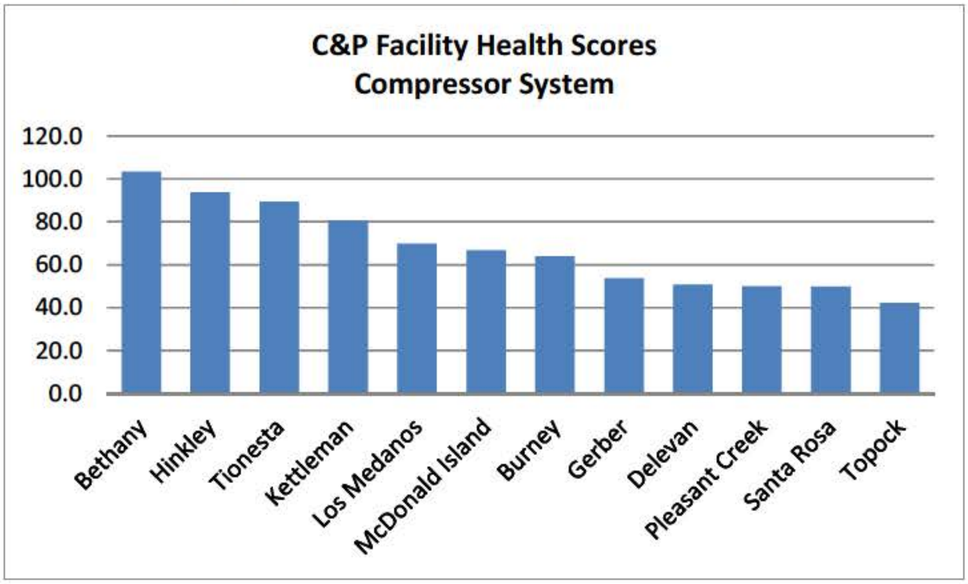


3. Compressor System

The results of the condition assessment are provided in the figure below for the compressor system for the various facilities. Based on discussions with the facility engineers, there has been recent work on Delevan, Gerber and Kettleman so these stations should have relatively good condition scores compared with other units. Also, Bethany has recent and pending replacement work so this can be reduced in significance. The facility rankings for actions based on facility engineer feedback are:

- Burney (older system with limited spare parts and is scheduled for rebuild; scored high in GIE assessment)
- Los Medanos (recent major performance problems and limited availability of parts; scored high in GIE assessment)

Figure 19 – Compressor System Health Scores

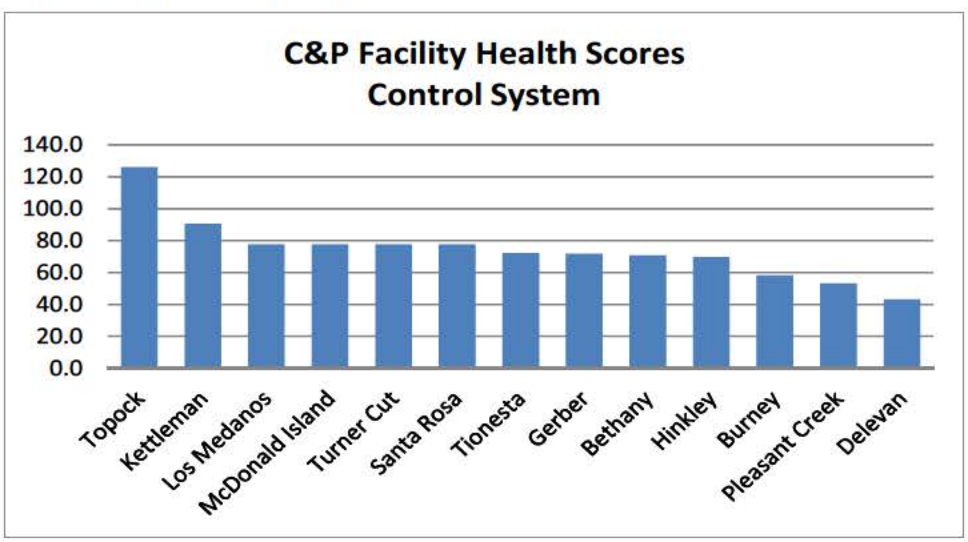


4. Control System

The results of the condition assessment are provided in the figure below for the control system for the various facilities. Based on discussions with the facility engineers, many of the stations have rebuilt or replaced control systems, including Los Medanos, Bethany, Tionesta, Hinkley, Pleasant Creek, Delevan, and Gerber. The facility rankings for actions based on facility engineer feedback are:

- Burney (included with compressor replacement project)
- Topock
- Santa Rosa

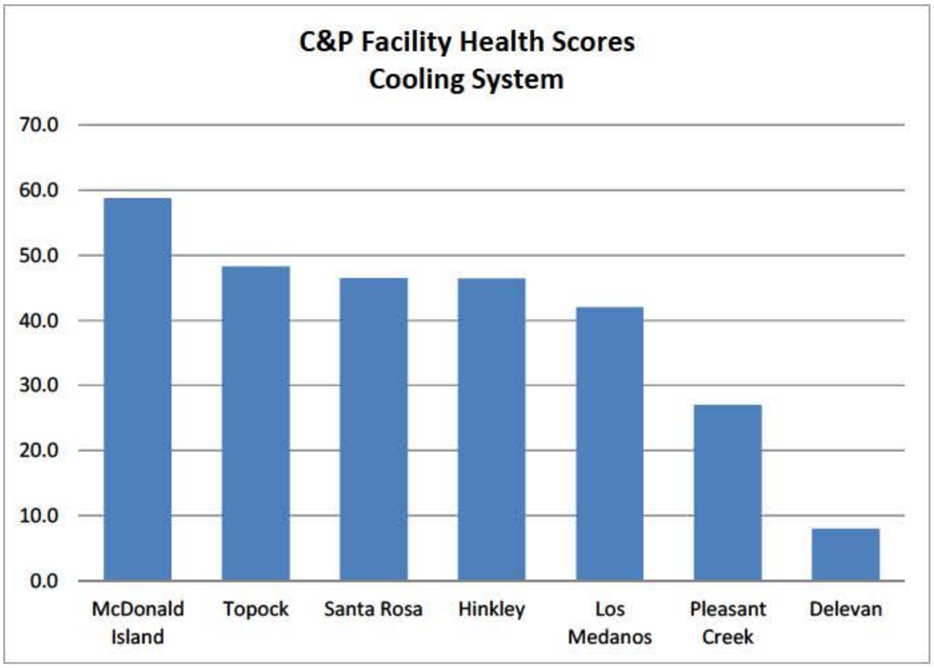
Figure 20 – Control System Health Scores



5. Cooling Systems

The results of the condition assessment are provided in the figure below for the cooling system for the various facilities. The overall results indicate that these stations are not a major condition issue. Feedback from the facility engineers indicates that McDonald Island has undergone some recent work which remediated its problems and that Topock and Hinkley have projects underway. Therefore, there are no major priority projects for the cooling systems.

Figure 21 – Cooling System Health Scores



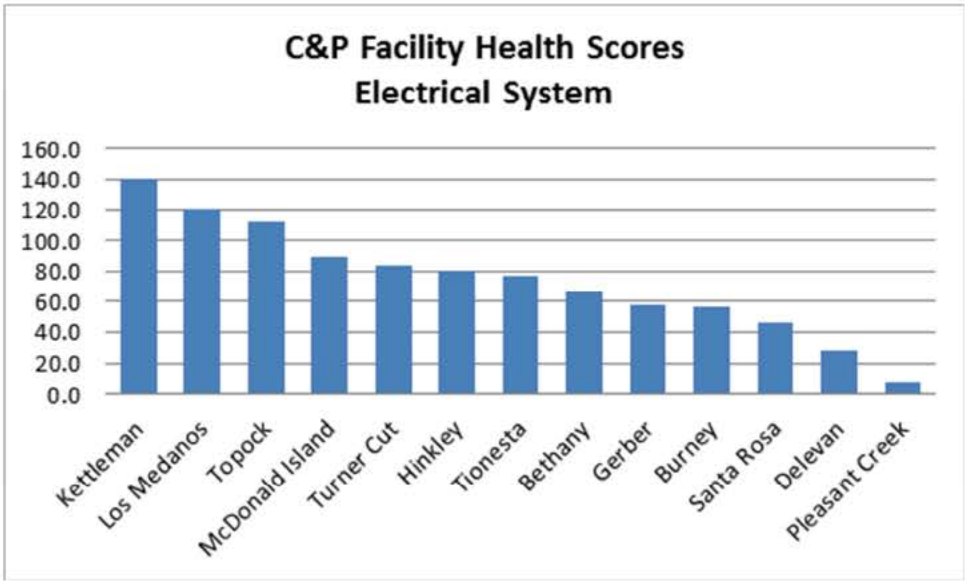
6. Electrical System

The results of the condition assessment are provided in the figure below for the electrical system for the various facilities. Based on discussions with the facility engineers, there is significant effort required to upgrade the electrical systems. The overall station scores for this system are high and indicate needed improvements in the electrical system health. Based on input from the facility engineers, the following stations have the biggest needs:

- Kettleman, Whisky Slough and Turner Cut have issues related to offsite power
- Santa Rosa and McDonald Island require transformer upgrades
- Topock has general electrical system aging and wear
- Pleasant Creek has issues with power supply and power quality

It should also be noted that Los Medanos has recent electrical system upgrades and that the Burney compressor replacement will include electrical system upgrades.

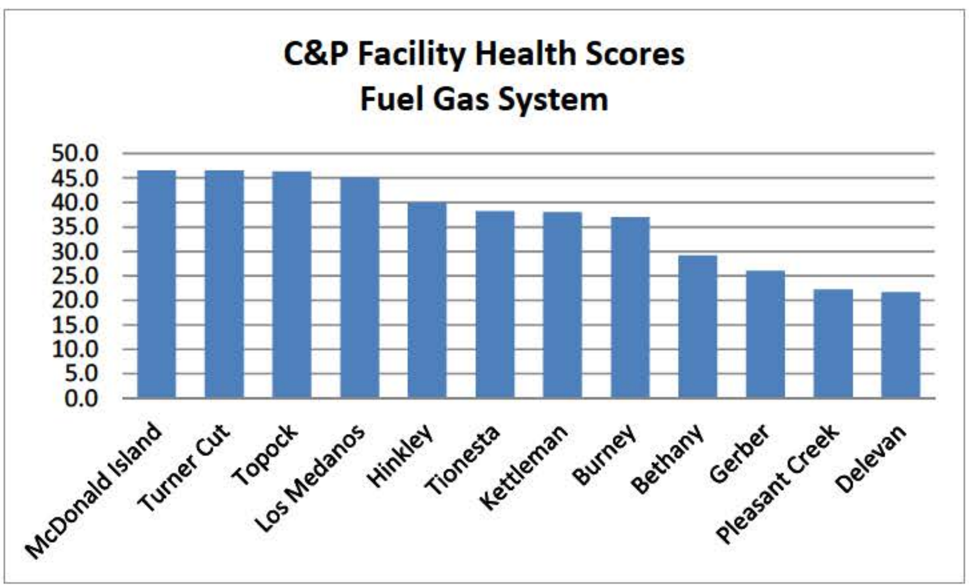
Figure 22 – Electrical System Health Scores



7. Fuel Gas System

The results of the condition assessment are provided in the figure below for the fuel gas system for the various facilities. The overall results and discussions with the facility engineers indicate that these stations are not a major condition issue. Therefore, there are no major priority projects for the fuel gas systems.

Figure 23 – Fuel Gas System Health Scores

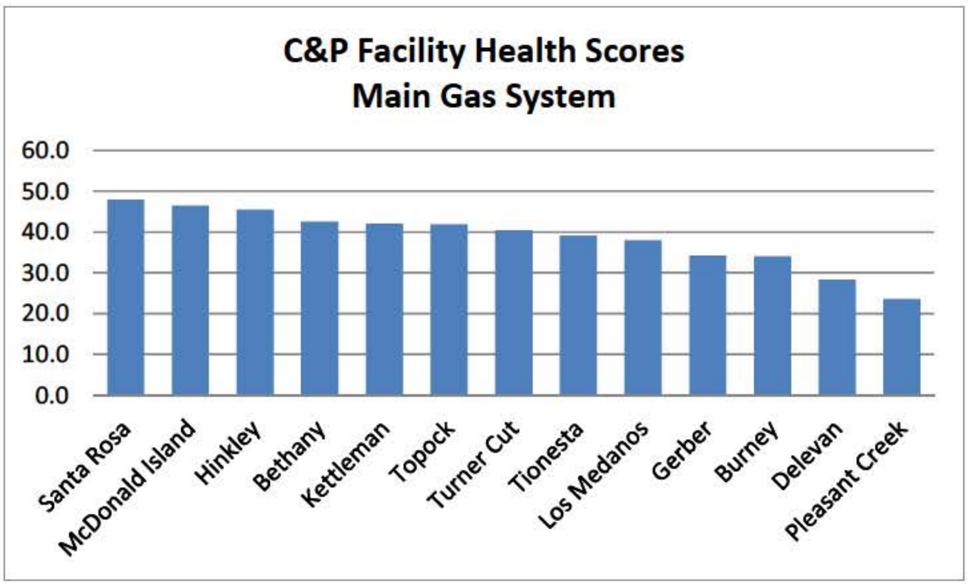


8. Main Gas System

The results of the condition assessment are provided in the figure below for the main gas system for the various facilities. The overall assessment scores indicate that there is not a system wide issue with the main gas systems. However, based on discussions with the facility engineers, there are specific problems that occur at the various stations. Some of the stations with identified issues include:

- Pleasant Creek (old, problem meters)
- Santa Rosa (Walworth valve issues)
- Bethany (obsolete Shafer valves)
- Delevan (obsolete hypersphere valves)
- Los Medanos (cooler)

Figure 24 – Main Gas System Health Scores

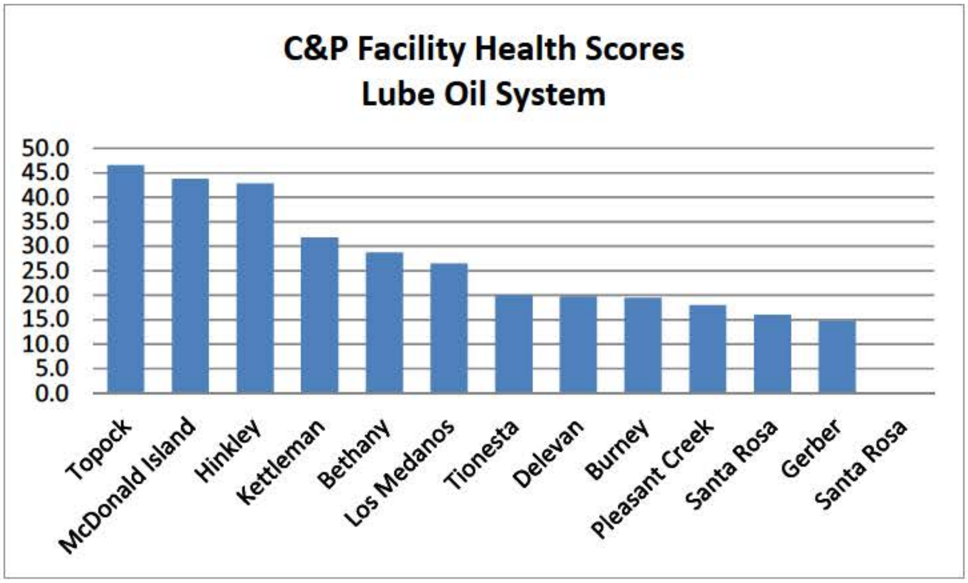


9. Lube Oil System

The results of the condition assessment are provided in the figure below for the lube oil system for the various facilities. The overall assessment scores indicate that there is not a system wide issue with the lube oil systems. However, based on discussions with the facility engineers, the following stations may require attention:

- Tionesta
- Hinkley
- Topock

Figure 25 – Lube Oil System Health Scores

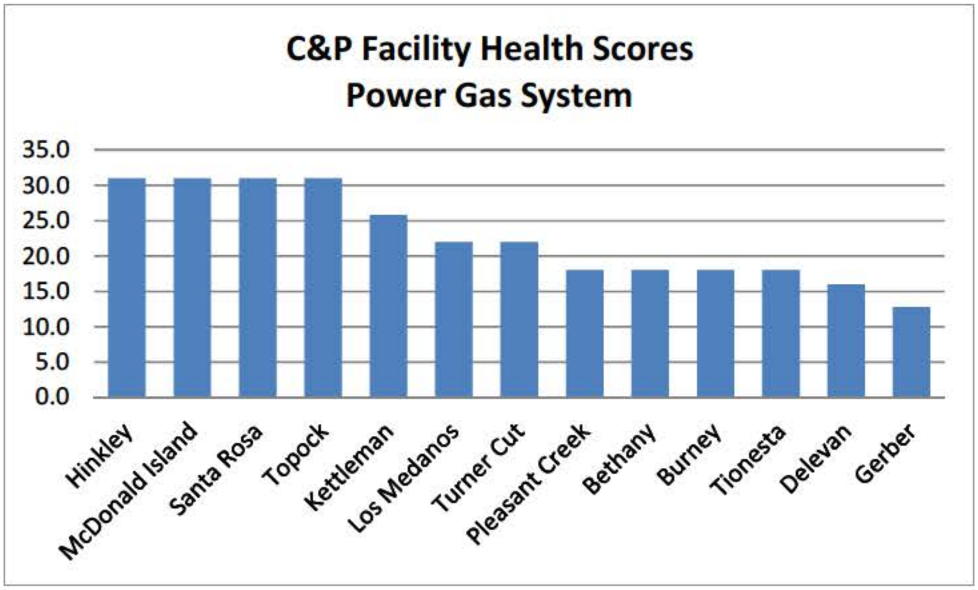


10. Power Gas System

The results of the condition assessment are provided in the figure below for the power gas system for the various facilities. The overall assessment scores indicate that there is not a system wide issue with the lube oil systems. However, based on discussions with the facility engineers, there are potential requirements to these systems depending on environmental requirements for greenhouse gas mitigation. There are 6 units that may be affected by Title 5 and would require retrofits and monitoring for greenhouse gases. These include:

- McDonald Island
- Turner Cut
- Whisky Slough
- Burney
- Tionesta
- Gerber

Figure 26 – Power Gas System Health Scores

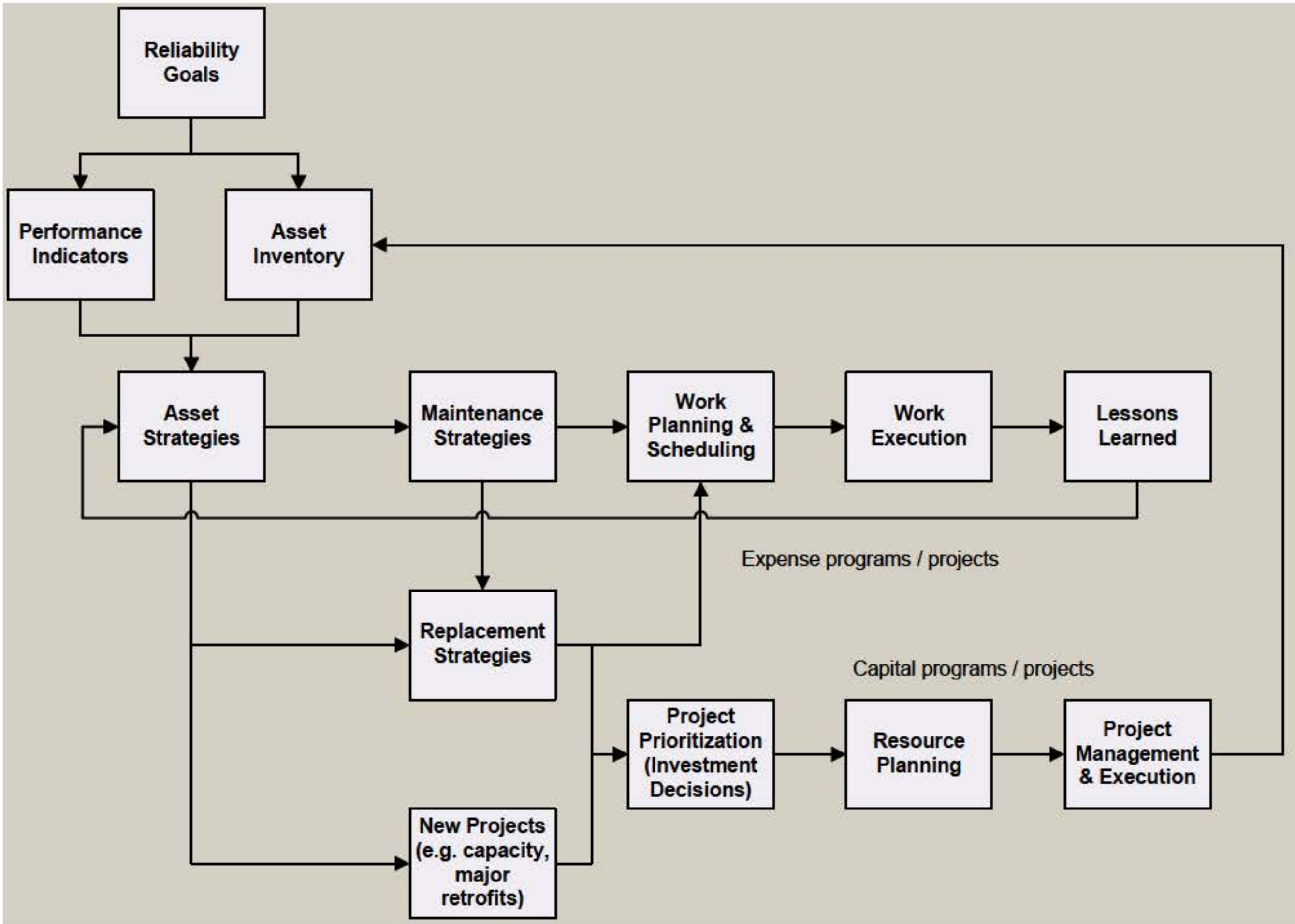


K. Proposed C&P Reliability Plan

The C&P reliability plan is prepared to maintain and ensure reliability of the compressor stations that support the company mission to serve and maintain the flow of gas throughout the system. The reliability plan is an integral part of the asset management program. An effective reliability plan is depicted in the figure below and includes the following elements:

- Specified reliability goals to support system operation and to guide development of the asset strategies
- Complete list of assets including manufacturer, make and model numbers, and installation date
- Regular and visible operational performance indicators
- Defined asset strategies for each asset that supports the reliability goals
- Development of maintenance and replacement strategies
- Proposal of major projects (capacity increases, major retrofits, etc.)
- Effective maintenance work management and capital project management processes
- Effective feedback loops to guide strategy changes

Figure 27 – Reliability Model



This appendix describes the reliability program for the C&P assets moving forward as part of the asset management strategy. This asset management plan addresses the key elements defined above and provides the available information on these program elements as well as recommendations for future actions related to the program elements.

1. **Reliability Goals**
   The Facilities Integrity Management Program (FIMP) team is currently working with Gas Control to develop appropriate reliability goals for the compressor and processing stations. These goals are intended to be at the system, path, station and unit levels to support the overall gas capacity commitments. The typical measures for these systems are availability and reliability. Given the current operating environment, the ability to track committed capacity versus available system capacity is also a driver. The goals have typically been developed based on historical performance, but recent discussions indicate a need to provide better operational feedback to set appropriate reliability goals.

2. **Asset Inventory**
   The asset register for the compressor and processing stations is mainly housed in PLM, the maintenance and work management tool used for these stations. There is a current

initiative to transfer the PLM data to SAP, which will be the future maintenance and work management tool for the C&P assets.

The recent condition assessment indicated the lack of a complete asset registry in PLM (or SAP) and the lack of key asset information as a weakness in the current asset management program. The completeness of the asset register with accurate information is needed to make decisions on asset strategy based on the known performance of these assets by make and model, by age and obsolescence, and by functional performance. Recommendations from the condition assessment have identified actions to refresh the current asset registry, to continue to accurately update the asset registry after projects replace or add new equipment, and the need to better identify obsolete and problem equipment. These asset inventory initiatives will be driven as part of the overall FIMP program. However, the ability to have complete asset information will benefit the overall reliability program.

3. Performance Indicators

Regular and visible metrics and performance indicators provide a means to identify trends in performance that require action. There is a significant amount of data captured on the C&P assets; however, this data is not easily retrieved and converted to information that can be analyzed for action. There are several initiatives underway to improve the overall frequency and accuracy of performance metrics for use by the facility engineers in developing strategies and remedial actions for the C&P assets.

Figure 31 in Appendix M, provides a set of metrics that can be applied to the operational performance and maintenance performance of the C&P assets. Some of this information exists today and other information streams will need to be developed. Several key indicators that exist today include:

- Availability by unit, station and path
- Reliability by unit, station and path
- Outages by station
- HP Utilization by unit and station
- Mean Time Between Failures by unit

The data for these metrics is available but not easily retrievable. There is a current program underway to work with Gas Control and other groups to collect and report this data more frequently. However, there is historic information that can be used to evaluate and prioritize work among the stations. Unfortunately, the data on outages is not always useful in identifying the cause of the outages to allow for better decision making.

Current information available for these metrics is shown on the following graphs. The first set of graphs (Figure 31) shows the availability and reliability metrics for the Baja, Redwood, and Mission paths over the past decade. The second set of graphs shows the availability, reliability and operating hours percent for the individual compressor units on the Baja (Figures 32 and 35), Redwood (Figures 33 and 36), and Mission (Figures 34 and 37) paths to provide an indication of past performance. The data for these graphs is taken from information reported by Gas Control through 2012 that was available for the condition assessment. This information is included here to provide baseline information for the reliability plan.

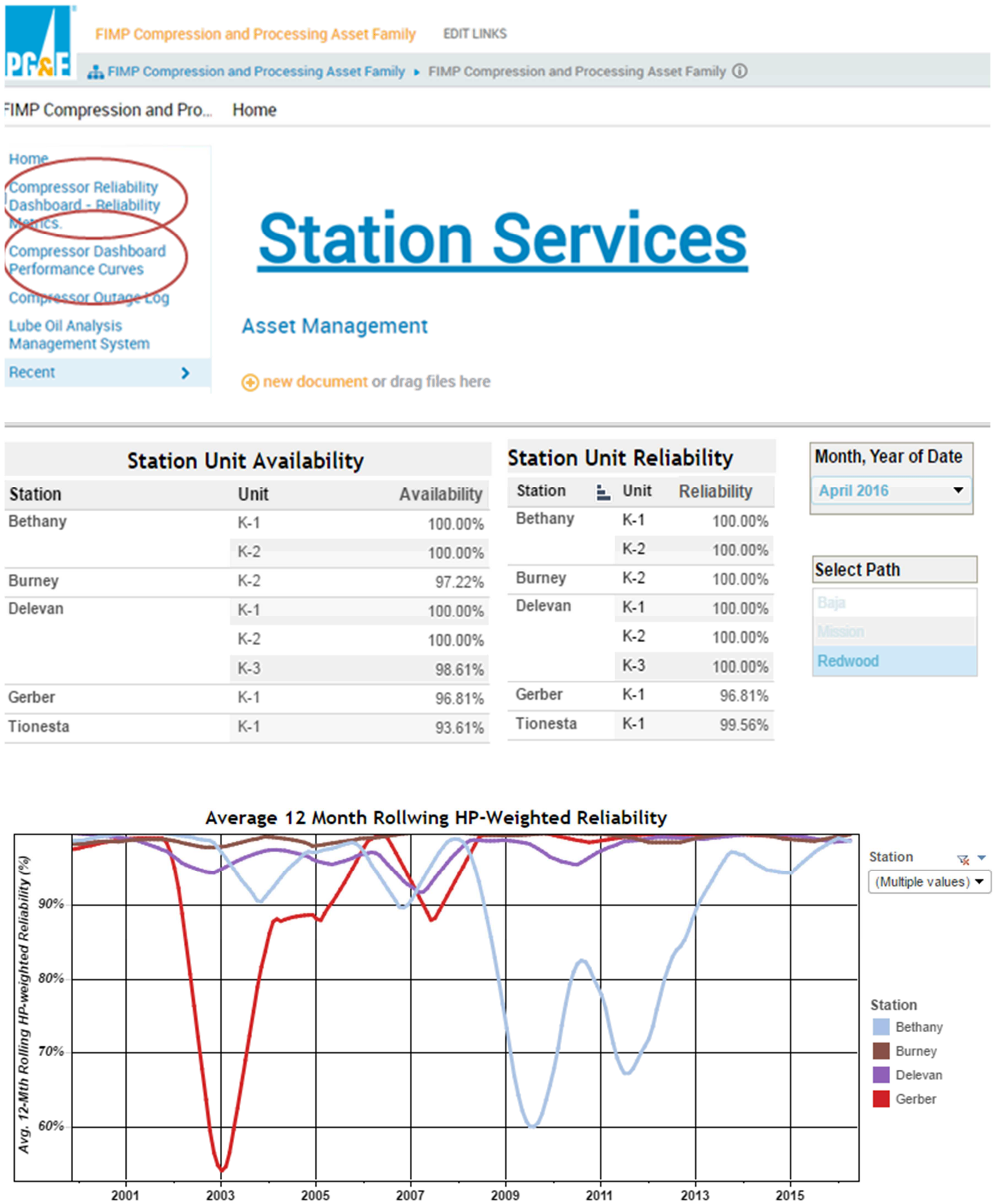
4. **Compressor Reliability Dashboard**

Late 2015, the compressor reliability dashboard was created to be the hub for all compressor related metrics and documentation. This dashboard contains the monthly reliability, availability, and HP utilization for each path, station, and unit. The source of this data is comprised of a lengthy manual process gathering engine run hours, compressor outages, and cause of outages from each district. Once the source file is linked, the dashboard automatically displays the data and is much more user friendly. This allows the data to be readily accessible to all PG&E employees. Here is the location of the dashboard, click hyperlink:

https://sps.utility.pge.com/sites/FIMPCPAssets/SitePages/Home.aspx

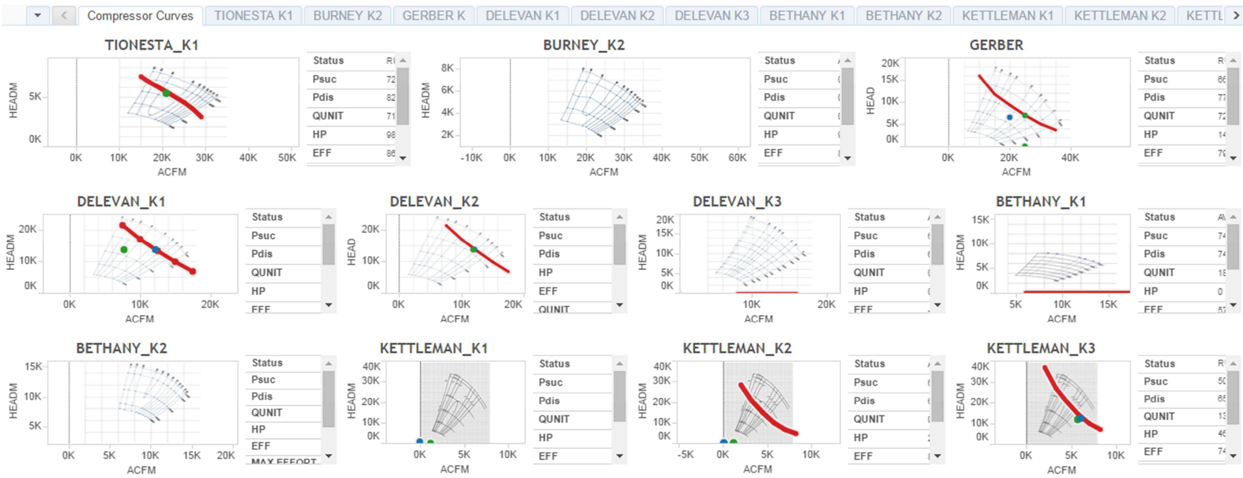
An example of the Compressor Reliability Dashboard is shown in Figure 28

Figure 28 – Compressor Reliability Dashboard



The Compressor Dashboard also contains several other links: Centrifugal compressor performance curves with live operating data, link to compressor station daily outage log, and lube oil management system. The purpose of these other links is to evaluate the performance and condition of all centrifugal units at a glance. Examples are shown in Figure 29.

Figure 29 – Centrifugal Compressor Performance Curves



Each individual performance curve also indicates the current or historic operating points, pressure, efficiency, capacity, and recycle valve position. These operating points help for trouble shooting if any issues occur as well as help predict potential irregular operating locations such as surge or stonewall. An example is shown in Figure 30 below.

Figure 30 – Compressor Curve Historic Operating Points

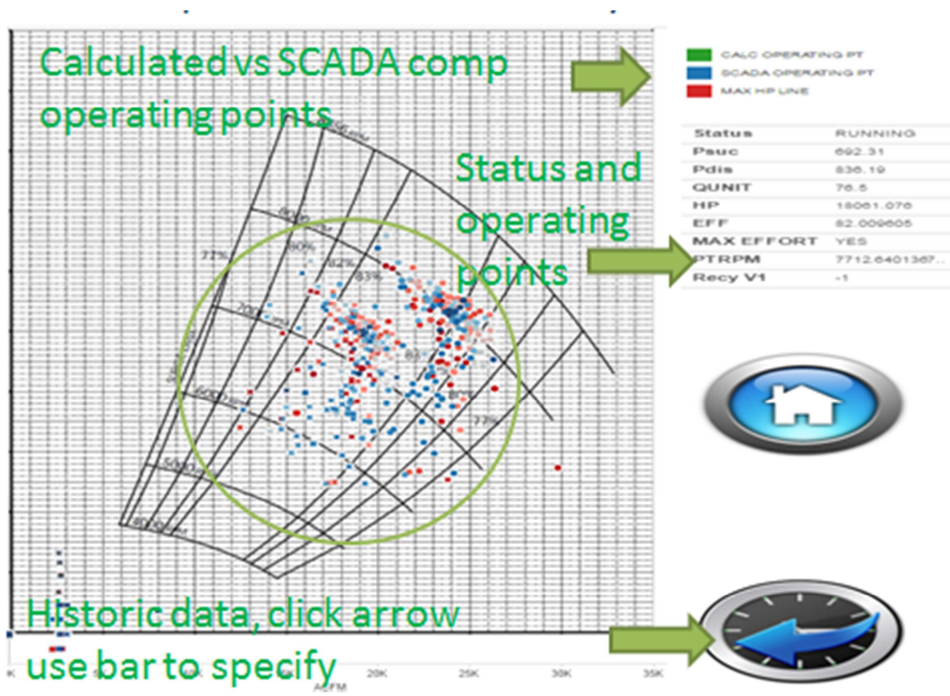


Figure 31 – Baja, Redwood and Mission Path Reliability Data

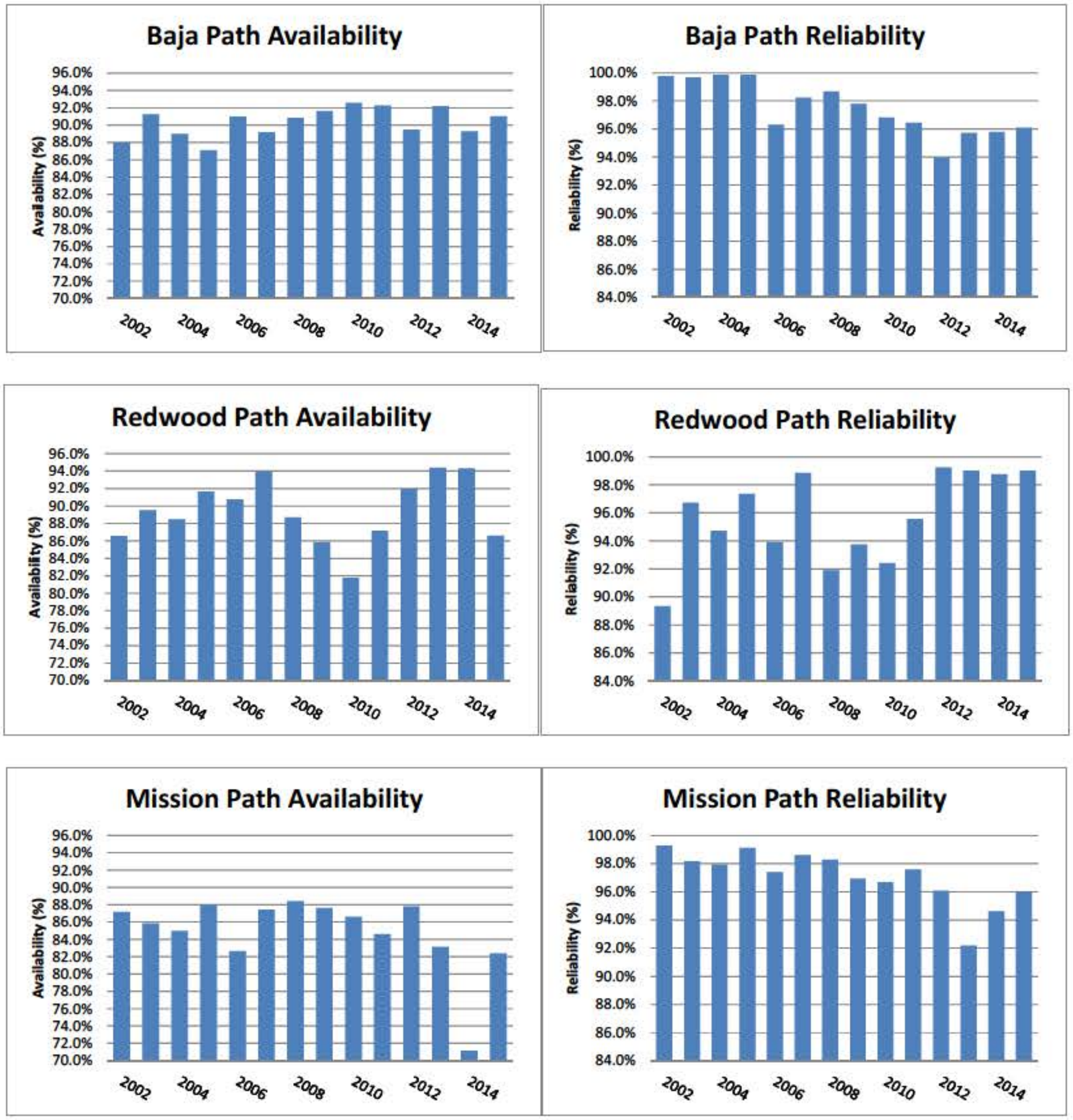
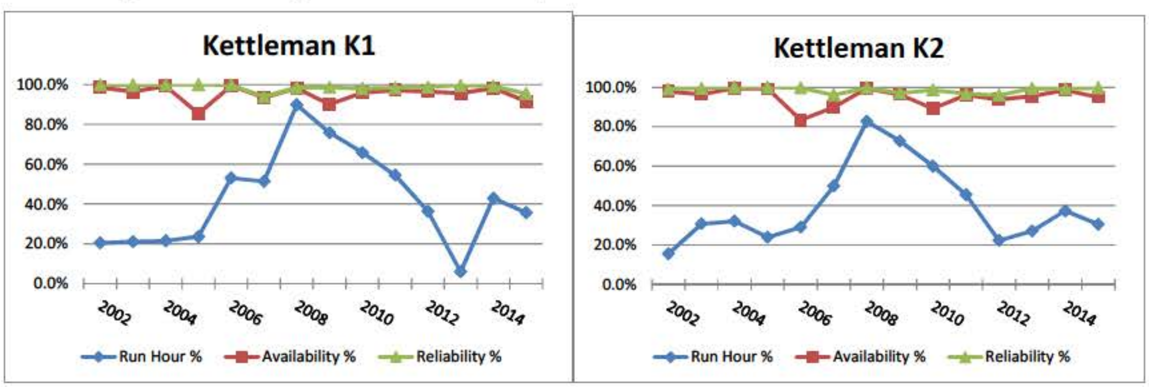
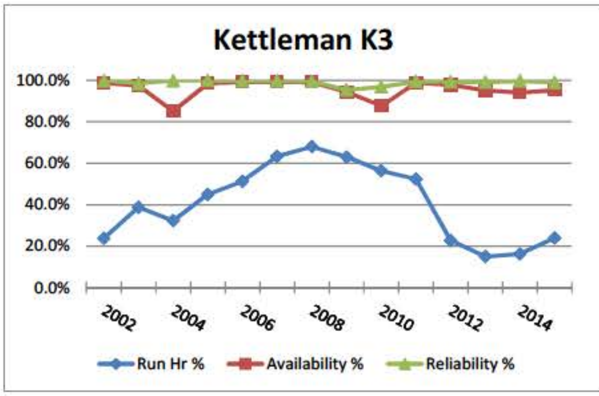
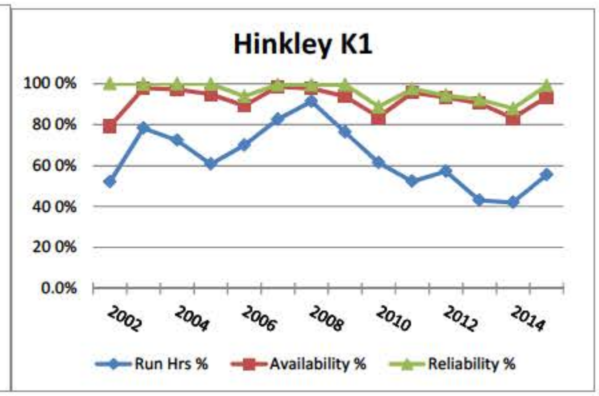


Figure 32 – Baja Path Compressor Reliability Data




Kettleman K3
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hr %
Availability %
Reliability %


Hinkley K1
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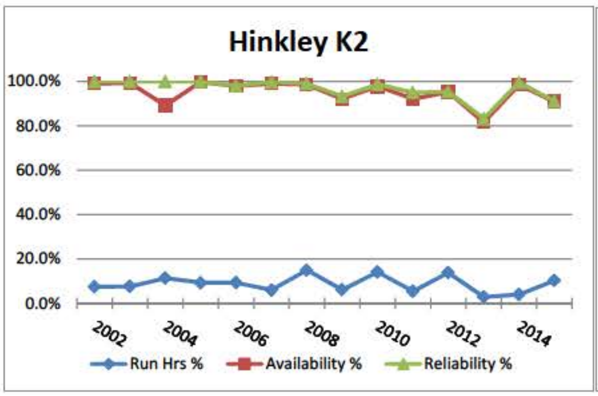
80 0%
60 0%
40 0%
20 0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %


Hinkley K2
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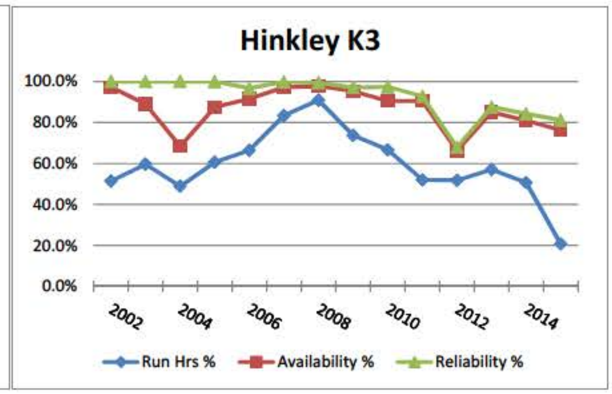
Hinkley K3
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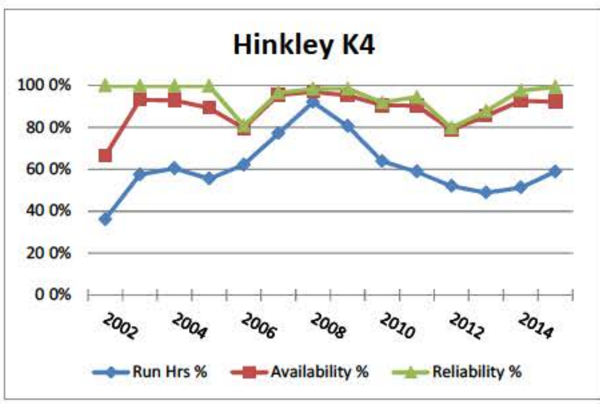
Hinkley K4
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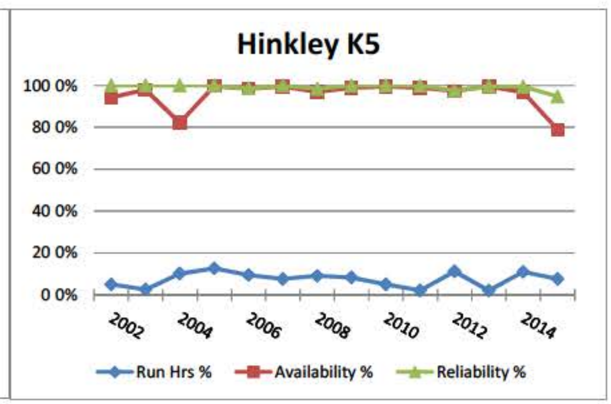
Run Hrs %
Availability %
Reliability %


Hinkley K5
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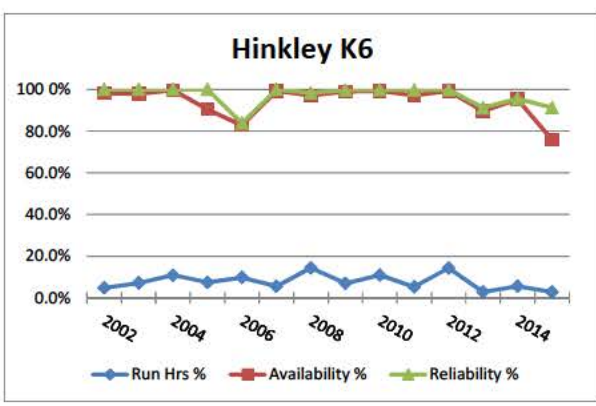
Run Hrs %
Availability %
Reliability %


Hinkley K6
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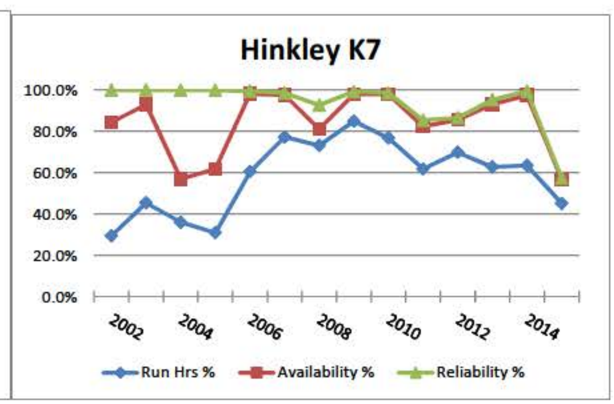
Run Hrs %
Availability %
Reliability %


Hinkley K7
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Run Hrs %
Availability %
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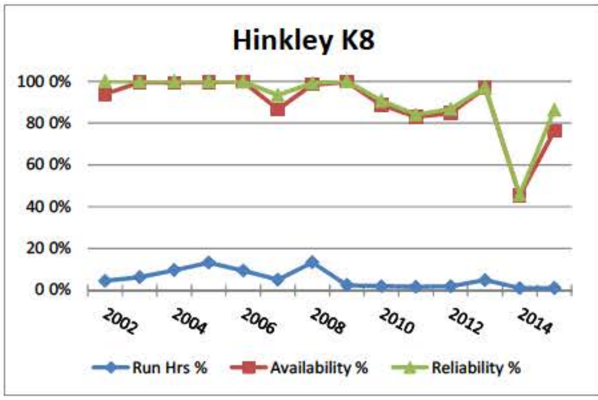
Hinkley K8
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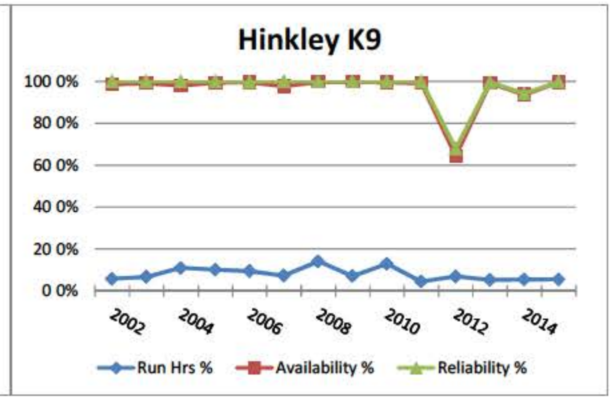
Run Hrs %
Availability %
Reliability %


Hinkley K9
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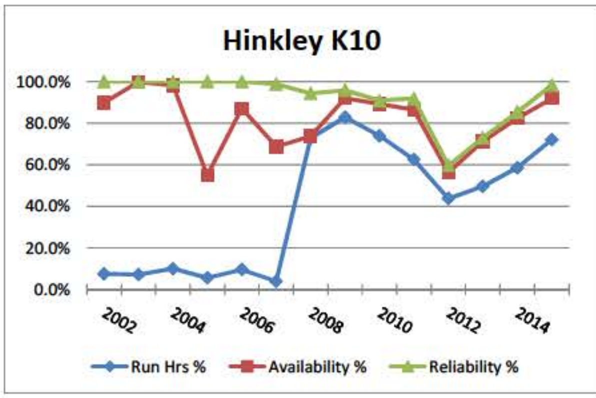
2014
Run Hrs %
Availability %
Reliability %


Hinkley K10
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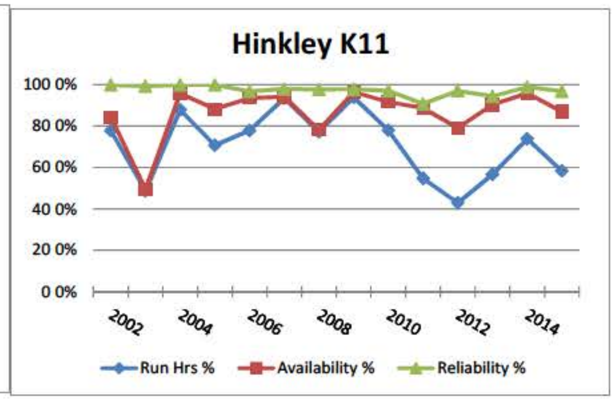
Run Hrs %
Availability %
Reliability %


Hinkley K11
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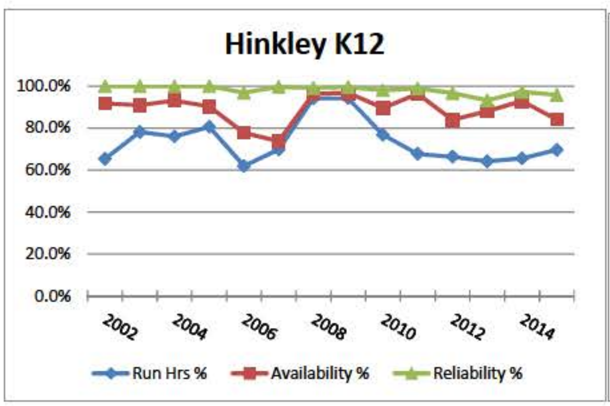
Run Hrs %
Availability %
Reliability %


Hinkley K12
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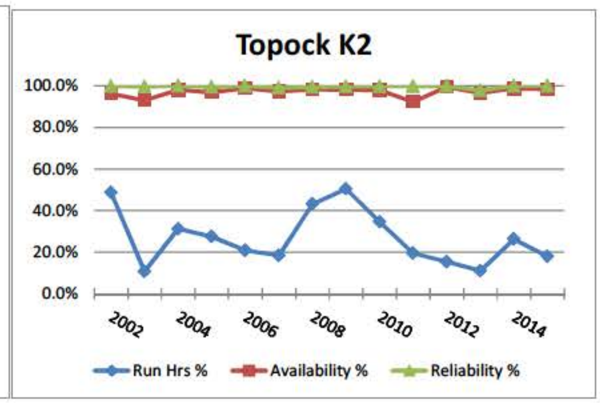
Run Hrs %
Availability %
Reliability %


Topock K2
100.0%
80.0%
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0.0%
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2006
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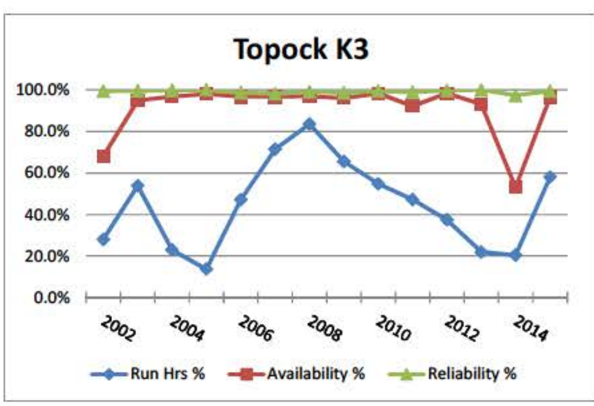
2012
2014
Run Hrs %
Availability %
Reliability %


Topock K3
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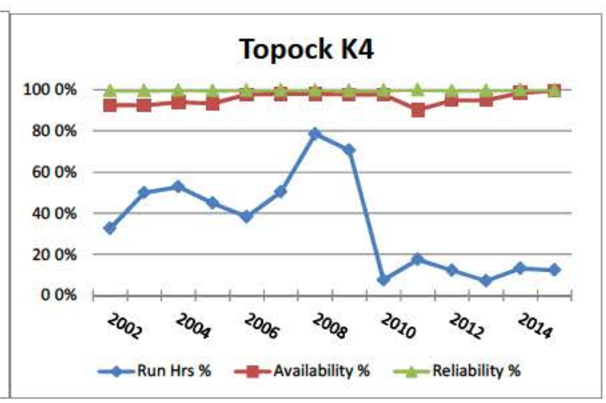
Run Hrs %
Availability %
Reliability %


Topock K4
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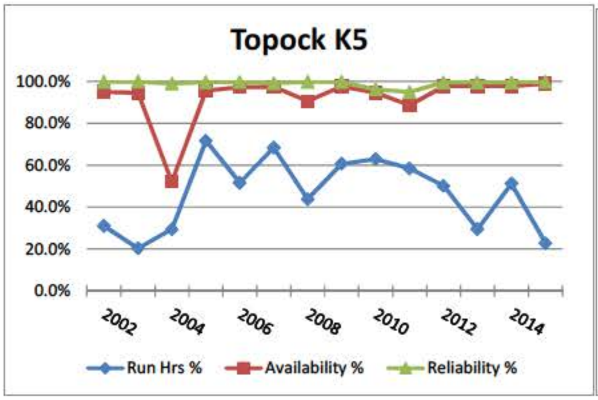
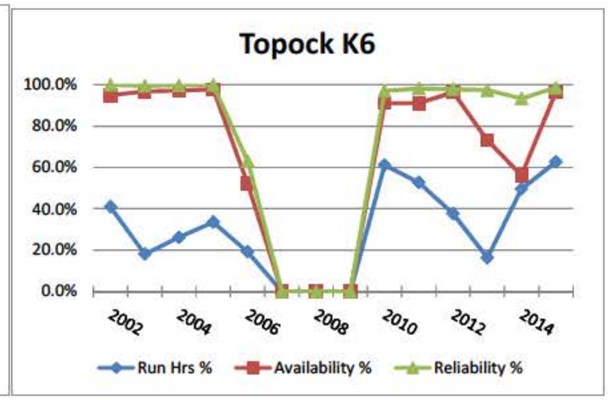
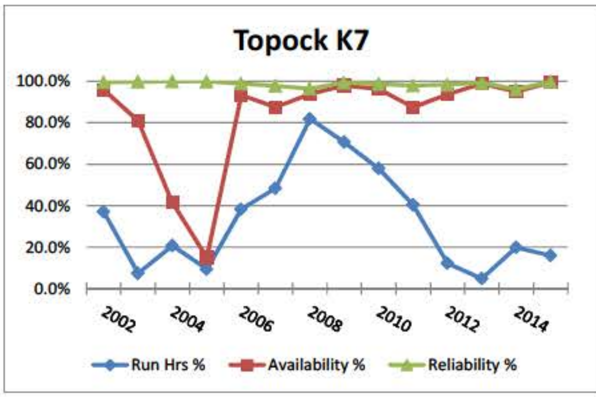
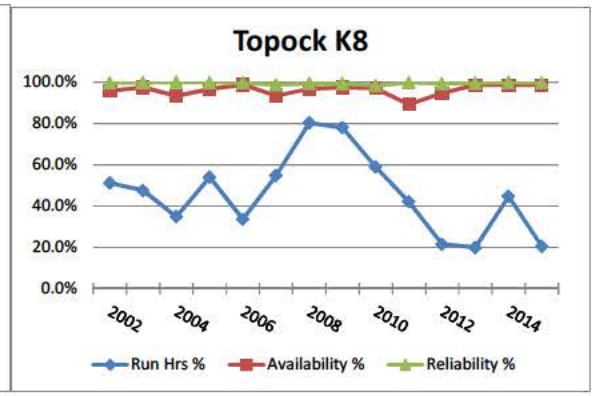
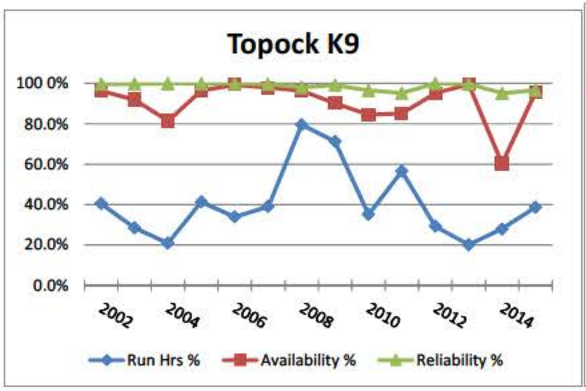
Run Hrs %
Availability %
Reliability %











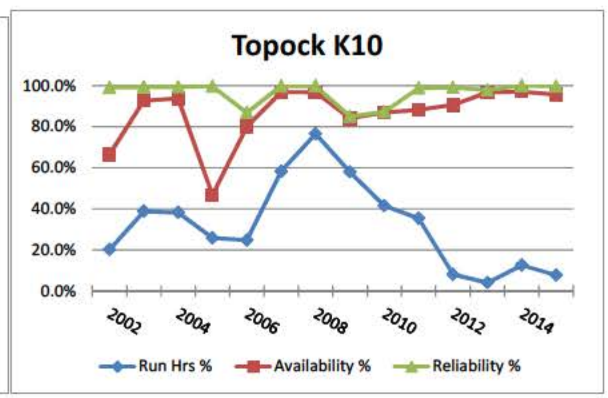
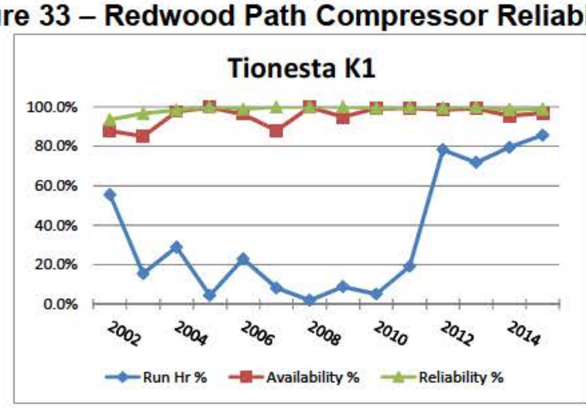
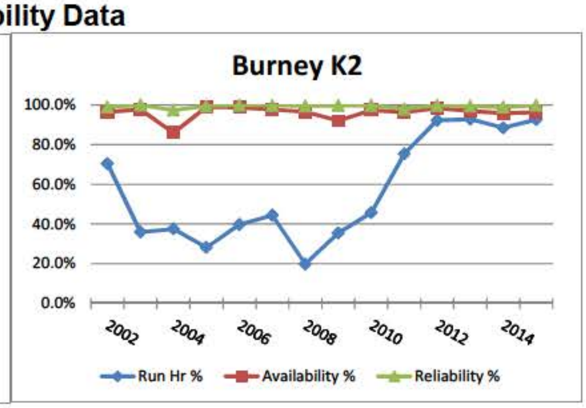
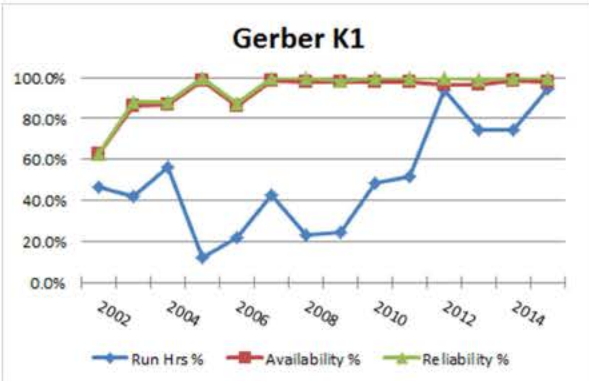
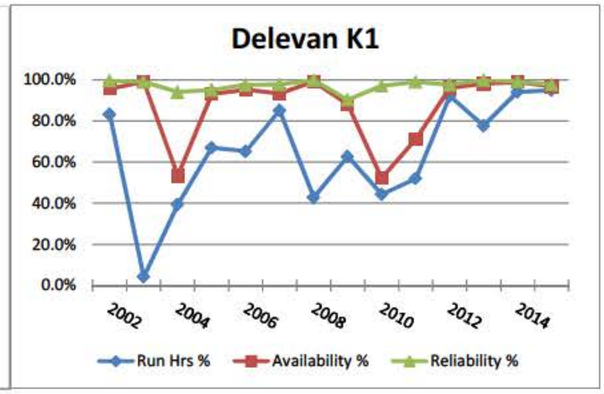


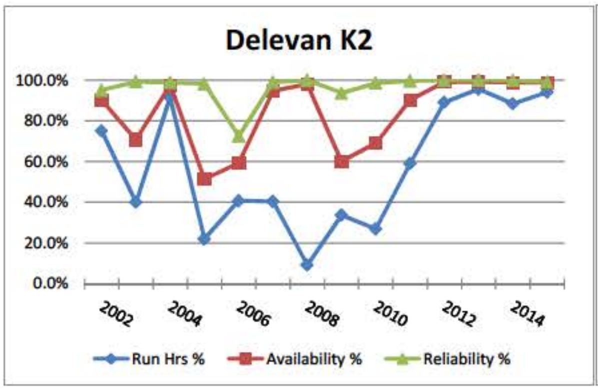
Figure 33 – Redwood Path Compressor Reliability Data

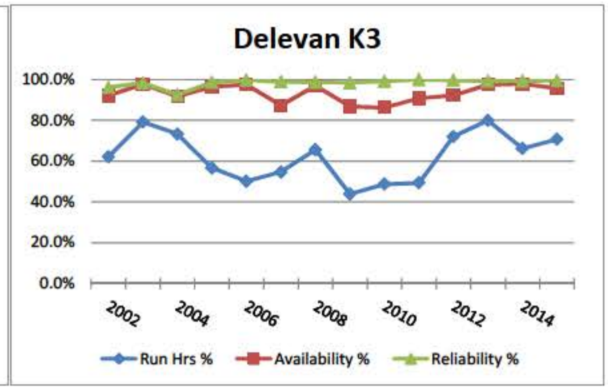


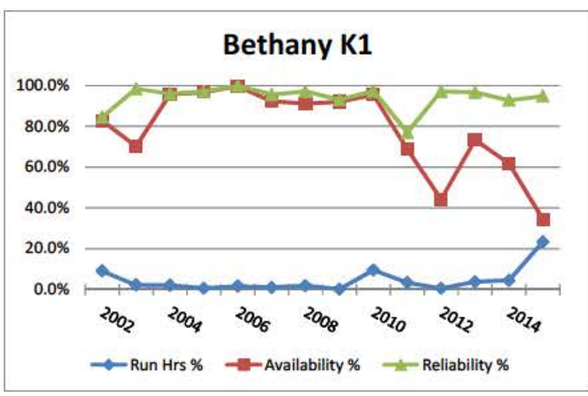



Gerber K1
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %


Delevan K1
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %


Delevan K2
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %


Delevan K3
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %


Bethany K1
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %

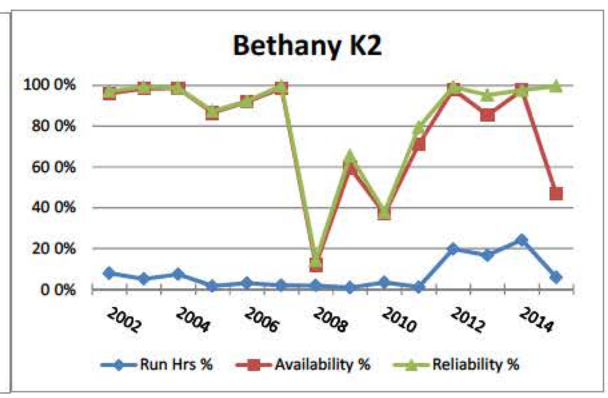

Bethany K2
100 0%
80 0%
60 0%
40 0%
20 0%
0 0%
2002
2004
2006
2008
2010
2012
2014
Run Hrs %
Availability %
Reliability %

Figure 34 – Mission Path Compressor Reliability Data (Excluding McDonald Island Rentals)

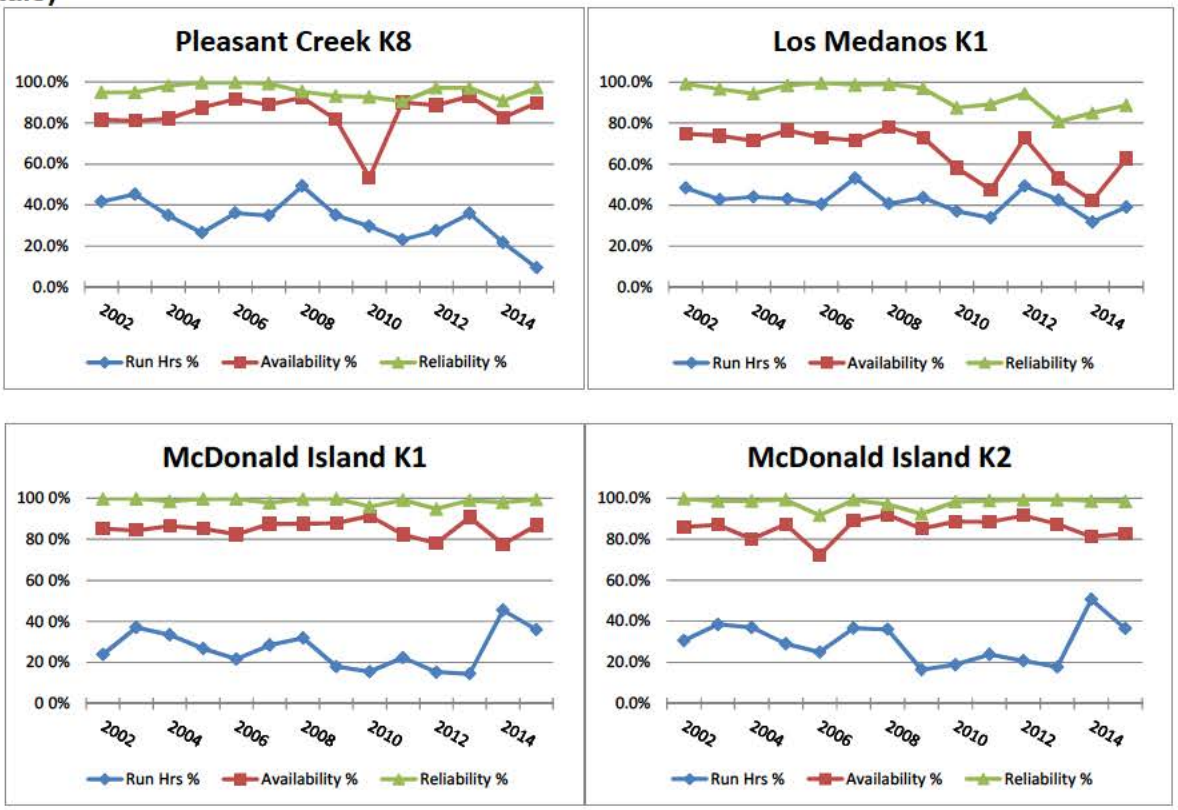


Figure 35 - Baja Path Availability & Reliability

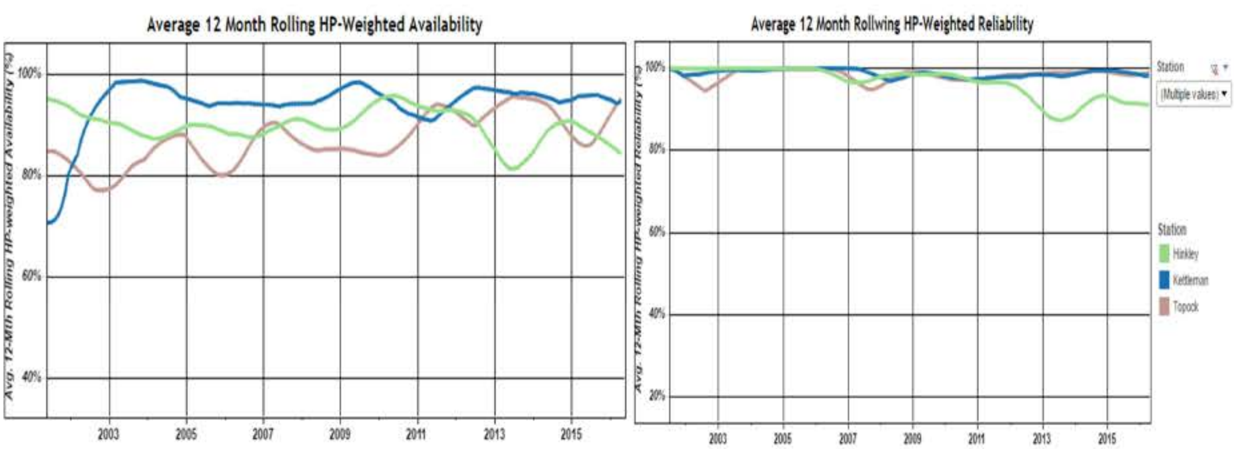


Figure 36 - Redwood Path Availability & Reliability

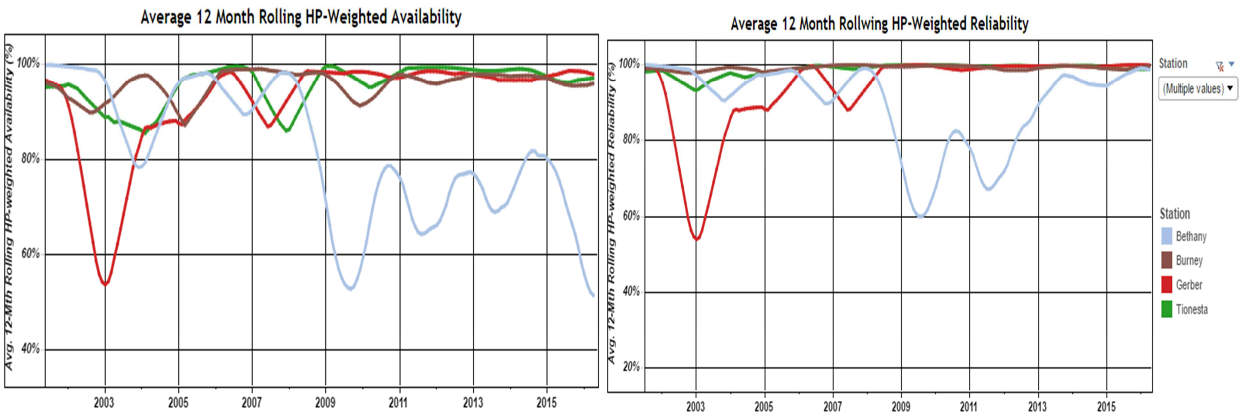
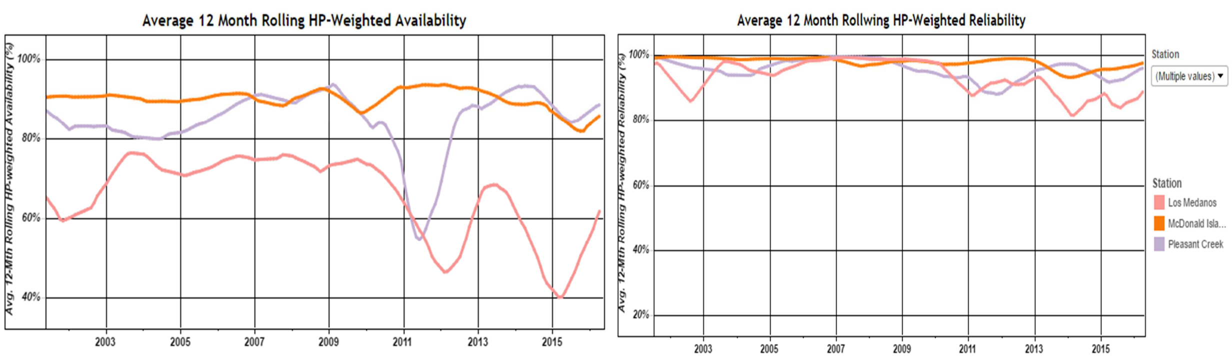
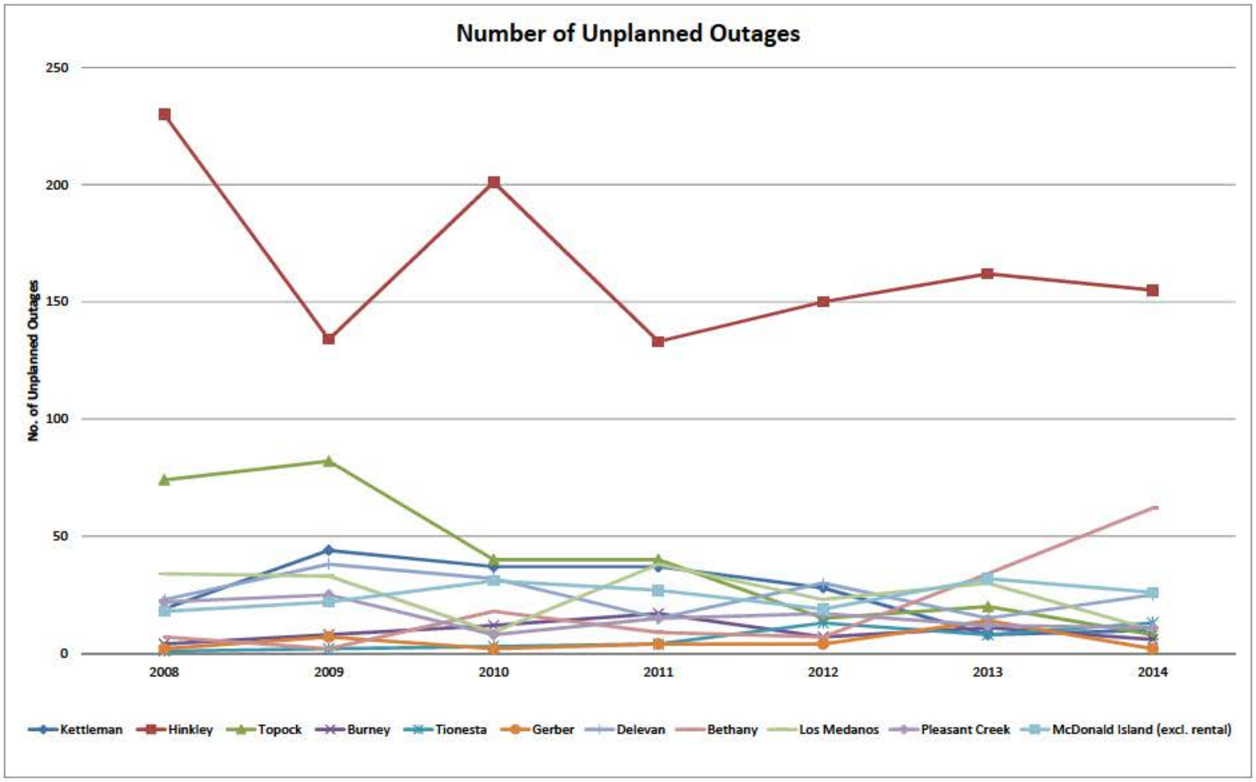


Figure 37 - Mission Path Availability & Reliability



Another metric that is useful to identify problems and trends is outage information. The outage information for the compressor stations is tracked but causal information often is not captured. However, the number of unplanned outages is captured here to provide some historical baseline for future decisions. The key action relative to outage information is to ensure that more accurate and complete data is collected relative to the cause of the outage (immediately at the time of the outage such as alarms, system, or component indications; and follow-up causal evaluation information). Figure 38 provides historical information on the number of unplanned outages occurring annually at the compressor stations (excluding the McDonald Island rental units).

Figure 38 – Historical Unplanned Outage Data (Excluding McDonald Island Rentals)



The performance indicators presented here provide a reference point for reviewing reliability. More detailed information and analysis is required to identify potential problem areas for investment.

5. Asset Strategies (Including Maintenance and Replacement Strategies)

The development and specification of asset strategies is a key function necessary to ensure the reliability of compressor and processing stations and equipment. The development of asset strategies is an on-going effort that requires the specification of inspection, maintenance and replacement intervals when a component is placed into service and requires periodic review and modification based on equipment performance (from maintenance or problem reporting information). A typical approach to defining asset strategies is based on the following steps:

- Identification of System and Component Classes: This activity includes a review of system and equipment components to develop classes of assets for use in developing the criticality of the assets and the overall asset strategies. For assets that are similar between facilities, the groupings provide consistency between the activities performed at each facility. Currently, for the compressor stations, this information is captured in the maintenance plans assigned to the systems and components within the facilities.
- Define System Criticality: Criteria are defined for use in determining criticality and priority of system-level assets. The criteria typically include items such as the system impact on safety, reliability, and costs. The criticality criteria will answer the questions:
    - Is the system required to maintain or enhance safety?
    - Is the system required to maintain or enhance reliability (the system functions as desired)?

    - Is the system costly to repair or replace?

Each system is evaluated against the defined criteria to define a priority for the system. Again, this information is currently reflected in the maintenance plans.

- Define Component Criticality: Similar to the system criticality, component criticality for each system classification is defined to establish the criticality and priority for the various equipment classes. The criteria will be similar to the system-level evaluation and will include items such as the component impact on safety, reliability, and costs. The criticality criteria will answer the questions:
    - Is the component required to maintain or enhance system safety?
    - Is the component required to maintain or enhance system reliability?
    - Is the component costly to repair or replace?

Each component is evaluated for criticality against the defined criteria to define a priority for the component. Again, this information is currently reflected in the maintenance plans.

- Select Maintenance Tasks: An abbreviated RCM analysis is typically performed on the system and equipment classes to define and select the appropriate maintenance strategies. Appropriate actions can then be defined to prevent or mitigate failure depending on the criticality of the component. The abbreviated RCM is based on a more qualitative approach. In many cases, the RCM analysis is based on the knowledge of key subject matter experts. This effort includes the following activities:
    - Prepare RCM templates for the equipment classes: A template is prepared that provides the basis for performing the RCM analysis and to document the results of the analysis. A typical template is shown in Table 42 below.

Table 42 – Sample RCM Template

System:						
System Criticality:						
Criteria	Components					
	1	2	3	4	5	6
Critical functional requirements						
Failure mechanism to not fulfill functional requirements						
Cause of failure mechanism						
Impact of failure						
What prevents failure						
What predicts failure						
Actions						

- Conduct RCM Analysis: Workshops with teams of subject matter experts are conducted to develop and populate the RCM templates. The teams typically consist of supervisors, operators, equipment specialists, and craftsmen to bring specific experience with the systems and equipment. This activity completes templates for the various system and equipment categories and classes, which provide the bases for defining the maintenance strategy. This type of information may be included in the various maintenance plans and procedures.
- Maintenance Strategy Development. Based on the results of the RCM analysis above, maintenance tasks are defined for each system and equipment class. These requirements are captured in the maintenance and inspection procedures and are managed through the work management system.

- Since the compressor stations vary in age, it may be appropriate for the asset strategies to be re-examined. Additionally, the pending migration of the PLM data to SAP provides an opportunity to develop a more detailed maintenance and inspection hierarchy within SAP. This hierarchy will involve the components that should be included as separate items for maintenance and inspection.

- In Q1 2016 a Pilot RCM study was conducted at Hinkley and Gerber Compressor stations. These two stations were selected as Hinkley has reciprocating compressors driven by natural gas engines. Gerber has a centrifugal compressor driven by a gas turbine. Hinkley K-11/12 and Geber K-1 and auxiliary systems were the scope of the study.

- Hidden and evident failures were identified during the RCM study. Likelihood and severity of failures were ranked using the enterprise risk matrix.

- The findings of the RCM study for Hinkley K-11/12:
  - 84 potential failures identified are prevented by current maintenance practices. Action: To be verified and validated.

- 57 potential failures identified with No scheduled maintenance or inspection. Action: To be added.
- 58 potential failures identified with no spares in stock. Action: To be added.

- The findings of the RCM study for Gerber K-1:
  - 83 potential failures identified are prevented by current maintenance practices. Action: To be verified and validated.
  - 53 potential failures identified with No Scheduled Maintenance or inspection. Action: To be added.
  - 65 potential failures identified with No spares in stock. Action: To be added.

- The detailed RCM study reports are stored at FIMP C&P SharePoint site located here: FIMP C&P SharePoint

Currently we are evaluating the cost & resources required to add all the identified failures with no maintenance, inspection, or spare parts. A path forward will be decided end of Q2 2016.

Figures 39 through 44 are charts that identify high level findings from the Hinkley RCM study:

Figure 39 - Overall failure modes in a System Level

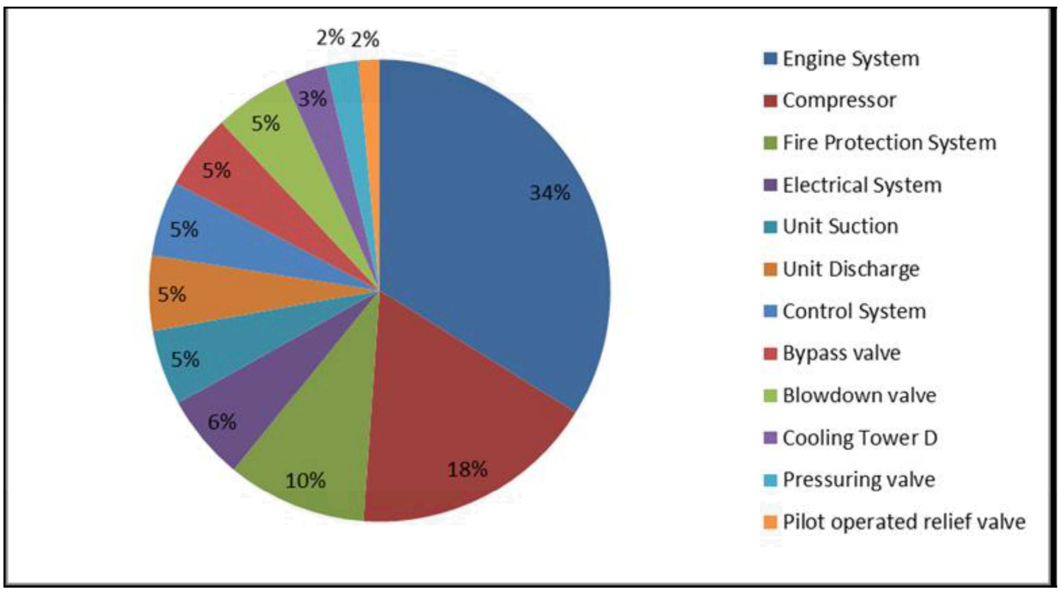


Figure 40 - Overall Top 10 Critical Failures

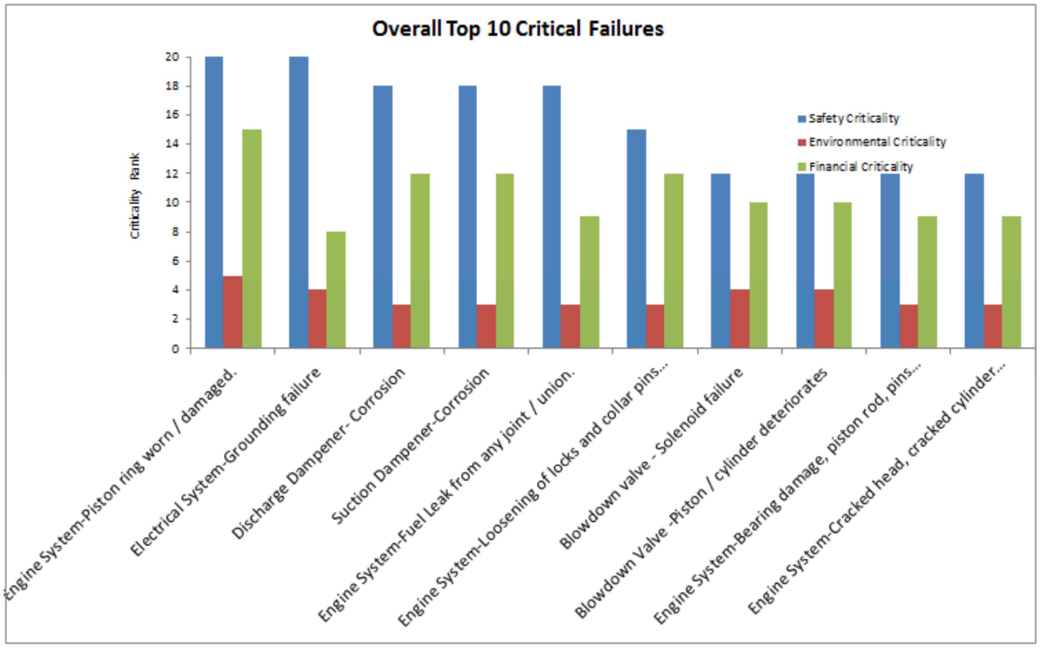


Figure 41 - Overall Top 10 Safety Critical Failures

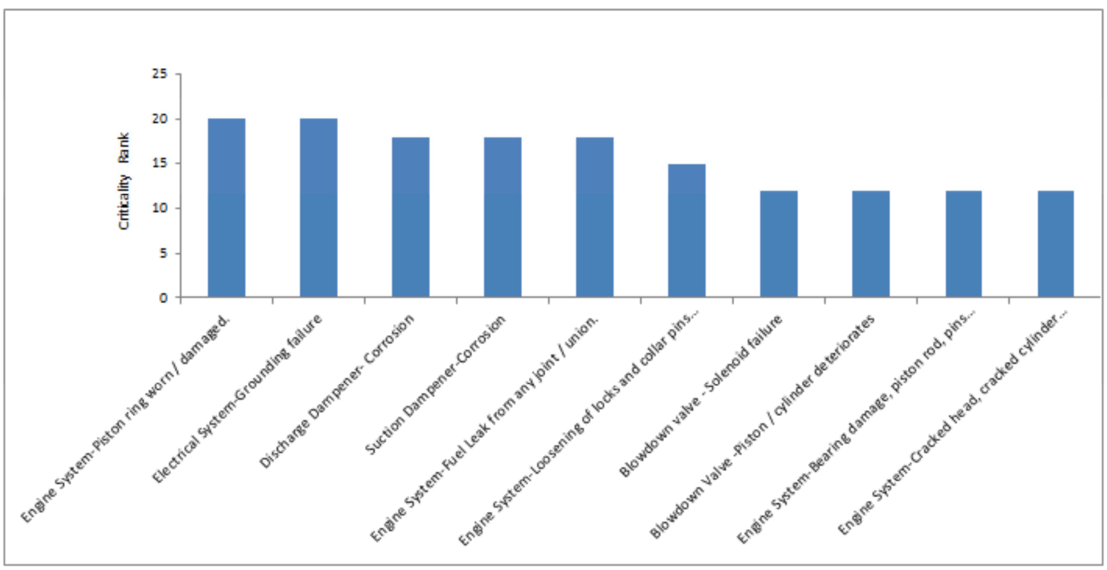


Figure 42 - Overall Top 10 Environmental Critical Failure Modes

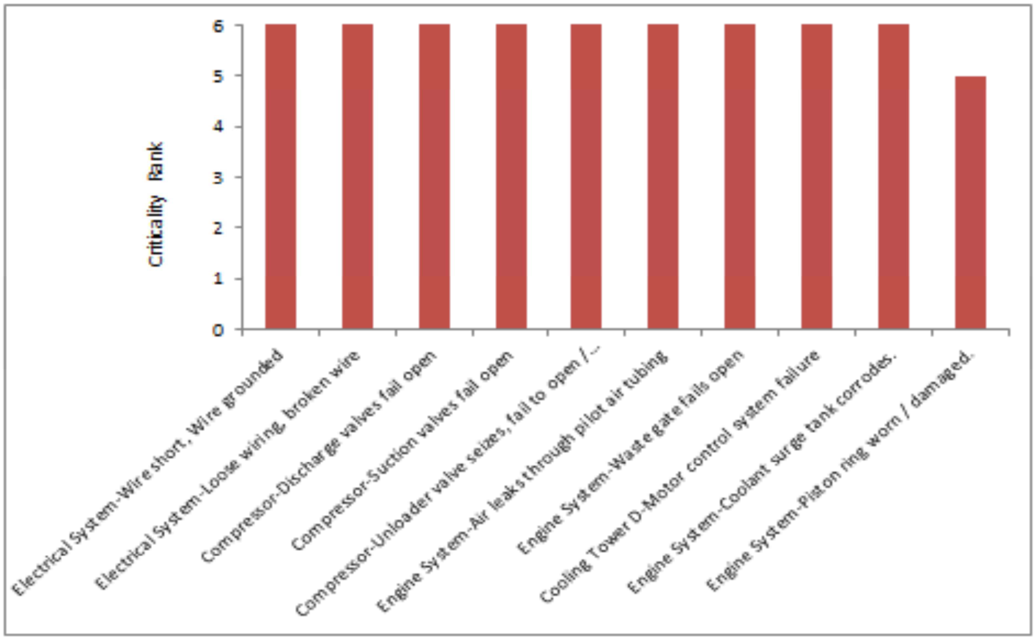


Figure 43 - Overall Top 10 Financial Critical Failure Modes

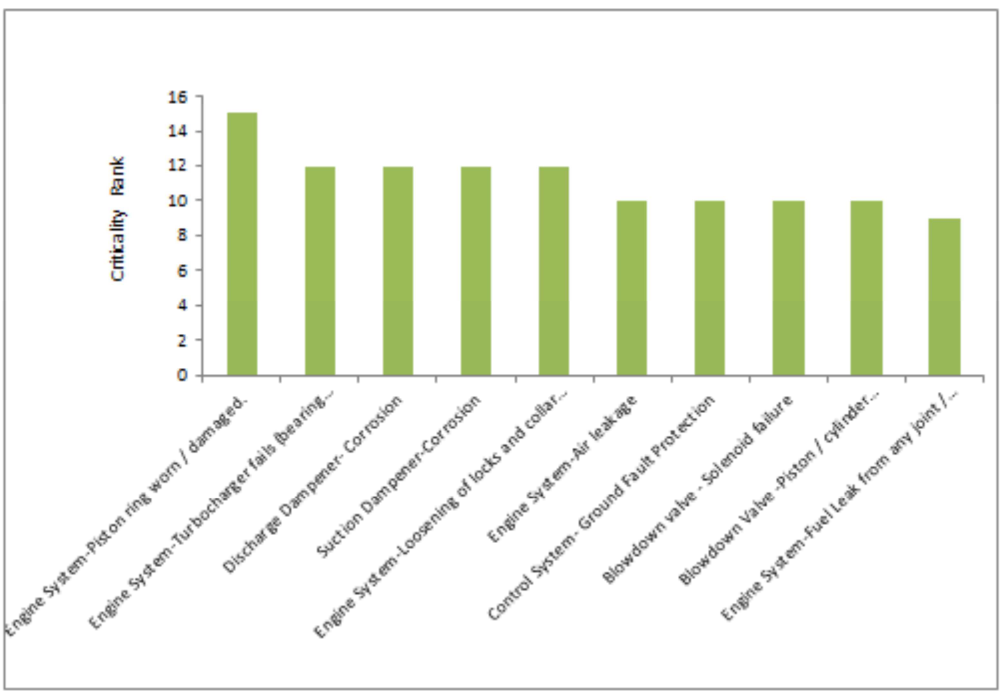
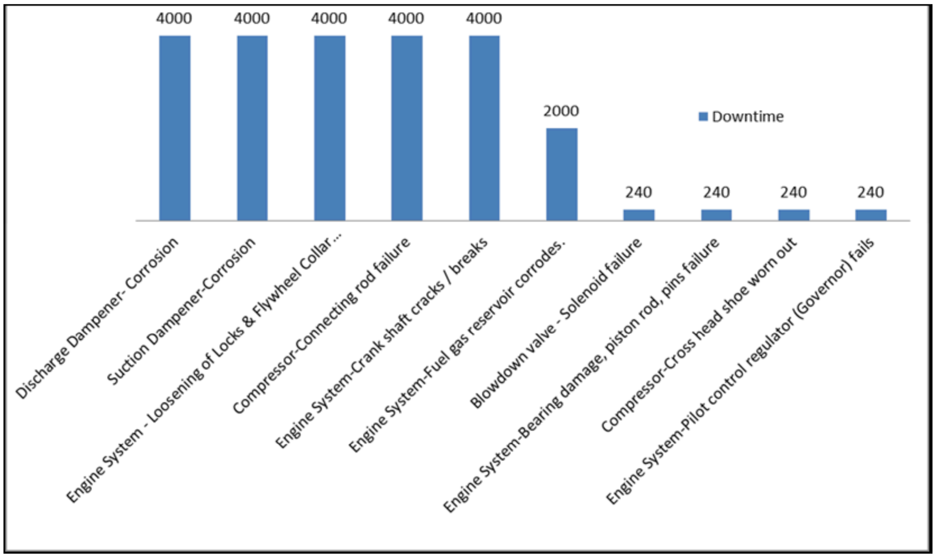


Figure 44 - Overall failure modes based on downtime in hours



Figures 45 through 50 are charts that identify high level findings from the Gerber RCM study:

Figure 45 - Overall Failure Modes in System Level

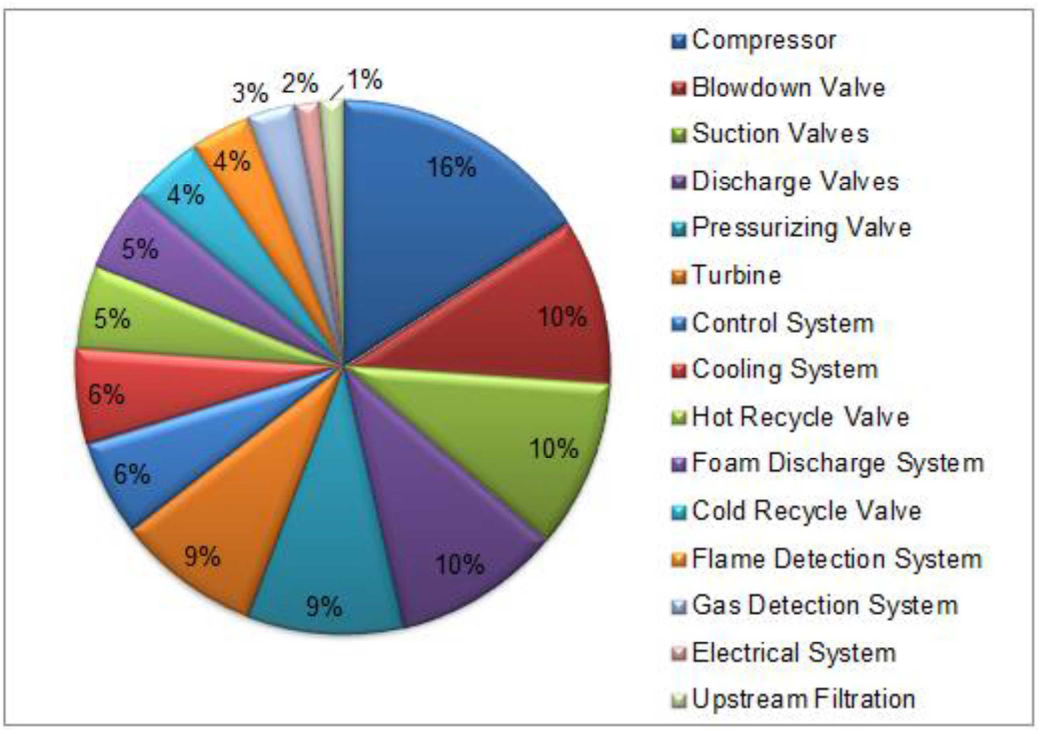


Figure 46 - Overall Top 10 Critical Failures

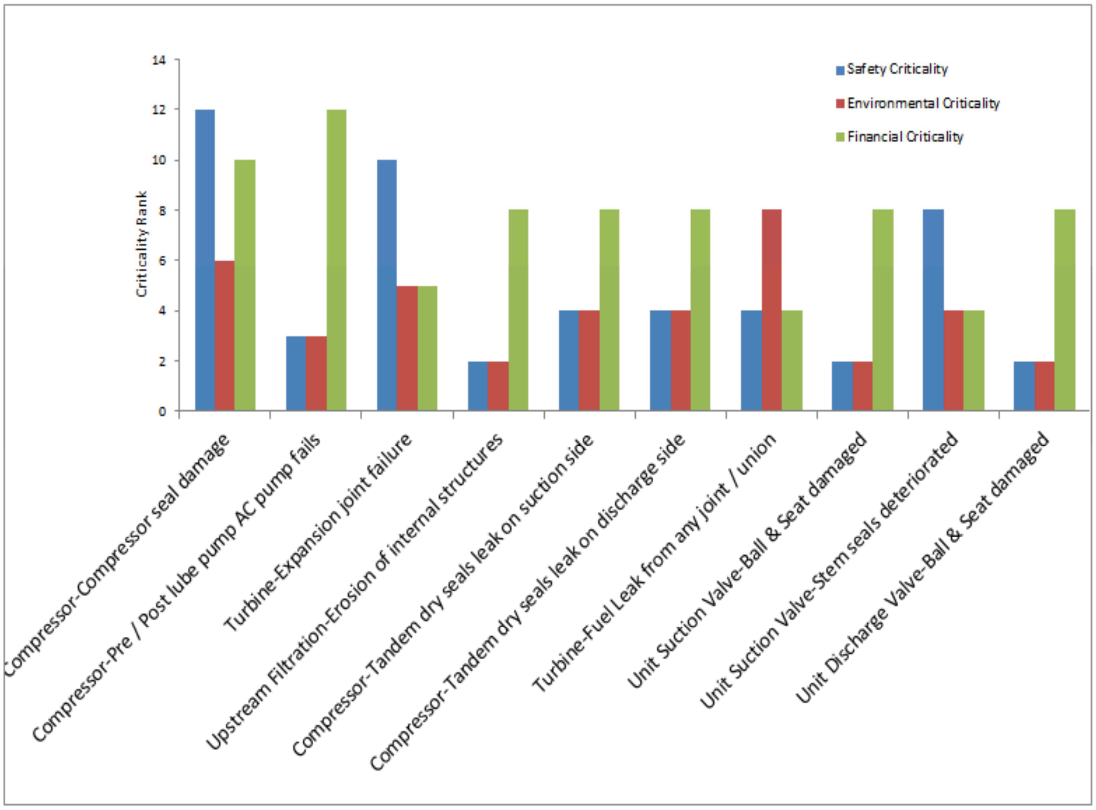


Figure 47 - Overall Top 10 Safety Critical Failure Modes

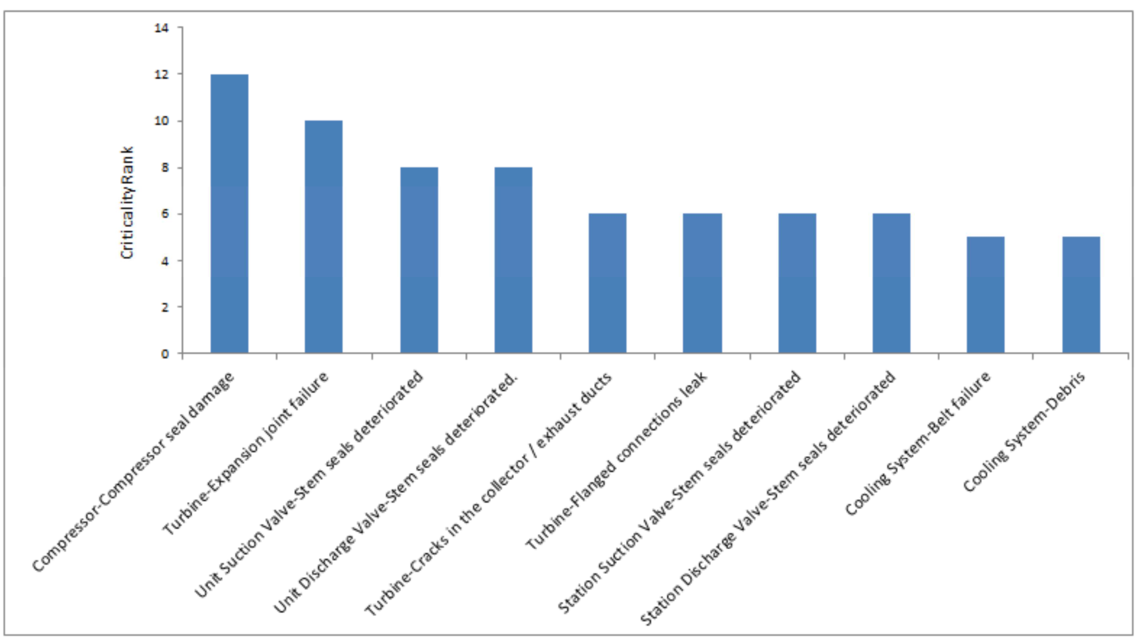


Figure 48 - Overall Top 10 Environmental Critical Failure Modes

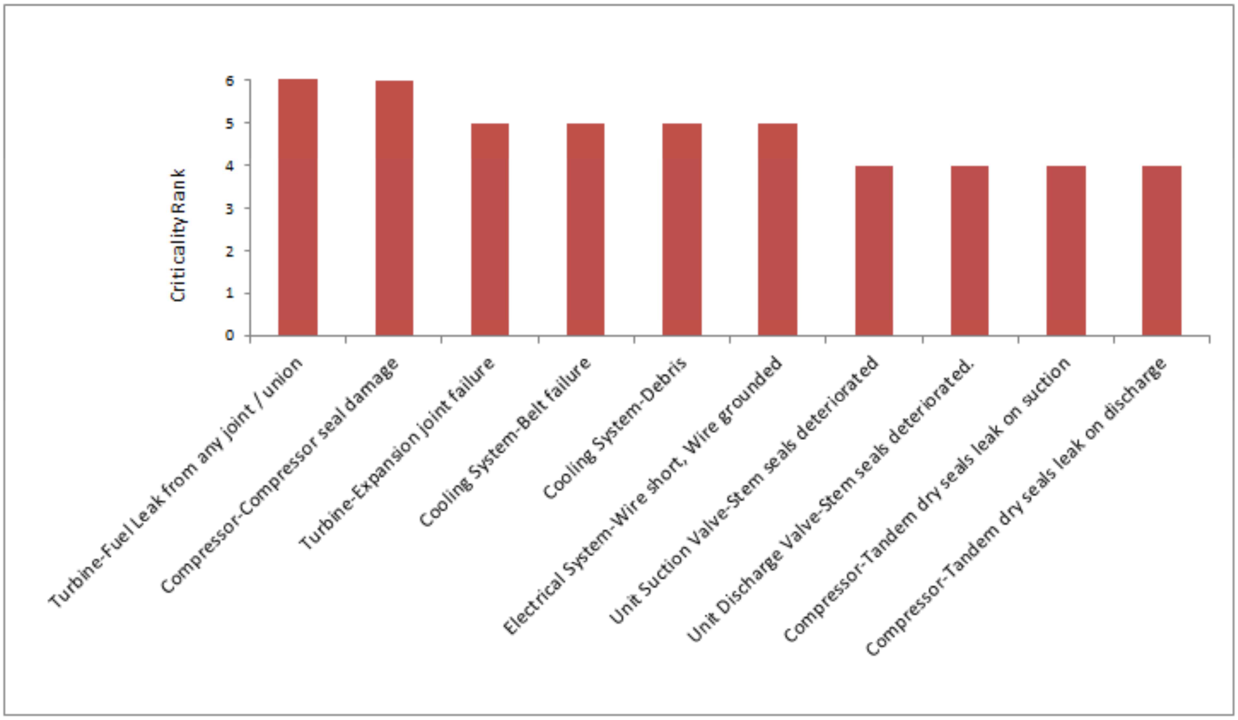


Figure 49 - Overall Top 10 Financial Critical Failure Modes

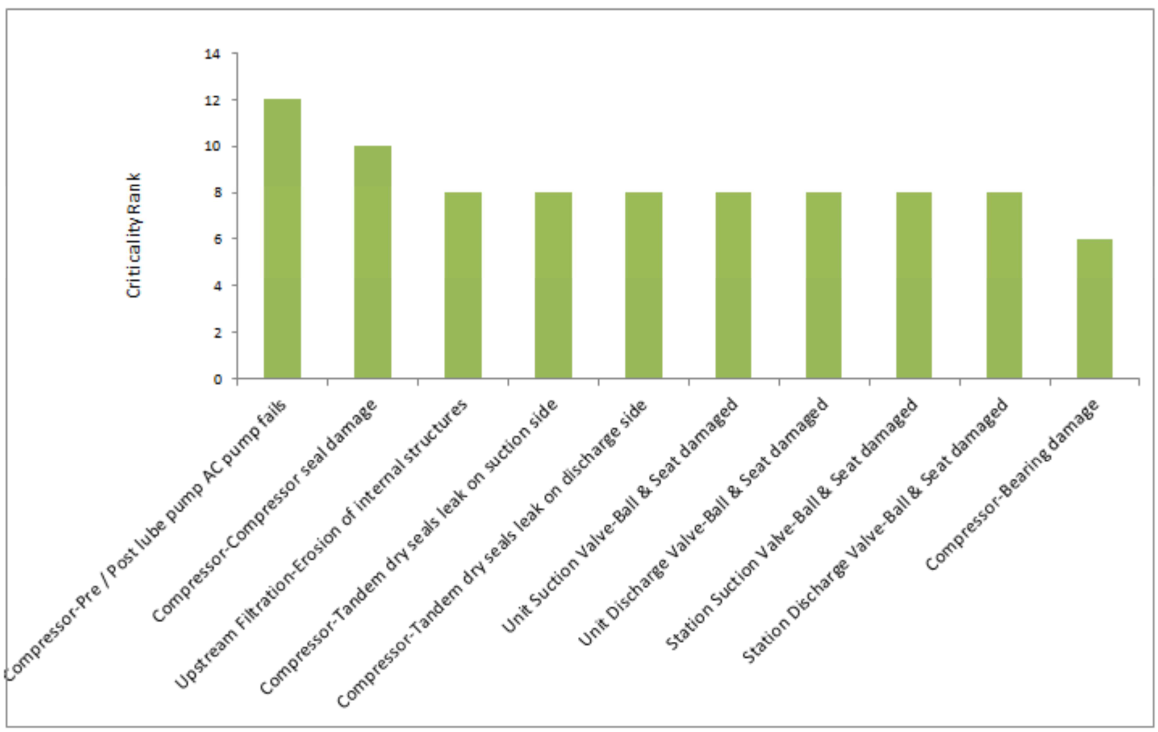
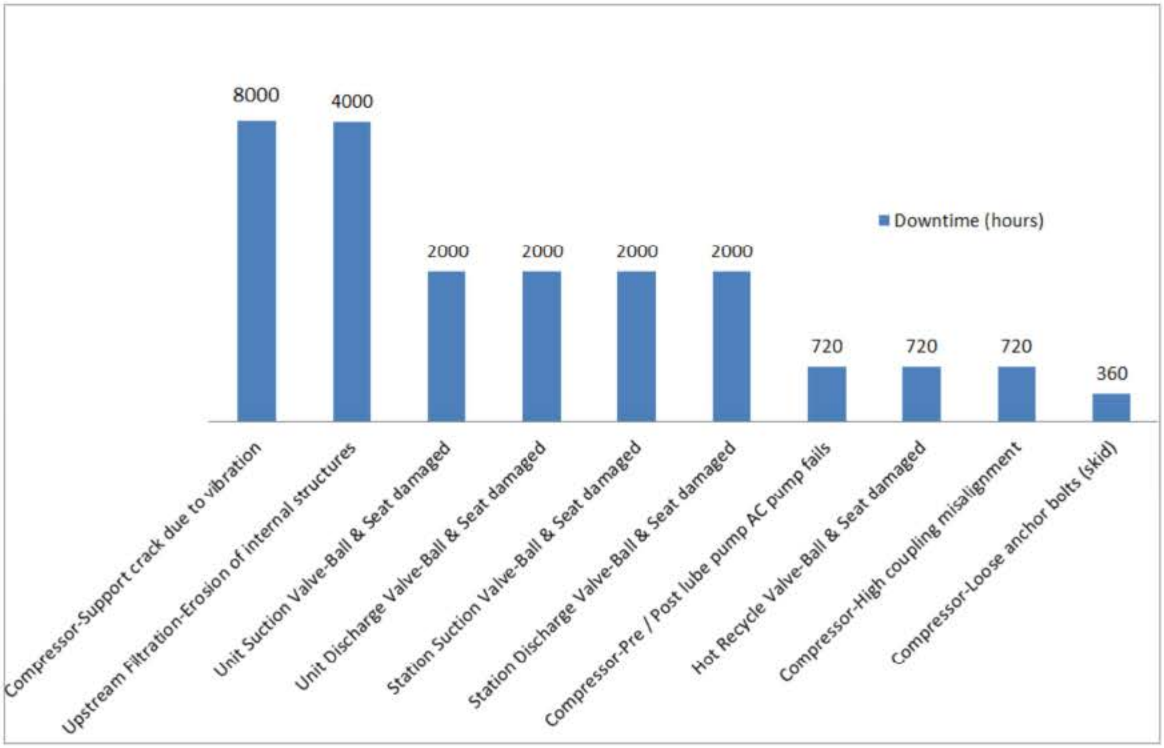


Figure 50 - Overall Top 10 Failure Modes Based on Downtime (hours)



6. Capital and Expense Projects

Another key aspect of reliability management is the proposal of capital projects to replace equipment based on age, condition, performance and cost of maintenance. These projects are typically identified through review of equipment based on excessive corrective maintenance, lack of available spare parts for repair, compatibility issues between new and old components, and functional performance or physical condition degradation. The facility engineers routinely review equipment performance records and input from maintenance crews to determine and identify projects. There are major projects defined as part of the rate case and these projects and programs are discussed in Chapter 6 of the 2015 GT&S Rate case submittal. Additionally, there are smaller or routine projects required. The facility engineers recently completed an exercise to identify key projects relative to performance and reliability of the units. Current projects identified as typical routine spend projects are included in Table 43.

Table 43 – Project Proposals by Station**

In Progress

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
BETHANY	COMPRESSORS	K2 MOTOR ROTOR	K2 MOTOR ROTOR NEEDS TO BE REPLACED OR NEEDS TO BE REPAIRED.
BETHANY	MAIN GAS	V-102	V-102 HAS A SECONDARY STEM SEAL LEAK.

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
BETHANY	COMPRESSOR	V-227	2" PRESSURIZING VALVE, (V-227), SOFT GOODS HAVE NOT BEEN REPLACED IN MANY YEARS AND VALVE SOMETIMES STICKS AND DOES NOT OPEN FULLY.
BETHANY	COMPRESSOR	LEAKAGE PUMP	BETHANY DRY GAS LEAKAGE PUMP
BETHANY	MAIN GAS	SHAFER ACTUATORS	BETHANY SHAFER ACTUATORS REPLACEMENT
BETHANY	FIRE DETECTION	GAS DETECTORS	BETHANY GAS DETECTORS REPLACEMENT
BETHANY	CONTROL		BETHANY STATION CONTROLS UPGRADE
BETHANY	COMPRESSOR		BETHANY COMPRESSOR UNITS MODIFICATION
BURNEY	ELECTRICAL	STANDBY GENERATOR	1960'S VINTAGE STANDBY GENERATOR SPARE PARTS NOT READILY AVAILABLE
BURNEY	CONTROL	FALLBACK MODE LOGIC	STATION DISCHARGE PRESSURE FALLBACK MODE LOGIC CHANGE. FOLLOWING A DISCHARGE PRESSURE CONTROL SET POINT CHANGE PER THE UNOFFICIAL 5/20 POLICY, NUISANCE SHUT DOWNS HAVE BEEN OCCURRING ON AND OFF WHEN THE PIPELINE CONDITIONS ARE RIGHT. THE LOGIC NEEDS TO BE MODIFIED TO ALLOW THE UNIT MORE TIME TO REACT TO THE SETPOINT CHANGE.
BURNEY	MAIN GAS	BROOKS-BRODIE VALVE	BROOKS-BRODIE VALVES REPLACEMENT PROGRAM
DELEVAN	ELECTRICAL	UPS	DELEVAN CS REPLACE UPS
DELEVAN	COMPRESSOR	K3 TURBINE	DELEVAN K-3 GAS TURBINE OVERHAUL
GERBER	CIVIL / STRUCTURAL	RETAINING WALL	THE RETAINING WALL BEHIND THE CONTROL ROOM IS DAMAGED. THE RETAINING WALL IS MADE OUT OF WOOD AND WAS BUILT SEVERAL YEARS AGO. SOME OF THE SUPPORTS HAVE DETERIORATED, AND PRESSURE DUE TO GRAVEL AND SOIL HAS PUSHED OVER THE WALL CAUSING IT TO LEAN.
GILL RANCH	CONTROL	SCADA	GILL RANCH STORAGE SCADA
GILL RANCH	OTHER		GILL RANCH PROJECTS - 2014
HINKLEY	CIVIL / STRUCTURAL	K2 FOUNDATION	FOUNDATION HAS DETERIORATED AND NEEDS TO BE REPLACED.
HINKLEY	CIVIL / STRUCTURAL	K5 FOUNDATION	FOUNDATION HAS DETERIORATED AND NEEDS TO BE REPLACED.
HINKLEY	CIVIL / STRUCTURAL	K8 FOUNDATION	FOUNDATION HAS DETERIORATED AND NEEDS TO BE REPLACED.
HINKLEY	FIRE DETECTION / SUPPRESSION	GAS DETECTORS	GAS DETECTORS AT HINKLEY CS ARE OBSOLETE. PARTS ARE NO LONGER AVAILABLE. SUPPORT IS LIMITED.

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
HINKLEY	ENVIRONMENTAL	PONDS #5 AND #8	INSTALL NEW LINERS IN POND #5 & #8 AND FIX POND #8 LYSIMETERS.
HINKLEY	ENVIRONMENTAL	WATER WELL	NEW WELL AND WATER LINE
HINKLEY	ENVIRONMENTAL	HOTWELL	REPLACE HOTWELL WITH SURGE TANKS TO REDUCE ENVIRONMENTAL RISK
HINKLEY	CONTROL	PLC	UPGRADE PLC'S AND COMMUNICATION ON RETROFITTED K UNITS
HINKLEY	FIRE DETECTION / SUPPRESSION	FIRE DETECTION	INSTALL FIRE DETECTION
HINKLEY	MAIN GAS	FILTER SEPARATORS	INSTALL FILTER SEPARATORS ON STATION SUCTION
HINKLEY	CONTROL	GENERATOR SET CONTROLS	MAJOR GENERATOR SETS CONTROLS ISSUES. TUNING AND CORRECTIVE WORK REQUIRED.
HINKLEY	ELECTRICAL	SWITCHGEAR	SWITCHGEAR UPGRADE REQUIRED TO CORRECT FEEDER BREAKER TRIP SETTINGS (CAUSING UNPLANNED STATION SHUTDOWN ISSUES). OTHER REPAIRS ASSOCIATED WITH SWITCHGEAR ALSO REQUIRED.
HINKLEY	ELECTRICAL	MCC	HINKLEY ELECTRICAL REPLACE MCC & CONDUCTOR
HINKLEY	ENVIRONMENTAL		HINKLEY ENVIRONMENTAL RISK MITIGATION
HINKLEY	COMPRESSOR	K12 ENGINE	HINKLEY K12 - ENGINE TOP END OVERHAUL
HINKLEY	COMPRESSOR	K11 ENGINE	HINKLEY K11 - ENGINE TOP END OVERHAUL
HINKLEY	CIVIL / STRUCTURAL		HINKLEY UPGRADE SHALLOW ROAD CROSSINGS
KETTLEMAN	ELECTRICAL	UTILITY POWER	RELIABILITY PROBLEMS WITH PGE UTILITY POWER TO THE STATION
KETTLEMAN	MAIN GAS	FILTER SEPARATORS	LIQUIDS ARE BEING FOUND IN THE STATION PIPING AFTER THE FILTER SEPARATOR.
KETTLEMAN	ELECTRICAL	SWITCHGEAR	KETTLEMAN - PERFORM SWITCHGEAR MAINTENANCE
LOS MEDANOS	PROCESSING	CI	TOWER LOSES GLYCOL ONLY WHEN ON CIRCULATING STANDBY
LOS MEDANOS	PROCESSING	REBOILERS	VACUUM PROTECTION CANNOT BE TESTED OR CALIBRATED WITH CURRENT PIPING CONFIGURATION
LOS MEDANOS	ELECTRICAL	PAD TRANSFORMERS	WELL PAD TRANSFORMERS OVERLOADED
MCDONALD ISLAND	COMPRESSOR	KI	K1 CYL #2 REPLACEMENT

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
MCDONALD ISLAND	PROCESSING	DEHYDRATOR 1A	D-1A NOT IN COMPLIANCE WITH HAZ WASTE CODES
MCDONALD ISLAND	COMPRESSED AIR	AIR COMPRESSORS	AIR COMPRESSORS
MCDONALD ISLAND	ELECTRICAL	K1 FANS	K2 LOADING VS. K1 COOLER VIBRATION
MCDONALD ISLAND	MAIN GAS	PIPE SUPPORTS	PIPE SUPPORTS NORTH SIDE
MCDONALD ISLAND	LUBE OIL	OIL MAKEUP CONTROL	SOLVE NEW OIL MAKEUP CONTROL ISSUE
MCDONALD ISLAND	ENVIRONMENTAL	K1/K2 BLOWDOWN	ELIMINATE OR REDUCE GHG BLOWDOWN ON SHUT IN OF K1/K2
MCDONALD ISLAND	STORAGE	OLD WELLS	PAINT OLD WELLS ROBERTS 1&2 TO PREVENT CORROSION
MCDONALD ISLAND	ELECTRICAL	NULMATICS SOLENOIDS	FAILING NULMATICS SOLENOIDS
MCDONALD ISLAND	PROCESSING	EXTERRAN TANKS	EXTERRAN TANKS
MCDONALD ISLAND	STORAGE	OLD WELLS	NEED DEFLECTION GUIDELINE
MCDONALD ISLAND	STORAGE	OLD WELLS	HIGH BLEED CONTROLLERS
MCDONALD ISLAND	CONTROL	ESD	ESD TIMING NOT COMPLIANT
MCDONALD ISLAND	COMPRESSORS	K1/K2 INDICATOR PINS	INDICATOR PINS ON K1/K2 DIVIDER BLOCKS
MCDONALD ISLAND	PROCESSING	D-1A TANK	MCD IS - MCS REPLACE TANK D-1A
PLEASANT CREEK	CONTROL	MOORE PNEUMATIC CONTROLS	OLD PNEUMATIC MOORE EQUIPMENT OBSOLETE
PLEASANT CREEK	PROCESSING	ORIFICE METERS	SEPARATE INJECTION AND WITHDRAWAL ORIFICE METERS ARE INACCURATE, RESULTING IN ACCOUNTING DISCREPANCIES
PLEASANT CREEK	ELECTRICAL	UPS	UNINTERRUPTABLE POWER SUPPLY IS NOT ALWAYS RELIABLE. UPS SUPPORTS STATION OPERATION DURING POWER OUTAGES, BUT NOT STATION AIR COMPRESSOR. LOSS OF STATION AIR RESULTS IN K-8 SHUTDOWN

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
PLEASANT CREEK	CIVIL / STRUCTURAL	BUILDING WALLS	LACK OF WALLS RESULTS IN EQUIPMENT DAMAGE AND UNSAFE WORKING CONDITIONS
TIONESTA	LUBE OIL	K1 LUBE OIL COOLER FAN MOTOR	TK-1 LUBE OIL COOLER FAN MOTOR REPLACEMENT
TOPOCK	CIVIL / STRUCTURAL	K2 FOUNDATION	FOUNDATION HAS DETERIORATED AND NEEDS TO BE REPLACED.
TOPOCK	CIVIL / STRUCTURAL	K4 FOUNDATION	FOUNDATION HAS DETERIORATED AND NEEDS TO BE REPLACED.
TOPOCK	CONTROL	STATION PLC	STATION PLC ISSUES. STATION CONTROLS REDUNDANCY IS NOT FUNCTIONAL, WHICH IN CASE OF A MASTER PLC FAILURE WILL RESULT IN THE COMPRESSOR UNITS, P-UNITS AND/OR STATION SHUTDOWN. AT ITS CURRENT SIZE AND COMPLEXITY LEVEL STATION CONTROLS PROGRAM IS TOO DIFFICULT FOR THE MAINTENANCE PERSONNEL TO BE USED FOR THE STATION EQUIPMENT TROUBLESHOOTING. ALL GENIUS BLOCKS NEED TO BE REPLACED.
TOPOCK	ELECTRICAL	EMERGENCY GENERATOR	EMERGENCY GENERATOR LOAD SHARE/SHED ISSUES. NEED TO BYPASS LOAD SHED TO RUN EMERGENCY GENERATOR.
TOPOCK	FIRE DETECTION / SUPPRESSION	GAS DETECTORS	GAS DETECTORS AT TOPOCK CS ARE OBSOLETE.
TOPOCK	COMPRESSORS	TW	TW BYPASS
TOPOCK	MAIN GAS	PIPING	REPLACE PIPING ACROSS THE BRIDGE
TOPOCK	COMPRESSORS	JW PIPING	REPLACE SELECTED SECTIONS OF JACKET WATER PIPING
TOPOCK	COMPRESSED AIR	AIR COMPRESSORS	REPLACE AND AUTOMATE AIR COMPRESSORS
TOPOCK	ENVIRONMENTAL		TOPOCK REMEDY PROJECT
TOPOCK	CONTROL	LOW FLOW CONTROL	TOPOCK-IMPROVE STATION LOW FLOW CONTROL
TOPOCK	ELECTRICAL	MCC	TOPOCK ELECTRICAL REPLACE MCC & CONDUCTOR
TOPOCK	ENVIRONMENTAL		TOPOCK ENVIRONMENTAL RISK MITIGATION
TURNER CUT	PROCESSING	WASTEWATER PIPING	WASTEWATER PIPING EVALUATION
TURNER CUT	FIRE DETECTION / SUPPRESSION	FIRE PUMP	FIRE PUMP

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
TURNER CUT	PROCESSING	DELUGE VALVE HEATING	ADDITIONAL HEATING REQUIRED ON STAND-ALONE DELUGE VALVE NEAR C-4
TURNER CUT	STORAGE	WELL HEADS	NEED DEFLECTION MEASUREMENTS AT WELL HEAD
TURNER CUT	ESD		MCD IS - TCS EXTEND ESD BOUNDARY
TURNER CUT / WHISKEY SLOUGH	PROCESSING	FIREWATER PSV /PILOT HEATING	ADDITIONAL HEATING REQUIRED ON FIREWATER PSV/PILOT
TURNER CUT / WHISKEY SLOUGH	PROCESSING	ODORANT SYSTEM	ODORANT SYSTEM PUNCHLIST
TURNER CUT / WHISKEY SLOUGH	PROCESSING	C5/C6	EVALUATE CORROSION IN C5/C6
TURNER CUT / WHISKEY SLOUGH	FIRE DETECTION / SUPPRESSION	ALARMS	SCADA SMOKE/ESD/FIRE ALARMS
TURNER CUT / WHISKEY SLOUGH	PROCESSING	REBOILER	WRITE PEER PERMIT REBOILER TEST PLAN
BETHANY	COMPRESSORS	K1 ROTOR	K1 ROTOR EXCHANGE AND REPAIR
BETHANY	MAIN GAS	BECKER CONTROLLERS	BECKER PROGRAM BETHANY COMP STATION
BETHANY	MAIN GAS	RELIEF VALVE	INSTALLATION OF RELIEF VALVE
BETHANY	COMPRESSOR	MOTOR	MOTOR REPLACEMENTS
BETHANY	ENVIRONMENTAL	WATER WELL	WATER WELLS & SEPTIC UPGRADE
BETHANY	CIVIL / STRUCTURAL	BOILER	BOILER REMOVAL

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
BETHANY	COMPRESSED AIR	AIR COMPRESSOR	AIR COMPRESSOR/DRYER REPLACEMENT
BETHANY	MAIN GAS	OVERPRESSURE PROTECTION DEVICE	INSTALL L-401 OPP
BURNEY	COMPRESSOR	COMPRESSOR	BURNEY COMP. STA. CP MITIGATION INSULAT.
BURNEY	LUBE OIL	PRESSURE REGULATOR	BK-2 RT/COMP OIL REGULATOR FAILURE
BURNEY	ELECTRICAL	BATTERY	BURNEY- BATTERY REPLACEMENT
BURNEY	MAIN GAS	V-24, V-2	VALVE AUTO - BURNEY PH2
BURNEY	CIVIL / STRUCTURAL	SITE PAVEMENT	REPAVE BURNEY COMPRESSOR STATION
BURNEY	MAIN GAS	GOV-101, GOV-101B	BURNEY STN BLOWDOWN VALVE/ACTUATOR REPLACEMENT
BURNEY	MAIN GAS	MAIN LINE VALVE ACTUATOR	BURNEY L-400 MLV ACTUATOR REPLACEMENT
BURNEY	COMPRESSOR	K-2	BURNEY K-2 GG OVERHAUL
DELEVAN	ELECTRICAL	SWITCHGEAR	DELEVAN SWITCHGEAR 5 YR MAINTENANCE
DELEVAN	ELECTRICAL	BREAKER RELAYS	REPLACE THE CURRENTLY INSTALLED GE MULTILIN RELAYS IN THE THREE BREAKERS (52-M1-2B, 52-M2-4B AND 52-T-3B) AS WELL AS BREAKERS 52-MVC-1A, 52-MVC-1B, 52-MVC-5A AND 52-MVC-5B WITH SCHWEITZER RELAYS AND INSTALL AN HMI IN THE SWITCHGEAR BUILDING
DELEVAN	LUBE OIL	LUBE OIL PUMP	DELEVAN REPLACE MOTOR AND PUMP SET
DELEVAN	COMPRESSOR	K-3 COMPRESSOR	DELEVAN K-3 HOT SECTION FIELD REPAIR
DELEVAN	SECURITY	VARIOUS	DELEVAN SECURITY UPGRADES

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
DELEVAN	COMPRESSOR	K-3	DELEVAN K-3 EXHAUST REPAIRS
DELEVAN	MAIN GAS	V-4	DELEVAN V-4 STEM SEAL LEAK REPAIR
DELEVAN	ENVIRONMENTAL		DELEVAN - GHG HIGH BLEED RETROFIT
DELEVAN	ELECTRICAL		DELEVAN K-1 & K-2 GROUND FAULT
DELEVAN	COMPRESSOR	K-3	DELEVAN K3 GAS COMP REPLACEMENT
DELEVAN	ELECTRICAL	BATTERY	DELEVAN-BATTERY REPLACEMENT
DELEVAN	ENVIRONMENTAL	K-3 CEMS	K-3 CEMS NOX ANALYZER REPLACEMENT
DELEVAN	COMPRESSOR	K-3 TURBINE	DELEVAN K-3 GAS TURBINE OVERHAUL
DELEVAN	COMPRESSOR	K-2 COMPRESSOR	DELEVAN K-2 GAS COMPRESSOR OVERHAUL
DELEVAN	MAIN GAS	RELIEF VALVES	DELEVAN STN RELIEF VALVES INSTALLATION
DELEVAN	MAIN GAS	OPP	DELEVAN MLVS INSTALL OPP
GERBER	ELECTRICAL	UPS	GERBER 5 YEAR ELECTRICAL AND UPS
GERBER	COMPRESSOR	CP	GERBER COMP NEW CP STATION ANODE/RECT
GERBER	MAIN GAS	MLV-149.18	GERBER CS: REPLACE MLV-149.18
GERBER	ENVIRONMENTAL	GHG	GERBER - GHG HIGH BLEED RETROFIT

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
GERBER	MAIN GAS	BECKER CONTROLLERS	BECKER SYSTEM UPGRADES - GERBER CS
GERBER	CONTROL	CONTROLS	GERBER UNIT & STATION CONTROLS UPGRADE
GERBER	ELECTRICAL	BATTERY	GERBER BATTERY REPLACEMENT
GERBER	COMPRESSOR	K-1 COMPRESSOR	GERBER K-1 GAS COMPRESSOR OVERHAUL
GERBER	MAIN GAS	RELIEF VALVES	GERBER STN RELIEF VALVES INSTALLATION
GERBER	MAIN GAS	BLOWDOWN VALVES	GERBER RPLCE STN L-400 BLOWDOWN VALVES
GERBER	MAIN GAS	GAS CHROMATOGRAPH	GERBER STATION INSTALL GAS CHROMATOGRAPH
HINKLEY	COMPRESSOR	K11 COMPRESSOR	HINKLEY K11 1LEFT REPAIRS
HINKLEY	COMPRESSOR	K10 TURBOCHARGER	HINKLEY K10 TURBOCHARGER OVERHAUL
HINKLEY	COMPRESSOR	K3 COMPRESSOR	HINKLEY K3 - REPAIR MAINFRAME
HINKLEY	CONTROL	ESD	HINKLEY INSTALL ESD PUSHBUTTONS AT EXITS
HINKLEY	COMPRESSOR	K7 COMPRESSOR	HINKLEY K7 CRANKSHAFT REPLACEMENT
HINKLEY	COMPRESSOR	P9 POWER UNIT	HINKLEY - REPLACE POWER UNIT P9 HEADS
HINKLEY	COMPRESSOR	P9 POWER UNIT	HINKLEY - REPAIR POWER UNIT P9 EXPENSE
HINKLEY	COMPRESSOR	K7 COMPRESSOR	HINKLEY K7 - FLYWHEEL REPAIR

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
HINKLEY	ELECTRICAL	ELECTRICAL SYSTEM	HINKLEY AND TOPOCK ELECTRICAL SYS REVIEW
HINKLEY	SECURITY	SECURITY	HINKLEY COMPRESSOR SECURITY UPGRADES
HINKLEY	CIVIL / STRUCTURAL	CRANES	HINKLEY REPLACE CRANES IN COMP BLDG
HINKLEY	COMPRESSOR	K5 COMPRESSOR	HINKLEY K5 COMPRESSOR OVERHAUL
HINKLEY	COMPRESSOR	P-UNITS	HINKLEY P-UNITS CAPITAL UPGRADES
HINKLEY	COMPRESSOR	STUDY	HINKLEY CS PULSATION STUDY
HINKLEY	ENVIRONMENTAL	POND 8	HINKLEY REPLACE POND 8 LYSIMETERS
HINKLEY	COMPRESSOR	K-UNITS	HINKLEY K-UNIT CAPITAL UPGRADES PH2
HINKLEY	CONTROL	SWITCHBOARDS	HINKLEY-P-UNITS SWITCHBOARD REPAIRS
HINKLEY	CONTROL	CONTROLS	HINKLEY-P-UNITS CONTROLS PROBLEMS
HINKLEY	ELECTRICAL	ELECTRICAL	HINKLEY ELECTRICAL UPGRADES
HINKLEY	COMPRESSOR	K-12 ENGINE	HINKLEY K12 - ENGINE TOP END OVERHAUL
HINKLEY	CIVIL / STRUCTURAL	ROAD CROSSINGS	HINKLEY UPGRADE SHALLOW ROAD CROSSINGS
KETTLEMAN	COMPRESSOR	K1, K2, K3 FILTERS	REPLACE ALL FILTERS IN 3 UNITS K1 K2 K3
KETTLEMAN	MAIN GAS	MLV S	KETTLEMAN - CHANGE CONTROLLERS ON MLV S

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
KETTLEMAN	SECURITY	SECURITY	KETTLEMAN SECURITY UPGRADES
KETTLEMAN	FUEL GAS	FILTER	KETTLEMAN - FUEL GAS COALESCING FILTER
KETTLEMAN	CONTROL	UNIT CONTROL	KETTLEMAN CS - REPLACE UNIT CONTROL SYST
KETTLEMAN	CIVIL / STRUCTURAL	VAULTS	KETTLEMAN CS - REPLACE WOODEN VAULTS
KETTLEMAN	CIVIL / STRUCTURAL	CATWALKS	KETTLEMAN CS - INSTL GAS COOLER CATWALKS
KETTLEMAN	ELECTRICAL	ELECTRICAL	KETTLEMAN CS POWER QUALITY IMPROVEMENTS
KETTLEMAN	MAIN GAS	V-49	KETTLEMAN COMPRESSOR STATION_REMOVE V-49
KETTLEMAN	ELECTRICAL	BATTERY	KETTLEMAN- BATTERY REPLACEMENT
KETTLEMAN	MAIN GAS	SEPARATORS	KETTLEMAN CS INSTALL LIQUID SEPARATORS
KETTLEMAN	MAIN GAS	V57	KETTLEMAN REPLACE V57 AND METERING
KETTLEMAN	MAIN GAS	MLV CONTROLS	KETTLEMAN REPLACE MLV CONTROLS AT CS
KETTLEMAN	COMPRESSOR	K2 TURBINE	KETTLEMAN K2 TURBINE EXCHANGE
KETTLEMAN	COMPRESSOR	K3 TURBINE	KETTLEMAN K3 TURBINE EXCHANGE
KETTLEMAN	COMPRESSOR	K1 TURBINE	KETTLEMAN K1 TURBINE EXCHANGE
KETTLEMAN	COMPRESSOR	VFD	KETTLEMAN TEMP AIR INSTALL VFD DRIVES

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
LOS MEDANOS	SECURITY	SECURITY	LOS MEDANOS COMPRESSOR SECURITY UPGRADES
LOS MEDANOS	FUEL GAS	HEATER	LOS MEDANOS FUEL GAS HEATER
LOS MEDANOS	ELECTRICAL	GROUDNING	LOS MEDANOS GROUNDING STUDY
LOS MEDANOS	MAIN GAS	OPP	LOS MEDANOS NORTONVILLE ZONE OPP
LOS MEDANOS	LUBE OIL	PUMP COTROLS	LOS MEDANOS PUMP CONTROLS REWORK
PLEASANT CREEK	PROCESSING	WELL TANKS	PLEASANT CREEK REPLACE TANKS
PLEASANT CREEK	PROCESSING	CONTACT TOWER	PCREEK CONTACT TOWER INSPECT AND REFURB
TIONESTA	CIVIL / STRUCTURAL	BOILER	TIONESTA STATION BOILER FALURE
TIONESTA	ELECTRICAL	CP	TIONESTA CP MITIGATION ANODE/INSULATION
TIONESTA	CONTROL	STATION CONTROLS	TIONESTA REPLACE UNIT/STATION CONTROLS
TIONESTA	ELECTRICAL	AC PANEL	TIONESTA AC PANEL REPLACEMENT
TIONESTA	COMPRESSOR	TURBINE	TIONESTA RT OVERHAUL
TIONESTA	ENVIRONMENTAL	GHG	TIONESTA - GHG HIGH BLEED RETROFIT
TIONESTA	COMPRESSOR	K-1 TURBINE	TIONESTA K-1 REACTION TURBINE OVERHAUL
TIONESTA	CIVIL / STRUCTURAL	PAVING	REPAVE TIONESTA COMPRESSOR STATION

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
TIONESTA	COMPRESSED AIR	AIR COMPRESSOR	TIONESTA AIR COMPRESSOR REPLACEMENT
TIONESTA	MAIN GAS	BLOWDOWN VALVE	TIONESTA STN BLWDWN VALVE/ACTUAT REPLCNT
TIONESTA	ELECTRICAL	UPS	TIONESTA CS RELOCATE STATION UPS
TIONESTA	MAIN GAS	RELIEF VALVES	TIONESTA REPLACE STA RELIEF VALVES
TIONESTA	FUEL GAS	GAS SAMPLER	TIONESTA CS FUEL GAS BTU MEASUREMENT INSTALL GAS SAMPLER
TOPOCK	FIRE DETECTION / SUPPRESSION	FIRE DETECTION	TOPOCK FIRE DETECTION
TOPOCK	ELECTRICAL	BREAKERS	TOPOCK- REPLACE ELECTRIC BREAKERS
TOPOCK	COMPRESSOR	ELECTRIC MOTOR	TOPOCK - REPLACE ELECTRIC MOTOR
TOPOCK	ENVIRONMENTAL	POND 3	TOPOCK POND 3 REPAIRS
TOPOCK	CIVIL / STRUCTURAL	CRANES	TOPOCK REPLACE CRANES IN COMP BLDG
TOPOCK	ELECTRICAL	ELECTRICAL SYSTEM	HINKLEY AND TOPOCK ELECTRICAL SYS REVIEW
TOPOCK	SECURITY	SECURITY	TOPOCK COMPRESSOR SECURITY UPGRADES
TOPOCK	COOLING WATER	COOLING TOWERS	TOPOCK COOLING TOWERS INSTALL CATWALKS
TOPOCK	COMPRESSOR	STUDY	TOPOCK CS PULSATION STUDY
TOPOCK	MAIN GAS	FLOW METERS	TOPOCK FLOW METERS

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
TOPOCK	MAIN GAS	BECKER CONTROLLERS	BECKER SYSTEM UPGRADES - TOPOCK CS
TOPOCK	MAIN GAS	MOISTURE ANALYZER	INSTALL MOISTURE ANALYZER - TOPOCK
TOPOCK	MAIN GAS	RELIEF VALVES	TOPOCK CROSSTIE & SUCTION PRVS TW ACTUAT
TOPOCK	CONTROL	K-2 & K-7 UNIT CONTROLS	TOPOCK RPLC K-2 & K-7 UNIT CTRL PANELS
TOPOCK	CONTROL	K-4 & K-8 UNIT CONTROLS	TOPOCK RPLC K-4 & K-8 UNIT CTRL PANELS
TOPOCK	CONTROL	K-5 & K-10 UNIT CONTROLS	TOPOCK RPLC K-5 & K-10 UNIT CTRL PANELS
TOPOCK	ELECTRICAL	MCC	TOPOCK ELECTRICAL REPLACE MCC & CONDUCTO
TOPOCK	COMPRESSOR	P4 UNIT	TOPOCK P4 UNIT OVERHAUL
TURNER CUT	SECURITY	SECURITY	TURNER CUT SECURITY UPGRADES
TURNER CUT	CONTROL	DELTA V CONTROLS	TCS DELTA-V CONTROL SYSTEM UPGRADE
TURNER CUT	PROCESSING	CONTACT TOWERS	MCD IS - TCS REPLACE LEVEL INDICATORS
TURNER CUT	FIRE DETECTION / SUPPRESSION	FIRE WATER	MCDI TCS & WSS REBUILD FIRE WATER SYSTEM
TURNER CUT	ENVIRONMENTAL	WASTE WATER	MCD IS TCS - REBUILD WASTE WATER SYSTEM
TURNER CUT	ELECTRICAL	MCC	MCD IS TCS - REPLACE MCC
WHISKY SLOUGH	MAIN GAS	V-38	MCD IS. REPLACE WSS V-38 & V-42

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
WHISKY SLOUGH	MAIN GAS	V-42	WHISKY SLOUGH V-42
MCDONALD ISLAND	COMPRESSOR	VARIOUS	MCDONALD ISLAND COMPRESSOR STAT RECOATING
MCDONALD ISLAND	SECURITY	SECURITY	MCDONALD IS UGS SECURITY UPGRADES
MCDONALD ISLAND	SECURITY	SECURITY	MCDONALD IS COMPRESSOR SECURITY UPGRADE
MCDONALD ISLAND	COMPRESSOR	K1 & K2 COMPRESSORS	MCDI ANNUAL MAINTENANCE 2018/2019
MCDONALD ISLAND	COMPRESSOR	K1 & K2 COMPRESSORS	MCDI ANNUAL MAINTENANCE 2017/2018
MCDONALD ISLAND	COMPRESSOR	K1 & K2 COMPRESSORS	MCDI ANNUAL MAINTENANCE 2016/2017
MCDONALD ISLAND	PROCESSING	CONTACT TOWERS	MCD IS - TCS REPLACE LTS ON TOWERS
MCDONALD ISLAND	COMPRESSOR	K1 & K2 COMPRESSORS	MCDI ANNUAL MAINTENANCE 2015/2016
MCDONALD ISLAND	MAIN GAS	PIPING	MCD IS. PIPING SETTLEMENT
MCDONALD ISLAND	MAIN GAS	V-48	MCD IS.REPLACE V-48
MCDONALD ISLAND	MAIN GAS	V-211	MCDONALD IS REPLACE V-211
MCDONALD ISLAND	CONTROLS	GENERATOR CONTROLS	MCD IS - MCS UPGRADE GENERATOR CONTROLS
MCDONALD ISLAND	CIVIL / STRUCTURAL	FENCING	MCD IS - EXTEND FENCING
MCDONALD ISLAND	CONTROL	ESD	MCD IS - REPLACE ESD SOLENOID VALVES

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
MCDONALD ISLAND	CIVIL / STRUCTURAL	REBOILER	MCD IS - TCS REBOILER 1 & 2 INSPECTION
MCDONALD ISLAND	CIVIL / STRUCTURAL	REBOILER	MCD IS - WSS REBOILER 1 & 2 INSPECTION
MCDONALD ISLAND	MAIN GAS	MOISTURE ANALYZER	MCD IS - INSTALL MOISTURE ANALYZER TC WS
MCDONALD ISLAND	LUBE OIL	K2 FEED TUBE	MCD IS - REPLACE K2 FORCE FEED LUBE
MCDONALD ISLAND	CONTROL	ESD	MCD IS - WSS EXTEND ESD BOUNDARY
MCDONALD ISLAND	ELECTRICAL	GROUNDING	MCD ISL REMOTE WELL GROUNDING
MCDONALD ISLAND	CONTROL	ESD	MCD IS - MCS ADD ESD PBS & GAS DETEC LTS
MCDONALD ISLAND	CONTROL	ESD	MCD IS - TCS EXTEND ESD BOUNDARY

** As part of this reliability plan, Facility Engineers were surveyed and asked to develop a list of recommended projects that would help support current levels of reliability for the C&P facilities that they are responsible for. The majority of these recommended projects are ultimately funded as part of the either the capital or expense Routine Spend programs. Since these projects are reliability related and address relatively low consequence risks of roughly equal weight, they do not score highly when evaluated by PG&E's Risk Based Allocation scoring system. As such, resources for execution of these projects are limited and it is therefore not possible to forecast an execution timeframe with any degree of certainty. Even though the timeframes for execution of these projects are unknown, as a group they are tied to a C&P goal: the execution of at least 10% of the projects on a yearly basis. Therefore, the C&P asset family sees value in retaining these lists even though timing and prioritization of individual project execution is uncertain.

Completed Tasks since Rev 2 of C&P Asset Management Plan

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
ALL	ENVIRONMENTAL		AB32 GHG HIGH BLEED DEVICE RETROFIT
BETHANY	COMPRESSOR	VFD	INTERMITTENT VFD TRIPS HAPPEN WHEN UNITS ARE RUNNING AND ON SHUTDOWN. THE TRIPS VARY ONE EXAMPLE IS WHEN K2 IS GIVEN A NORMAL STOP AND IS RAMPING DOWN; THE UNIT WILL GO INTO A SHUTDOWN AND LOCKOUT ON A "VFD TRIP EALL-253 CAP UNDER VOLT" ALARM. THIS SEEMS TO HAPPEN WHEN THE UNIT IS WITHIN THE 3000-2500 RPM RANGE. WE ASKED THE SIEMENS REP. TO LOOK AT THIS WHEN HE WAS OUT FOR THE DC LINK JOB BUT HE WAS UNABLE TO HELP. HE SUGGESTED THAT HE'D HAVE TO COME OUT AGAIN WITH EQUIPMENT TO

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
			MONITOR THE ANALOG CHANNELS DURING SHUTDOWN.
BETHANY	ELECTRICAL	ELECTRICAL EQUIPMENT	MAINTENANCE OF THE STATION'S ELECTRICAL EQUIPMENT, (TRANSFORMERS, RELAYS, SWITCH GEAR, ETC.) HAS NOT BEEN DONE. REQUIRED MAINTENANCE NEEDS TO BE IDENTIFIED AND ADDED TO PLM.
BETHANY	COMPRESSORS	K1/K2 VFD	AFTER DEC. 31 2010, THE UNITS ROSS HILL VFD'S WILL NO LONGER BE SUPPORTED BY SIEMENS. AFTER THAT DATE SUPPORT WILL NOT BE GUARANTEED AND BE ON A LIMITED BASIS. WE DO HAVE A FAIR AMOUNT OF SPARE PARTS ON HAND FOR THE VFDS
BETHANY	CONTROL	MICRON CONTROLLERS	1) THE UNITS SURGE CONTROL IS STILL BEING DONE WITH THE MICON CONTROLLER. SUPPORT FOR THESE CONTROLLERS IS LIMITED. 2014 JOB ITEM COMBINED WITH UNIT PLC REPLACEMENT. 2) DIFFICULT RESTARTING UNIT (K1) AFTER A UNIT TRIP, IT LOOKS LIKE THE UNIT PERMISSIVE DON'T RESET. IN ORDER TO GET THE UNIT BACK ONLINE A UNIT ESD HAS TO BE ACTIVATED. MAY HAVE SAME PROBLEM WITH K2.
BETHANY	ELECTRICAL	SWITCHGEAR	OUT OF SCOPE UPGRADES IDENTIFIED DURING SWITCHGEAR MODIFICATIONS REQUIRE INSTALLATION.
BETHANY	COMPRESSOR	K2 VFD TRANSFORMER	K2 UNIT VFD TRANSFORMER, (P05TR), HAS SHOWN AN INCREASE OF SEVERAL INTERNAL GASES INDICATING THE PRESENCE OF AN ARC. WHILE THIS IS NOT AN IMMINENT SAFETY CONCERN, MONITORING OF THE TRANSFORMER OIL IS CONTINUING. DECISIONS ARE ONGOING AS TO REPLACING THIS TRANSFORMER WITH ITS MATE CURRENTLY INSTALLED AT K1S VFD. HOWEVER, EQUIPMENT DELAYS HAVE POSTPONED THE DEMOLITION OF THE K1 EQUIPMENT SO THIS TRANSFORMER IS NOT CURRENTLY AVAILABLE.
BETHANY	MAIN GAS	V-201	V-201 HAS A SECONDARY STEM SEAL LEAK.
BETHANY	MAIN GAS	MLV-317.24	MLV-317.24, (GOV-5B), DOES NOT OPEN IF THERE IS A NEGATIVE UPSTREAM/DOWNSTREAM PRESSURE DIFFERENTIAL.

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
BETHANY	CONTROL	PLC	THERE ARE CONTROL DIFFERENCES BETWEEN LOCAL AND REMOTE MODE ON UNIT AND STATION PLCS.
BETHANY	COMPRESSOR	MOTOR PURGE AIR DIFFERENTIAL SHUTDOWN SWITCH	MOTOR PURGE AIR DIFFERENTIAL SHUTDOWN SWITCH, (FSL-110), IS INOPERATIVE AND NEEDS TO BE REPLACED.
BETHANY	COMPRESSOR	MOTOR PURGE AIR DIFFERENTIAL SHUTDOWN SWITCH	MOTOR PURGE AIR DIFFERENTIAL SHUTDOWN SWITCH RESET BUTTONS ARE OLD AND STICKY AND NEED TO BE REPLACED.
BETHANY	COMPRESSOR	V-127	4" VENT VALVE, (V-127), SOFT GOODS HAVE NOT BEEN REPLACED IN MANY YEARS AND VALVE SOMETIMES STICKS AND DOES NOT OPEN FULLY.
BETHANY	COMPRESSOR	V-227	4" VENT VALVE, (V-227), SOFT GOODS HAVE NOT BEEN REPLACED IN MANY YEARS AND VALVE SOMETIMES STICKS AND DOES NOT OPEN FULLY.
BETHANY	ENVIRONMENTAL	K1 SCR	ONE SCR IS FAILED ON K1; A SECOND WILL REMOVE THE UNIT FROM SERVICE.
BETHANY	COMPRESSOR	K2	K2 COMPRESSOR VIBRATIONS CAUSE THE UNIT TO TRIP ON START-UP.
BETHANY	COMPRESSOR	FILTER SEPARATORS	THE STATION HAS SEEN LIQUIDS (MOSTLY GLYCOL) IN THE COMPRESSOR; THIS CAN LEAD TO VIBRATION ISSUES AND DRY GAS SEAL FAILURES. PIPING REMOVED AS PART OF REVERSE COMPRESSION PROJECT WAS CLEAN - LIQUIDS MAY BE SETTLED IN LOW AREAS OF STATION PIPING. A BIGGER FILTER/SEP JOB IS BEING EVALUATED.
BETHANY	ELECTRICAL	K2 VFD UPS	K2 VFD BUILDING SMOKE DETECTOR FAULTS.
BETHANY	ELECTRICAL	ELECTRIC CABLE	THERE IS A BAD CABLE FAULT IN THE 480 VOLT FEEDER FROM THE CONTROL BUILDING MCC TO THE ISOLATION TRANSFORMER P-12TR FEEDING THE UPS. UNIT HAS LOCKED OUT WITH A GREAT MANY FAULTS ANNUNCIATED AT THE STATION CONTROLS. THIS HAS CAUSED A LARGE TROUBLESHOOTING EFFORT AND HAS BEEN TRACED TO THE VFD UPS SUPPLY POWER IN AT LEAST TWO INSTANCES. ONCE WHEN THE PORTABLE SUPPLY IN THE VFD BUILDING FAILED AND AGAIN WHEN A PLANNED STATION POWER OUTAGE DRAINED THE UPS BATTERIES. THE VFD UPS IS SENSITIVE TO ELECTRICAL NOISE AND HAS BEEN THE MAIN CAUSE OF THE ALARMS.

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
BETHANY	CONTROL	CONTROL	UNITS DON'T SEEM TO BE LOADING PROPERLY OR SPEEDING UP IN RESPONSE TO SUCTION PRESSURE SET POINTS IN THE REVERSE COMPRESSION CONFIGURATION. THIS MAY ALSO BE TRUE IN NORMAL COMPRESSION CONFIGURATION BUT TESTING IS NEEDED TO VERIFY. ALSO, VERIFY WHAT SPEED TRIGGERS 'MAX EFFORT' INDICATION.
BETHANY	MAIN GAS	GOV 3	STATION MLV INTERMITTENTLY GOV 5 INTERMITTENTLY DOES NOT RESPOND (CLOSES DURING START-UP).
BETHANY	COMPRESSOR	K1	K1 UNIT VIBRATIONS ARE HIGH, THE UNIT WILL TRIP WHEN SPEEDS AND OR/ DIFFERENTIAL GETS TOO HIGH. BABBITT IS PRESENT IN THE LUBE OIL DRAIN SIGHT GLASSES. DESIGN PROBLEMS FOUND IN K2 MOST LIKELY PRESENT IN K1.
BURNEY	COMPRESSOR	EXHAUST STACK	EXHAUST STACK HAS CRACKS. THIS STACK HAS BEEN REPAIRED ON MULTIPLE OCCASIONS BUT CONTINUES TO CRACK.
DELEVAN	COMPRESSOR	K3	GAS COMPRESSOR HIGH ON HOURS, AND OBSOLETE
DELEVAN	ELECTRICAL	MCC K1 BREAKER	THE MCC-K-2 LOW VOLTAGE MAIN BREAKER (52A-LVC-2D) IS TRIPPING WHEN THE NEW FIRE PUMP IS OPERATED WHILE FED THROUGH THIS BREAKER. THIS POWER SOURCE IS CONSIDERED THE ALTERNATE SOURCE. THE MAIN SOURCE GOES THROUGH THE MCC-K1 BREAKER, WHICH IS NOT TRIPPING DURING OPERATION OF THE FIRE PUMP.
DELEVAN	ENVIRONMENTAL	K3 CEMS	DK-3 CEMS NOX ANALYZER REPLACEMENT
GERBER	COMPRESSOR	K1 TURBINE	GERBER K-1 GAS TURBINE OVERHAUL
HINKLEY	CONTROL	GENIUS BLOCKS	ALL GENIUS BLOCKS AT STATION NEED TO BE REPLACED.
HINKLEY	COMPRESSOR	IGNITION SYSTEM WIRING	REPLACE IGNITION SYSTEMS / WIRING
HINKLEY	COMPRESSOR	K10 #3R	HINKLEY K10 - #3R PISTON SEIZURE
HINKLEY	COMPRESSOR	K1 / K4 TURBOCHARGERS	HINKLEY UPGRADE K1 & K4 TURBOCHARGERS
KETTLEMAN	FIRE DETECTION / SUPPRESSION	GAS DETECTORS	GAS DETECTORS AT KETTLEMAN CS ARE OBSOLETE. PARTS ARE NO LONGER AVAILABLE. SUPPORT IS LIMITED.
KETTLEMAN	ENVIRONMENTAL	NOX ANALYZERS	HIRE A REPLACEMENT CONTRACTOR TO MAINTAIN THE NOX ANALYZERS.

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
LOS MEDANOS	ELECTRICAL	PAD TRANSFORMERS	TRANSFORMERS AND RELAYS OLD AND UNRELIABLE
LOS MEDANOS	CONTROL	STATION ALARMS	NO WAY TO ALERT OPERATOR TO ALARMS IF THE OPERATOR IS NOT IN THE CONTROL ROOM
LOS MEDANOS	ELECTRICAL	BACKUP GENERATOR	DOES NOT MAINTAIN ACCURATE FREQUENCY, RESULTING IN FAILED TRANSFERS
LOS MEDANOS	LUBE OIL	OIL FILTER	OIL FILTER KNOWN TO BYPASS DURING OPERATION
LOS MEDANOS	COMPRESSOR	K1 #3R	LOS MEDANOS K-1 CYLINDER 3R REPLACEMENT
LOS MEDANOS	OTHER		LOS MEDANOS PURCHASE ADD L SPARE PARTS
MCDONALD ISLAND	COMPRESSOR	K1/K2	K1/K2 CRANKCASE OIL SWITCHES
MCDONALD ISLAND	PROCESSING	OIL STORAGE TANK	AS BUILT OIL STORAGE TANK RELIEF AND SPECTACLE BLINDS
MCDONALD ISLAND	PROCESSING	MASTER METER	MASTER METER OVER-RANGE
MCDONALD ISLAND	COMPRESSORS	K1/K2 MOTOR HEATERS	K1/K2 MOTOR HEATERS NOT PERFORMING ADEQUATELY
MCDONALD ISLAND	PROCESSING	ODORIZER	MCDONALD ISLAND CS, INSTALL NEW ODORIZER
PLEASANT CREEK	COMPRESSED AIR	AIR COMPRESSORS	PULLING EXCESSIVE POWER AND OCCASIONALLY TRIPPING BREAKER
PLEASANT CREEK	PROCESSING	PIPELINE LIQUIDS TANKS ALARMS	PER EFS, OVERFILL ALARMS AND SHUTDOWNS REQUIRED
TIONESTA	COMPRESSOR	K1	HIGH PRESSURE HYDRAULIC SYSTEM HAMMERING. THE HYDRAULIC SYSTEM HAS A HAMMERING ISSUE DURING A UNIT STARTUP. DURING A STARTUP THE AUXILIARY PUMP TURNS ON, THIS OCCASIONALLY CAUSES THE HYDRAULIC OIL LINES TO SHAKE VIOLENTLY.
TOPOCK	CONTROL	PNEUMATIC CONTROL PANELS	THE EXISTING PNEUMATIC UNIT CONTROL PANELS NEED TO BE REPLACED WITH MODERN PLC CONTROL PANELS.
TOPOCK	COMPRESSOR	P2	POWER CYLINDER OVERHAUL
TURNER CUT	PROCESSING	HOKE ACTUATORS	REPLACE HOKE ACTUATORS
TURNER CUT	PROCESSING	DHSV 3-WAY VALVE	MCD IS - TCS REPLACE DHSV 3 WAY VALVE
TURNER	ESD		MCD IS - TCS EXTEND ESD BOUNDARY

STATION	SYSTEM	COMPONENT / ITEM	DESCRIPTION / ISSUE
CUT			
TURNER CUT / WHISKEY SLOUGH	PROCESSING	REBOILER SECURITY VALVES	REBOILER SECURITY VALVES
TURNER CUT / WHISKEY SLOUGH	PROCESSING	GLYCOL PUMP	GLYCOL PUMP FAILURES
TURNER CUT / WHISKEY SLOUGH	FUEL GAS	FUEL GAS HEATERS	FUEL GAS HEATERS

7. Maintenance Work Management and Project Management

The maintenance work management and capital project management processes provide the implementation of the asset strategies as well as provide feedback to the facility engineers relative to asset register information, equipment health, and equipment performance. The asset strategies are captured in these processes through maintenance and inspection procedures, equipment procurement requirements, and specified project requirements. However, there are several activities that may be considered as part of the reliability plan and these are described below.

During the performance of capital or expense projects which replace equipment, it is important to capture this new asset register information into the asset register and work management systems. The processes that govern update of the asset register and work management system are the responsibility of other organizations (e.g., I&R, Mapping, Project Management, and Technology, Strategy, and Solutions). However, to ensure accurate and current data, the asset information requirements must be included in the asset register and work management system. The C&P asset family should address specific requirements for asset information from new work with these groups to develop an on-going approach to consistently updating this asset information. With the migration of PLM data to SAP, this is an appropriate time to define and incorporate these asset register requirements.

Another approach includes periodic review and / or audit of station asset records to determine the effectiveness of these asset register update activities. These reviews can be performed on a subset of stations to determine if current information is included in the asset register and work management systems and to provide feedback on the asset register update process.

8. Effective Feedback

A critical activity to effective asset and reliability management is the feedback from operations and maintenance to the facility engineers to allow for analysis of problems and determination of strategy changes. There are several actions for consideration relative to feedback that are discussed below.

During the performance of preventive or corrective maintenance, it is necessary to capture information that allows for effective analysis of potential problem equipment. There is a need for the C&P facility engineers to define and ensure that maintenance reports data needed for analysis and to incorporate these requirements in the maintenance program procedures and initiatives. Additionally, this information needs to be captured transferred to the work management system to allow for retrieval and analysis. There is a current initiative to use mobile technology for maintenance reporting. This initiative allows for the use of templates to collect information captured during maintenance and to be collected in a database feeding the work management system. The C&P asset family should develop a set of requirements for inclusion in this initiative to ensure that appropriate maintenance information is collected, such as:

- As-found and as-left condition
- Description of corrective maintenance performed
- Identification of failure codes and equipment tags
- Description of any problems found during the work
- Any related notifications for additional work

Information on equipment problems is often captured in a material problem reporting (MRP) system; however, the work management system can also be used to collect this information. This information provides the basis for identifying obsolete equipment as well as equipment that may have system-wide problems. The process for problem reporting needs to be addressed to ensure an appropriate feedback loop for modification of asset strategies.

Gas Control also provides data for the C&P assets relative to outages and operating issues. However, there is a lack of causal information related to the outages. This is a data collection issue that needs to be addressed. There is an on-going initiative to work with Gas Control to identify specific information to be captured after an outage occurs that is related to the following:

- Initiating alarms
- System and equipment identified as the initial cause of the outage
- Subsequent failure analysis information on the cause

The incorporation of these requirements into the outage records is important to drive specific and targeted corrective measures and to identify potential outage trends.

L. Data Assessment

Available Data

Currently available asset data falls into three categories, 1) equipment type and installation records, 2) maintenance and condition data and 3) operating and performance information. Table 44 below lists the various available data sources and maps them to the asset lifecycle stage.

Table 44 - Applicability of Available Data over Asset Lifecycle Stages

	Creation / Enhancement						
Data Sources	Conception	Design	Procure	Construct / Start-up	Utilization	Maintenance	Decommissioning/Dispose
Equipment Type & Installation Data							
Site specific documentation (job files, drawings, etc.)	X	X	X	X	X	X	X
Maintenance and Condition Data							
Computer based maintenance management (SAP)	X	X	X		X	X	X
Results, trends from predictive tests, inspection, investigations, and analyses	X	X	X			X	X
Station log books	X					X	
Operating and Performance Data							
SCADA	X	X			X	X	X
Unit and station PLC's					X	X	
Data historians	X				X	X	
Compressor hour report	X				X	X	
Event tracking databases (CAP)					X	X	
Project tracking (PSRS, SAP)	X	X	X	X			X

While the quality of the data varies by type and source, the data sources listed in Table 45 are adequate to support threat assessment and trending and reporting of the metrics for compression and processing assets. Gaps in trends due to missing data, gaps in data, or less than desired data quality is being mitigated by benchmarking other companies, or by conducting focused tests or investigations of equipment or facilities to provide data for specific investment decisions.

Table 45 - Data Summary Table

Threat	Data Type		Comments
Compression Facilities			
Equipment Manufacturing Related Defects Welding / Fabrication Related	Equipment Type & Installation		• Typically have maintained formal record drawings, stored centrally • Critical Station Document Initiative provides good understanding of the facility
Equipment Incorrect Operations	Maintenance & Condition		• Maintenance records documented in SAP, CM data is incomplete and difficult to extract

Threat	Data Type		Comments
External/Internal Corrosion Stress Corrosion Cracking Weather & Outside Forces 3rd Party / Mechanical Damage			• Documents are not centrally maintained and there is no index to aid in finding a report • Station log books are manual
Equipment Incorrect Operations Stress Corrosion Cracking	Operating & Performance		• Good visibility by SCADA • Data historian, station and unit PLC data quality is good • Assigned facility engineers tracking asset condition & performance issues
Processing Facilities			
Equipment Manufacturing Related Defects Welding / Fabrication Related	Equipment Type & Installation		• Typically have maintained formal record drawings, stored centrally • Critical Station Document Initiative provides good understanding of the facility
Equipment Incorrect Operations External/Internal Corrosion Stress Corrosion Cracking Weather & Outside Forces 3rd Party / Mechanical Damage	Maintenance & Condition		• Maintenance records documented in SAP, CM data is incomplete and difficult to extract • Reports of inspections or analyses are not centrally maintained and there is no index to aid in finding a report
Equipment Incorrect Operations	Operating & Performance		• Limited SCADA visibility • Assigned facility engineers tracking asset condition & performance issues
Odorizers			
Equipment Manufacturing Related Defects Welding / Fabrication Related	Equipment Type & Installation		• Central data base of odorizers maintained
External/Internal Corrosion Stress Corrosion Cracking Weather & Outside Forces 3rd Party / Mechanical Damage	Maintenance & Condition		• Maintenance records in SAP
Equipment Incorrect Operations	Operating & Performance		• Engineer assigned to monitor asset condition & performance issues • No SCADA visibility

What Are the Gaps in Current Data?

The gaps identified for the existing records include:

Equipment Type and Installation

- Record drawings are missing, incomplete or not kept up to date at all facilities. Although records are maintained in a central database, they can be difficult to find due to inconsistencies in titling.
- Some original installation documents such as strength test reports and radiographs of welds are currently being researched to understand the projected scope of unavailable records.

Maintenance and Condition

The condition assessment provided a specific data review for condition-related information. As pertains to the condition assessment, the following discussion provides information on this data set. There is very little centralized storage of data in a manner that it can be easily extracted and utilized in assessment or decision making regarding the facility condition. Much of the data is stored in multiple locations (SAP and PSRS) and in multiple formats. SAP is the asset and work management tool; and PSRS is the project planning tool. There is limited capability to compare condition across the entire sub-family or overall family by asset management or investment planning groups because the condition data is not well documented and is often in the heads of key engineering and maintenance personnel.

In addition, there is very limited metric information available to understand and confirm risks identified through the knowledge and experience of field and engineering personnel.

The condition assessment reviewed and evaluated many data sources relative to determining component and station health and to assessing asset management decision-making for gas transmission stations. The evaluation of the data is based on the following criteria.

Table 46 – Data Condition Criteria

Condition	Description
Good	Meets most data availability and quality requirements
Medium	Meets some data availability and quality requirements
Poor	Meets few, if any, data availability and quality requirements
N.A.	Not available at present

Table 47 below shows where key asset management data is available and its current adequacy for decision making and prioritization. While this applies specifically to gas transmission stations, it is expected that this will apply to gas distribution also.

Table 47 - Data Availability and Quality Determination – Gas Transmission Stations

		FIMP	SAP	PSRS	IGIS GIS	CAP	MPR	Gas Ops	Adequacy
Asset Registration	Facility ID	X	X		X	X			Good
	Equipment ID	X	X						Med
	Equipment Tag	X	X						Med
	Object Type (e.g., Regulator)	X	X						Med
	Address		X						Med
	City		X						Med
	Latitude (minimum of 4 decimal points of accuracy)		X		X				Med
	Longitude (minimum of 4 decimal points of accuracy)		X		X				Med
	Equipment Manufacturer	X	X				X		Med
	Equipment Model	X	X				X		Med
	Equipment Serial Number						X		Poor
	Equipment Installation Date (Age)	X	X	X			X		Poor
Maintenance Management	MPR Ref Number						X		Good
	Leak Ref Number		X		X				Med
	Work Ref Number [Order Ticket]		X	X					Med
	Maintenance Strategy by Component [Preventative, Run to Failure, etc.]		X						Med
	Work Type by		X						Good

		FIMP	SAP	PSRS	IGIS GIS	CAP	MPR	Gas Ops	Adequacy
	Task [Corrective Maintenance, Preventative Maintenance, Predictive Maintenance]								
	Task by Equipment		X						Med
	As Found Condition (Damage and Cause Codes) by Equipment and Task		X		X	X			Med
	Activity Performed by Equipment and Task		X		X				Med
	As Left Condition by Equipment and Task				X				Poor
	Task Completion Date		X	X	X				Good
	Actual Wrench Time by Equipment and Task [man hrs]		X						Poor
	Total Cost by Task [$]								N.A.
	Total Cost by Project [$]			X					Good
Maintenance Scheduling	Scheduled Due Dates by Equipment and Task		X						Good
	Compliance Due Dates by Equipment and Task		X						Good
	Resource Requirements by Task [OQ]								N.A.

		FIMP	SAP	PSRS	IGIS GIS	CAP	MPR	Gas Ops	Adequacy
	Resource Assignments by Equipment and Task [LAN ID]		X						Good
	Estimated Time by Task [man hrs]								Med
	Resource Availability by Task/Date/Location								N.A.
Performance	Regulatory Violations by Location and Date					Reg. Data base			Good
	Gas Event Corrective Actions by Location and Type				X	X			Med
	Equipment Performance by Equipment Type (e.g., availability / reliability)							X	Med
Condition	Equipment Physical Condition	X	X						N.A.
	Physical Condition by Facility	X	X						N.A.
	Environmental Condition	X	X						N.A.

Note: X = Data currently identified in the defined database.
O = Data currently being placed in this database.

Current gaps in the data include:

- Asset information (SAP)
  - Facility names are not consistently used across the multiple databases
  - Multiple systems are used to collect similar information (SAP, PSRS)

- Data validation of asset information (make, model, serial number, etc.) is not readily available to enable lookups within the various databases.
- Maintenance (SAP)
  - All assets are not included in the maintenance system (SAP)
  - Process to ensure data accuracy/completeness is not effective
  - Data is not easily retrievable
  - Maintenance reporting varies significantly across the system relative to the amount and type of information reported
  - Corrective maintenance is not uniformly reported against specific equipment and is used for all non-preventive maintenance tasks
- Project Finance (PSRS)
  - Projects are not consistently mapped to facility
  - Assets that have been replaced are not easily identified
  - No straightforward way to map investment to facility when an order covers multiple facilities
  - For large facilities, no straightforward way to map investment to system (such as electric system, compressor, lube oil, etc.)
- Performance
  - No consistent way to capture information about equipment which was not able to perform its function
  - No or limited standard failure modes exist for the various equipment types
  - Leaks are not mapped to stations
  - Limited information from outages to determine cause
- Condition
  - No consistent way to report equipment condition
  - Reported in paper format and not necessarily transferred to maintenance systems
  - Typically reported at the facility level (not equipment level)

Operating and Performance
There is currently little operating and performance information or SCADA visibility on gas processing equipment (dehydrators, reboilers, thermal oxidizer units) or odorizers. Going forward, for new units or modifications to existing, include operating data needs into the design criteria.

Some asset operating information is collected on the compressor units, but is not maintained in a central database that facilitates performance trending and analysis, or unit comparisons. Data quality is good, but the data can be difficult to work with and is currently more often used for post incident investigation rather than making asset management decisions.

An on-going multi-year initiative currently in progress will increase the quantity and improve quality of operating data collected on critical compressor station components through installation of unit and station data collection historians. The data collection historians will have trending, alarm analysis, data archiving, and other attributes. The units will be installed at the compressor stations and storage facilities.

Another initiative being investigated is the use of SCADA OSI Pi to develop algorithms that will utilize data points from local PLCs and data historians to provide an indication of asset health.

Long Term Strategy for Data
Good data quality and availability is a foundational area to creating a high quality asset management plan. Improving data quality and availability will be a key initial focus of the implementation plan for C&P stations. This improved data will provide the “data to information to action” capability to turn data into effective asset management. This is the vision provided in the future metrics defined in Section 4.

There are several initiatives underway to close the gaps in the current data. These include:

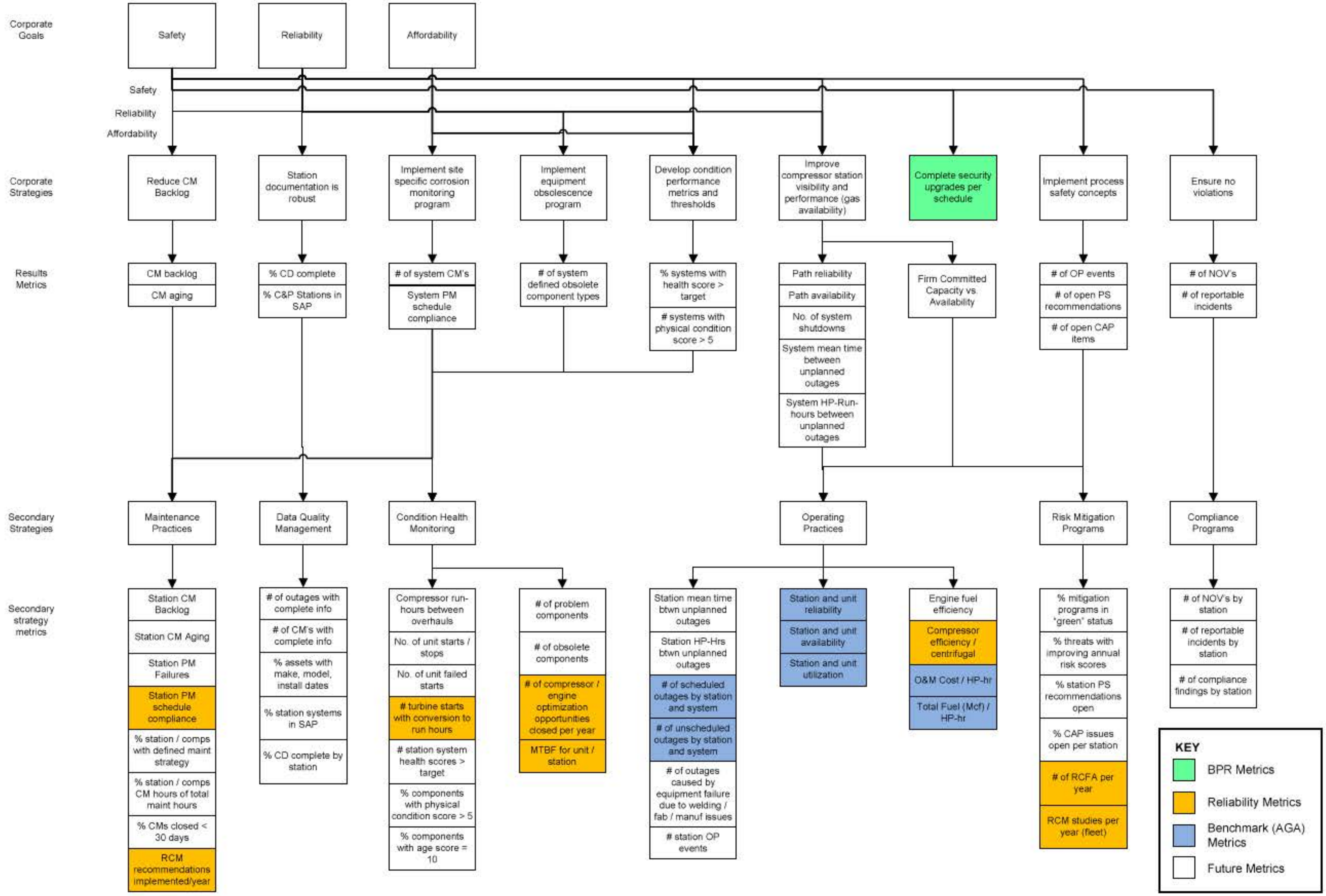
- The Critical Documents program to revise, update, or create documents that are critical to promote the safe operations and maintenance of C&P facilities.
- The migration of PLM data into SAP to ensure one source of asset and maintenance related data and for use in on-going health determination has been completed.
- The condition assessment program defined the current equipment and station condition and developed a process for continual evaluation of condition. This process will be incorporated into the SAP program.
- Condition assessment has identified the need and potential approaches for updating and maintaining asset and maintenance data for future use.
- Development of KPI’s to support condition and asset management decisions.

These programs will lead to collection of critical data and the identification of changes to the data collection process to provide for improved trending and analysis of the data.

M. Key Performance Indicators (KPIs)

The key performance indicators and metrics developed for use with the C&P Asset Family are shown in the figure below which relates metrics from the corporate strategies down to the secondary strategies for the C&P asset family. These metrics are considered for tracking performance from a fleet level down to the system and component level, and are based on the work from the Condition Assessment, which reviewed the availability of pertinent data.

Figure 51 – C&P Metrics



The specific metric definitions from the previous chart are defined in Table 48 along with a determination of their current status relative to:

- Source and availability of data
- Quality of data
- Metric Type: Identifies metric as “reportable” metric (dashboard to asset health scorecard) or “asset family” metric for review by asset family team
- Status of metric (current or future)
- Ability to potentially benchmark

As the asset family decision-making matures, it is expected that new metrics may be added and some existing metrics will be subtracted. This continuous improvement provides assurance that the metrics are providing information necessary to make informed risk decisions.

Table 48 - C&P Metrics Definitions

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
Complete security upgrades per schedule	Percent completion of physical security upgrades at defined stations per scheduled completion dates	Project schedules	Good (based on project schedules)	BPR Metric	Current	N.A.
RCM recommendations implemented per year	Percent completion of RCM recommendations implemented per year	RCM analysis results	Good (based on defined RCM recommendations)	Compressor Reliability	Current	N.A.
Turbine starts to run hours	Number of turbine starts with conversion to run hours (successful starts to operation)	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	Moderate
Compressor engine optimization	Number of compressor / engine optimization opportunities completed each year	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	N.A.
Mean-time between failure (MTBF) for stations	MTBF for outages or failures at a station	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	N.A.
Root cause / failure analysis	Number of root cause / failure analysis performed per year	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	N.A.
RCM studies	Number of RCM studies performed at a fleet level per year	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	N.A.
CM backlog	Number of open CM's for all C&P facilities	SAP	Fair (not fully complete for analysis)	Reportable	Current	Moderate

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
CM aging	Average age of open CM's for all C&P facilities	SAP	Fair (not fully complete for analysis)	Reportable	Current	Moderate
% Critical Documents complete	Percent of total C&P Critical Documents complete (or revised)	Manual from updated Ops Diagrams and O&MI's (from Mapping)	Good (based on status in mapping)	Asset Family	Current	N.A.
% C&P stations in SAP	Percent of C&P stations with asset register and maintenance work management in SAP	SAP	Poor (still in conversion)	Reportable	Current	N.A.
# of CM's open for corrosion related issues	Number of open CM's for all C&P stations related to cathodic protection or corrosion related issues	SAP	Fair (not fully complete for analysis)	Asset Family	Current	Low
System PM schedule compliance for corrosion related issues	% of PM's performed on-time for cathodic protection or corrosion related issues	AP	Fair (not fully complete for analysis)	Asset Family	Current	Low
# of overpressure events	Number of overpressure events due to C&P facilities	Gas Control and CAP	Good (based on current event tracking in Gas Ops)	Asset Family	Current	High
# of open Process Safety recommendations	Number of open Process Safety recommendations requiring action from the PS audits	PS audit reports and CAP; not all facilities currently audited	Good (based on current process of tracking in CAP)	Asset Family	Current	Low
# of open CAP issues	Number of open CAP items for C&P facilities	CAP	Good (based on current process of tracking in CAP)	Asset Family	Current	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
Path reliability	Compressor reliability by path	Gas Control	Good	Reportable	Current	High
Path availability	Compressor availability by path	Gas Control	Good	Reportable	Current	High
# of system shutdowns	Number of system shutdowns as measured by count of trips of running units, ESD shutdowns in standby, and failed starts	Gas Control	Fair: Modified metric from unplanned outages	Asset Family	Future	Moderate
System mean time run-hours between unplanned outages	Fleet level mean time run-hours between unplanned outages	Gas Control	Good	Asset Family	Current	Moderate
System HP-run hours between unplanned outages	Fleet level HP-hours between unplanned outages	Gas Control	Good	Reportable	Current	Moderate
# of system defined obsolete component types	Number of identified obsolete component types (by make and model) included in the obsolete equipment list	Not currently available, but needs to be included in SAP	N.A.	Asset Family	Future	Low
# C&P systems with health score > target	Number of C&P systems (fleet wide) with health score > target	Available from condition assessment; needs to be included in SAP	Fair: Based on quality of data available from all sources in condition assessment	Reportable	Future	Low
# C&P systems with physical condition score > 5	Number of C&P systems (fleet wide) with physical condition score > 5	Available from condition assessment; needs to be included in	Fair: Based on quality of data available from all sources in	Asset Family	Future	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
		SAP	condition assessment			
# of NOV's	Number of NOV's received for all C&P facilities	Regulatory Compliance database	Good	Reportable	Current	Moderate
# of reportable events	Number of reportable events for all C&P facilities	Regulatory Compliance database	Good	Asset Family	Current	Moderate
Station CM backlog	Number of open CM's for each C&P facilities	SAP	Fair (not fully complete for analysis)	Asset Family	Current	Moderate
Station CM aging	Average age of open CM's for each C&P facilities	SAP	Fair (not fully complete for analysis)	Asset Family	Current	Moderate
Station PM failures	Number of CM's associated with equipment protected by PM for each C&P station	SAP	Poor: Strategy of "run-to-failure" or "no action" is not defined for all components so analysis cannot be performed	Asset Family	Future	Low
Station PM schedule compliance	% of PM's performed on time for fleet, station and system level	SAP	Fair (not fully complete for analysis)	Compressor Reliability	Current	Low
% station components with defined maintenance strategies (in PLM or SAP)	Percent of station or system components with defined maintenance strategies	SAP	Poor: Strategy of "run-to-failure" or "no action" is not defined for all components	Asset Family	Future	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
% station and components CM hours over total maintenance hours	Ratio of CM hours to total maintenance hours at a station and system level	SAP	Fair (not fully complete for analysis)	Asset Family	Current	Moderate
% CM's closed in < 30 days	Percent of CM's closed in less than 30 days for those CM's due to PM failures	SAP	Fair (not fully complete for analysis)	Asset Family	Current	Moderate
Station and unit reliability	Compressor reliability by station and unit measured by unit available for operation divided by available hours (annual minus planned outages)	Gas Control	Good	Asset Family / AGA Benchmark	Current	High
Station and unit availability	Compressor availability by station and unit measured by unit available for operation divided by annual hours	Gas Control	Good	Asset Family / AGA Benchmark	Current	High
Station and unit utilization	Compressor utilization by station and unit measured by unit run hours divided by annual hours	Gas Control	Good	Asset Family / AGA Benchmark	Current	High
Station and unit mean time between unplanned outages	Station and unit level mean time run-hours between unplanned outages	Gas Control	Good	Asset Family	Current	Low
Station and unit HP-hours between unplanned outages	Station and unit level HP-hours between unplanned outages	Gas Control	Good	Asset Family	Current	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
Planned outages by station and system	Number of planned outages by station and system	Gas Control	Good	Asset Family / AGA Benchmark	Current	High
Unscheduled outages by station and system	Number of unscheduled outages by station and system	Gas Control	Good	Asset Family / AGA Benchmark	Current	High
Outages caused by equipment failure due to welding, fabrication, or manufacturing issues	Number of station and unit outages caused by welding, fabrication or manufacturing issues	Gas Control	Fair: additional information required for system level	Asset Family	Future	Low
Overpressure events by station	Number of overpressure events due to C&P facilities by station	Gas Control and CAP	Good (based on event tracking in Gas Ops)	Asset Family	Current	High
Compressor run-hours between overhauls	Unit compressor run-hours between overhauls	Gas Control	Good	Asset Family	Current	High
# of unit starts / stops	Number of unit starts and stops between overhauls	Gas Control	Good	Asset Family	Current	High
# of unit failed starts	Number of unit failed starts	Gas Control	Good	Asset Family	Current	High
# of systems with health scores > target (station level)	Number of station systems with health scores > target	Available from condition assessment; needs to be in SAP	Fair: Based on quality of data available from all sources in condition assessment	Asset Family	Future	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
% components with physical condition score > 5	% of station components with physical condition score > 5	Available from condition assessment; needs to be in SAP	Fair: Based on quality of data available from all sources in condition assessment	Asset Family	Future	Low
% components with age score = 10	% of station components with age score = 10	Available from condition assessment; needs to be in SAP	Fair: Based on quality of data available from all sources in condition assessment	Asset Family	Future	Low
# of problem components	Number of problem components within a station	Available from condition assessment; needs to be included in SAP	Fair: Based on quality of data available from all sources in condition assessment	Asset Family	Future	Low
# of obsolete components	Number of obsolete components within a station	Available from condition assessment; needs to be included in SAP	Fair: Based on quality of data available from all sources in condition assessment	Asset Family	Future	Low
% mitigation programs in "green" status	Number of mitigation programs from risk register with "green" status	Risk register	Fair: based on updated information from programs. Needs to be more established	Asset Family	Future	Low
% threats with improving annual risk	Percent of asset family threats with improving	Risk register	Fair: only 2 years of information	Asset Family	Future	Low

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
scores	scores each year					
% of station Process Safety recommendations open	Number of open Process Safety recommendations requiring action for each C&P facility from the PS audits	PS audit reports and CAP; not all facilities currently audited	Good (based on current process of tracking in CAP)	Asset Family	Current	Low
% CAP issues open per station	Number of open CAP items for each C&P facility	CAP	Good (based on current process of tracking in CAP)	Asset Family	Current	Low
# of outages with complete information	Number of outages with complete outage information	Gas Ops (future)	Poor: New request for information	Asset Family	Future	Low
# of CM's with complete information	Number of CM's with complete information	SAP	Poor: New request for information	Asset Family	Future	Low
% assets with make, model and install dates	% of assets (all C&P, station and system) with make, model and installation dates in SAP	SAP	Poor: Significant asset register information not readily available	Asset Family	Future	Low
% station systems in SAP	Percent of C&P station systems with asset register and maintenance work management in SAP	SAP	Poor (still in conversion)	Asset Family	Current	N.A.
% CD complete per station	Percent of total C&P Critical Documents complete (or revised) per station	Monthly project dashboards prepared by CD mgmt. team and shared with the LOB	Good	Asset Family	Current	N.A.

Metric	Definition	Data Source and Availability	Data Quality	Metric Type	Metric Status	Ability to Benchmark
# of NOV's by station	Number of NOV's received for each C&P facility	Regulatory Compliance database	Good	Asset Family	Current	Moderate
# of reportable incidents by station	Number of reportable events for each C&P facility	Regulatory Compliance database	Good	Asset Family	Current	Moderate
# of compliance findings by station	Number of compliance findings (internal and external audits) by fleet and station	Regulatory Compliance database	Good (since now captured in CAP)	Asset Family	Current	Moderate
Engine operational efficiency	Ratio of O&M cost to work (hp-hrs) (actual calculation to be determined)	Gas Operations	Good	Asset Family / AGA Benchmark	Current	High
Engine fuel efficiency	Ratio of fuel cost to work (hp-hrs) (actual calculation to be determined)	Gas Operations	Good	Asset Family / AGA Benchmark	Current	High
Compressor efficiency (centrifugal)	Calculation based on inlet and outlet temperatures and pressures (actual calculation to be determined)	RCM analysis results	Good (based on RCM program)	Compressor Reliability	Current	Moderate

KEY
- BPR Metrics
- Reliability Metrics
- Benchmark (AGA) Metrics
- Future Metrics

N. Long Term Compression Investment Plan

Facility Integrity Management

Long Term Compression Investment Plan

May 4, 2016

Plan Owner: Terry White

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Introduction

Planning for and funding of compression asset investments historically have been based on a 5-year or shorter financial outlook driven largely by budget development and Rate Case cycles. Initiatives currently underway to implement facility integrity management and asset life cycle management for compression assets have pointed to a need for a longer view to give visibility into and enable long term planning for investments to address compression assets and infrastructure that are nearing the end of their service life.

The Long Term Compression Investment Plan provides a 30-year (2016 – 2045) forecast of investments associated with life cycle management of PG&E's compression assets. It is intended to provide Gas Operations with a long term view of the timing and duration of compression asset investment as well as estimated financial impact so that key stakeholders can be involved early to provide input on potential operational impacts, the need for the investment, and investment alternatives.

Plan Basis

The investment plan is built around design criteria which the assets will be required to meet. The design criteria are shaped largely by external supply and demand forecasts along with internal corporate and Gas Operations business strategies. The "most likely" gas supply and demand forecast scenario is used in developing the design criteria.

Backbone Transmission and Local Transmission

This plan uses the "Average Day" demand forecasts in the 2014 California Gas Report which projects low to flat load growth in all sectors as the basis for the most likely or "Status Quo" forecast scenario. Separate design criteria using this scenario were then developed for Backbone Transmission and Local Transmission (Santa Rosa Compressor Station).

Although the Average Day demand forecast includes gas demand by the Electric Generation (EG) sector, forecasting this demand is highly uncertain. Increasing promotion and implementation of renewable energy sources and initiatives addressing greenhouse gas emissions can potentially lead to declining EG gas demand within the investment plan time horizon. Based on the uncertainties associated with the use and timing of renewables and its effect on EG gas demand, the investment plan includes an analysis of a high renewables scenario for Backbone Transmission in addition to the Status Quo scenario. Under the "High Renewables" scenario, renewables would lessen the need for capacity and consequently compression on the backbone transmission system by 2030. Due to the uncertainty associated with this scenario, it was not selected for the investment plan design criteria, but it is analyzed and discussed in the investment plan to provide a perspective on how the compression needs might change in the future under such an environment.

Storage

Until recently, incremental investments in PG&E's gas storage facilities were made primarily to increase market storage service offerings. However, since 2010, the market value of storage has declined due in part to ample natural gas supplies and storage capacity in Northern California. In response, PG&E is currently evaluating a number of scenarios related to its storage assets as a part of its 2018 Gas Transmission & Storage Rate Case filing. In the interim, the investment strategy developed for storage compression and used in this plan is focused on maintaining current levels of reliability of the compression assets used for injection.

Investment Plan Summary

Status Quo

Figures 52 and 53 below display the projected annual system capital and expense expenditures, respectively, by path over the 30-year time frame based on the Status Quo scenario. The 2016 costs are obtained from the approved 2016 S2 budget. Costs shown for the subsequent years are estimates derived by trending historic costs or are based on actual costs of similar scope replacement projects. All costs are based on the "Old Cost Model" and include 3% escalation through 2030. Cost estimate accuracy falls in the range of a Class 5 estimate (Conceptual Engineering) as defined by the AACE, International Estimate Classification System.

Figure 52 - Status Quo System Capital Investment by Path

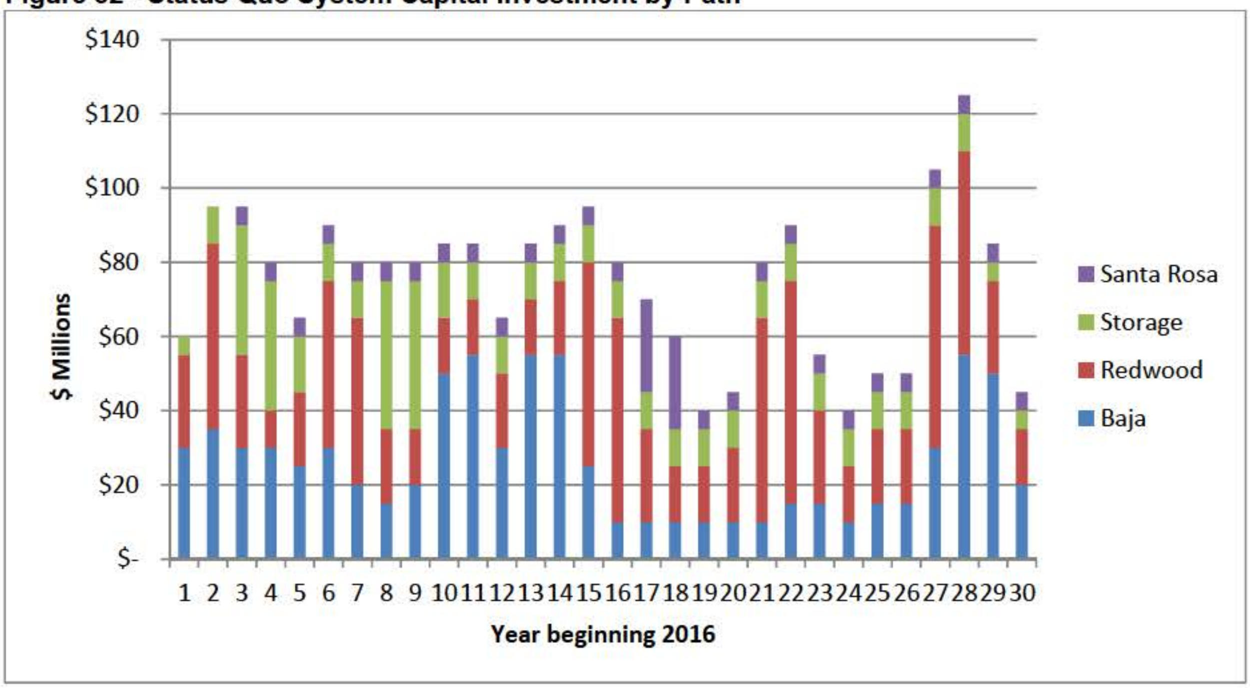
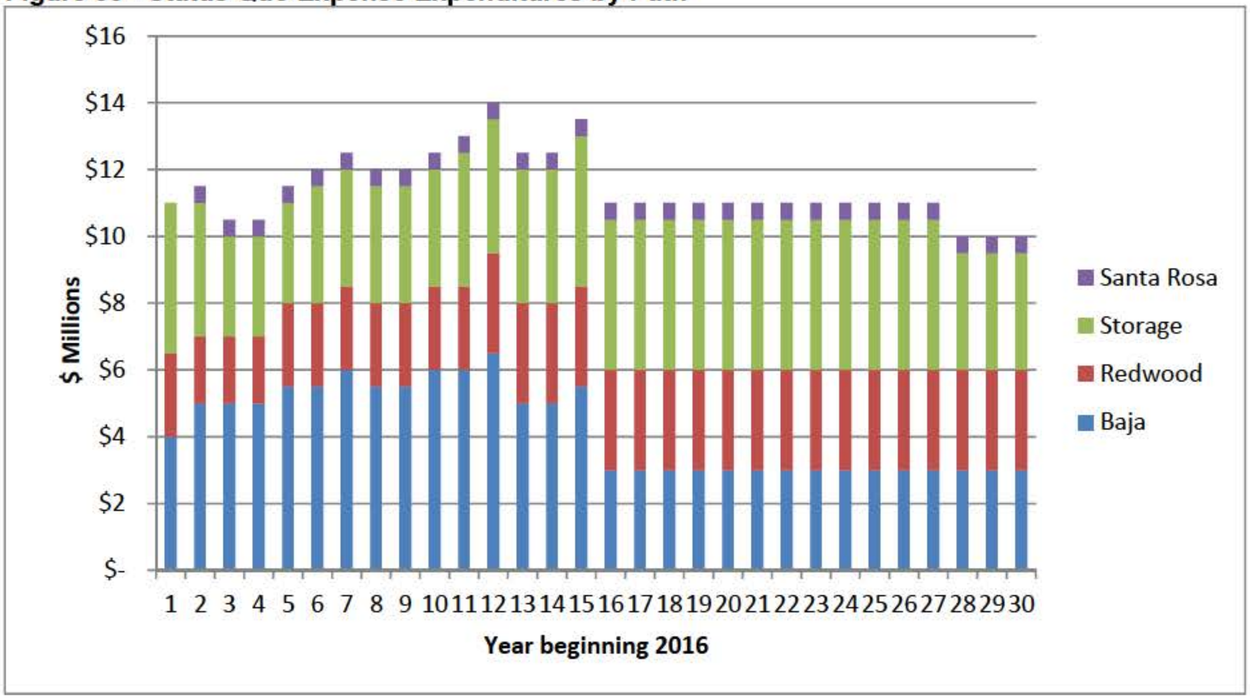


Figure 53 - Status Quo Expense Expenditures by Path



The spikes seen in Figure 52 are due primarily to compressor unit replacements. The current schedule for compressor replacements is shown in Table 49 below. Cost of compressor replacement was spread over a 4-year period with construction occurring in the second and third years.

Table 49 - Compressor Unit Replacements

Compressor Unit	Replacement Time Frame (Yr.)		Compressor Unit	Replacement Time Frame (Yr.)	
Burney K2	1 – 3	(2016 – 2018)	Delevan K3	14 – 17	(2029 – 2032)
Los Medanos K1	2 – 5	(2017 – 2020)	Santa Rosa K1 & K2	13 - 19	(2031 – 2034)
Tionesta K1	5 – 8	(2020 – 2023)	Gerber K1	20 – 23	(2035 – 2038)
McDonald K1 & K2	7 – 10	(2022 – 2025)	Bethany K1 & K2	26 – 29	(2041 – 2044)
Topock (all units)*	9 – 12	(2024 – 2027)	Kettleman K1, K2, & K3	27 - 30	(2042 – 2045)
Hinkley (all units)*	12 – 15	(2027 – 2030)			

*Assumes that the entire station will be rebuilt and units not replaced on an individual basis.

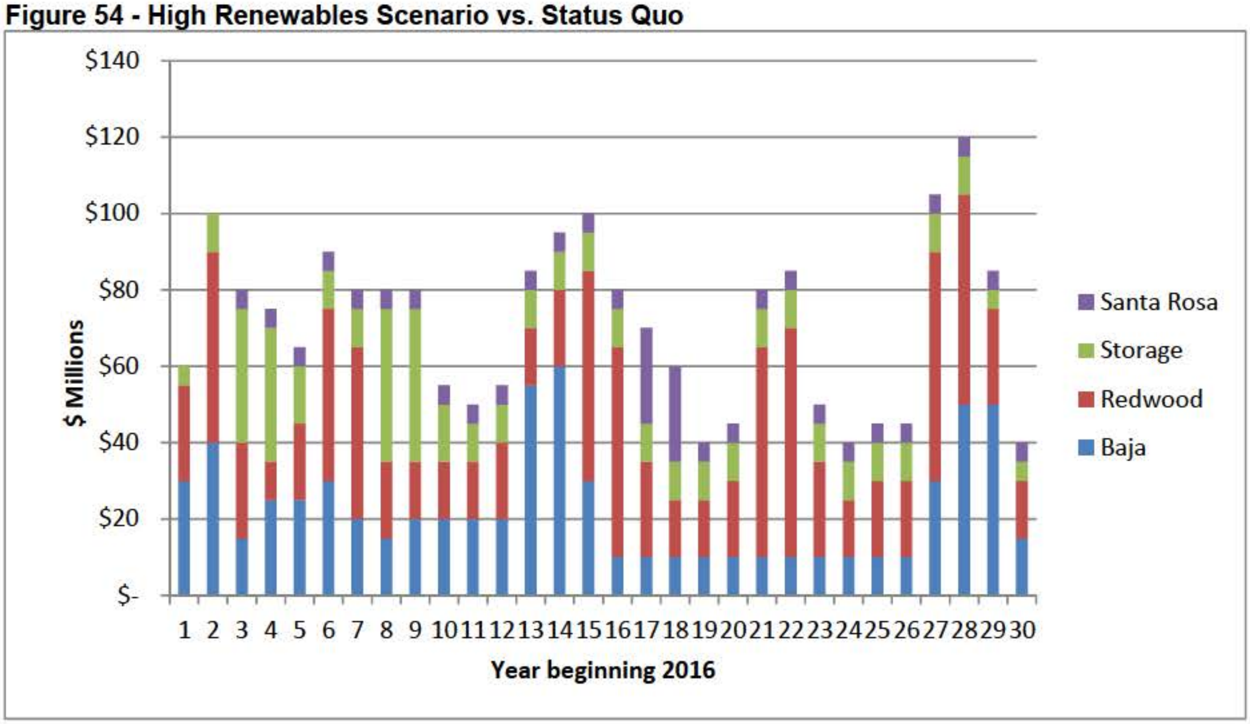
High Renewables

The High Renewables scenario adopts an EG gas demand scenario developed by McKinsey & Company (McKinsey). PG&E contracted with McKinsey in 2015 to develop a corporate strategy to address the impact of renewable energy on PG&E's electric and gas systems. McKinsey identified six scenarios that could result in reduced utilization at power plants on the PG&E gas system by the year 2030. EG gas demand reductions ranged from 55 MMCFD to 747 MMCFD across the six scenarios. EG scenario B1 which assumes a moderate reduction in EG gas demand of 446 MMCFD was selected for the High Renewables case. Since Redwood Path is projected by Wholesale Marketing and Business Development to remain the preferred pipeline for the foreseeable future, the reduced gas demand is subtracted entirely from the Baja Path for the analysis. Based on analysis by Gas Planning, Baja firm capacity would be reduced to 564 MMCFD under the B1 EG scenario from the Status Quo firm capacity of 1010 MMCFD. This translates into the following compression requirements at the three Baja Path compressor stations:

	Topock	Hinkley	Kettleman
Current No. of Units (Status Quo)	9	12	3
No. Units Required to Meet B1	0	5	2

Figure 54 below compares capital investments for the Status Quo and High Renewables scenarios. Gross reduction in capital investment spending for over Status Quo is projected to be approximately $145 million over 30 years. Reductions are primarily due to not replacing the compressor units at Topock in years 10 through 12 (2025 – 2027) and reduced compressor unit replacement costs at Kettleman in years 27 through 30 (2042 – 2045). Gross reduction in expense expenditure over Status Quo (not charted) is projected to be $15 million over 30 years due primarily to having fewer units to maintain.

Figure 54 - High Renewables Scenario vs. Status Quo

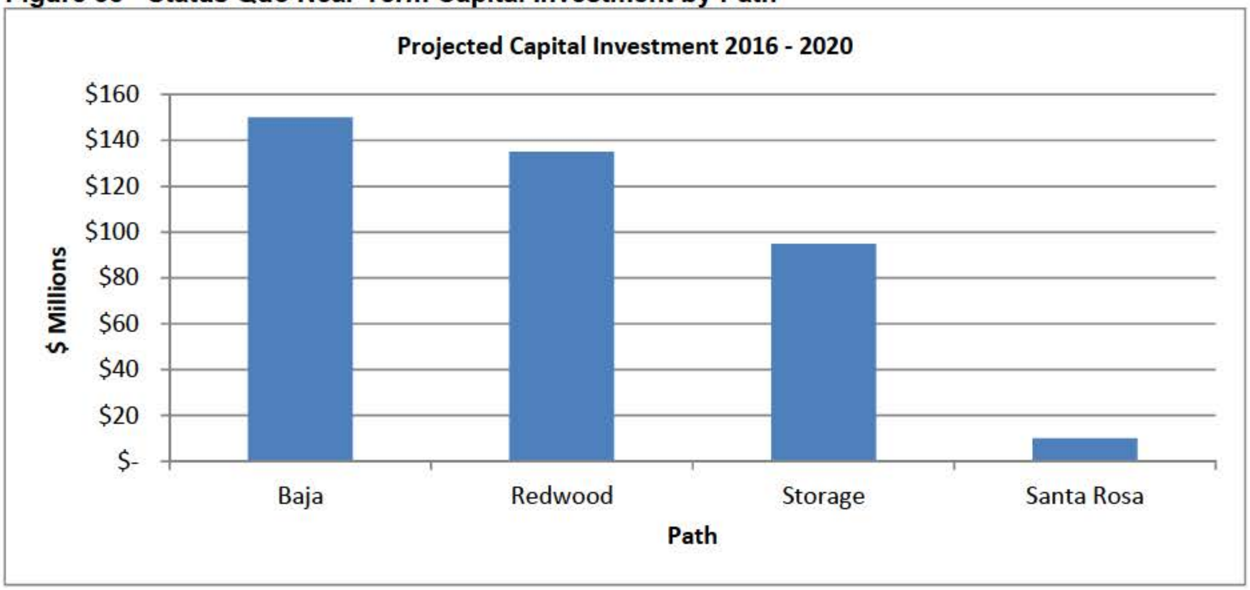


Near Term Capital Investment Analysis

Expenditures forecast for years 1 through 5 (2016 – 2020) are characterized in the plan as Near Term investments. As stated earlier, the investment plan is built around design criteria which reflects external supply and demand forecasts along with internal corporate and Gas Operations business strategies. Ideally, Near Term investments are consistent with Gas Operations business and operating strategies or at the very least, are "no regrets" investments which do not result in stranded assets or the need to go back and undo previous work.

Figure 55 below shows the projected Near Term capital investment by path for the Status Quo scenario. Approximately $150 million and $95 million in capital investment are projected for Baja Path and Storage, respectively, over the next 5 years. These investments warrant review in light of studies underway that may potentially recommend asset or reliability reduction strategies for these business lines.

Figure 55 - Status Quo Near Term Capital Investment by Path



The stations and associated specific projects that make up the majority of the forecast investment for Baja Path and Storage are shown in Table 50 below. The level of investment forecast for Hinkley and Topock Compressor stations and Los Medanos particularly should be reviewed considering:

- Current projections that Baja Path will continue to be the marginal pipeline and as such would assume any capacity reductions due to decreased EG gas demand.
- Potential shift in business strategy for gas storage assets.

Table 50 - Near Term Baja Path and Storage Projects

Station	Forecast	Projects
Hinkley	$75 million	• Major upgrades/replacement of station cooling water, electrical, and control systems • Pond liner replacement • Foundation repair/replacement

Station	Forecast	Projects
Topock	$55 million	• Major upgrade/replacement of station power generating system (P-units) (year 1 of 3 year effort) • Replacement of compressor unit control panels • Upgrades station electrical, compressed air, and cooling water systems • Foundation repair/replacement • Upgrades to station suction relief valves
Los Medanos	$65 million	Compressor replacement

Implementation of asset and reliability reduction strategies would result in reductions in capital or expense investments, or both. The amount of reduction, however, depends on a number of factors. A key factor is whether the investment is being made to restore or maintain a particular level of performance reliability, to maintain reliability of safety critical systems and components, or to address safety issues.

Safety issues are most often an outcome of prolonged deferral of investment to maintain reliability of safety critical systems or components. Once a safety critical system or component degrades to the point that it becomes a safety issue, the investment to mitigate the issue must be made if the facility is expected to continue operation. In Table 50, Baja Path investments at Hinkley and Topock are driven primarily by safety issues whereas investment at Los Medanos is driven by reliability concerns.

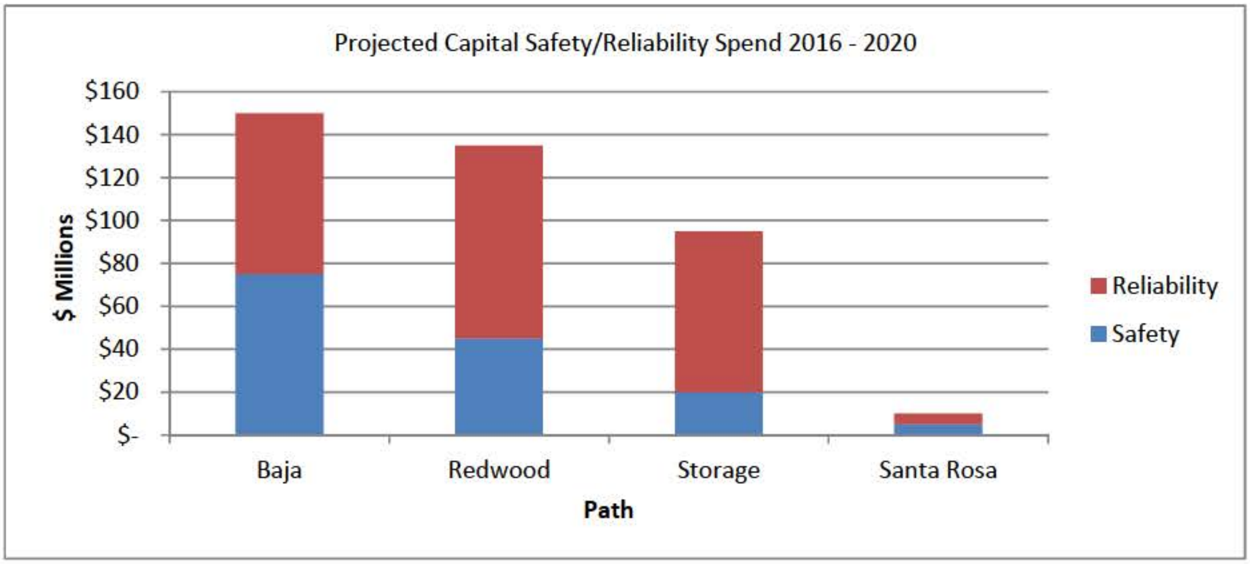
The safety and reliability investment amounts can be estimated by allocating the projected investment for station systems between safety-critical and reliability categories using the matrix shown in Table 51 below. The station systems listed are used in the investment plan to develop the station and path investment forecasts. See Section 3.3 and Appendix A for additional discussion.

Table 51 - Safety/Reliability Investment Allocation Matrix

Station System	Percent of System Investment	
	Safety Critical	Reliability
Compressor Unit	0	100
Civil/Structural	50	50
Compressed Air	100	0
Controls	100	0
Cooling Water	100	0
Electrical	100	0
Environmental	50	50
Fire Detection/Suppression	100	50
Fuel Gas	50	50
Gas System	50	50
Lube Oil	100	0
Power Gas	50	50
Security	50	50

Figure 56 below provides view of the Near Term safety and reliability investment spend by path.

Figure 56 - Status Quo Near Term Safety vs. Reliability Spend



As shown in the figure, investments are equally split between reliability and safety for Baja Path facilities and Santa Rosa. For Redwood Path facilities and Storage, reliability investment, driven primarily by compressor replacements, represent approximately 70% and 80% of the total investment, respectively. The higher percentage of safety investment for Baja facilities; specifically, Hinkley and Topock Compressor stations, and Santa Rosa Compressor Station is not unexpected. Investments in safety critical systems at these facilities had been deferred for many years.

Part I – General

1. Purpose

This document presents a long term investment strategy and plan for life cycle management of gas compression assets. The investment plan covers a 30-year period and implements an investment strategy that is based on a forecast of the operating scenarios and other external and internal drivers that define the performance requirements that the assets must meet. The forecasts, especially going out beyond 10 years, are subject to uncertainty, but represent the best estimates for the future based on the information currently available. The plan and assumptions underlying the investment strategy will be updated annually.

The objectives of the plan are to:

- Provide visibility into the priority for investment at each compressor station
- Ensure investments align and keep pace with projected capacity needs for each path
- Provide a spending profile showing the relative amount and timing of investments
- Aid in planning and staffing maintenance resources
- Aid in planning work so that future disruptions to the system are minimized
- Enable PG&E to address long term infrastructure sustainability risk identified by the Liberty Group in its report to the CPUC

2. Scope

The physical assets that are in scope for the long term compression investment plan include the compressor units and associated station equipment installed at the nine transmission compressor stations and the compressor units installed at the three PG&E-owned and operated underground storage facilities. The compressor stations and storage facilities are installed along approximately 6,700 miles of transmission pipeline. Transmission pipelines connecting the facilities are not included in the scope of the investment plan.

The map provided in Figure 57 below shows the location of the compressor stations, gas storage facilities and interconnecting pipelines. The inventory of compression assets can be found in GP-1105, Compression & Processing Asset Management Plan.

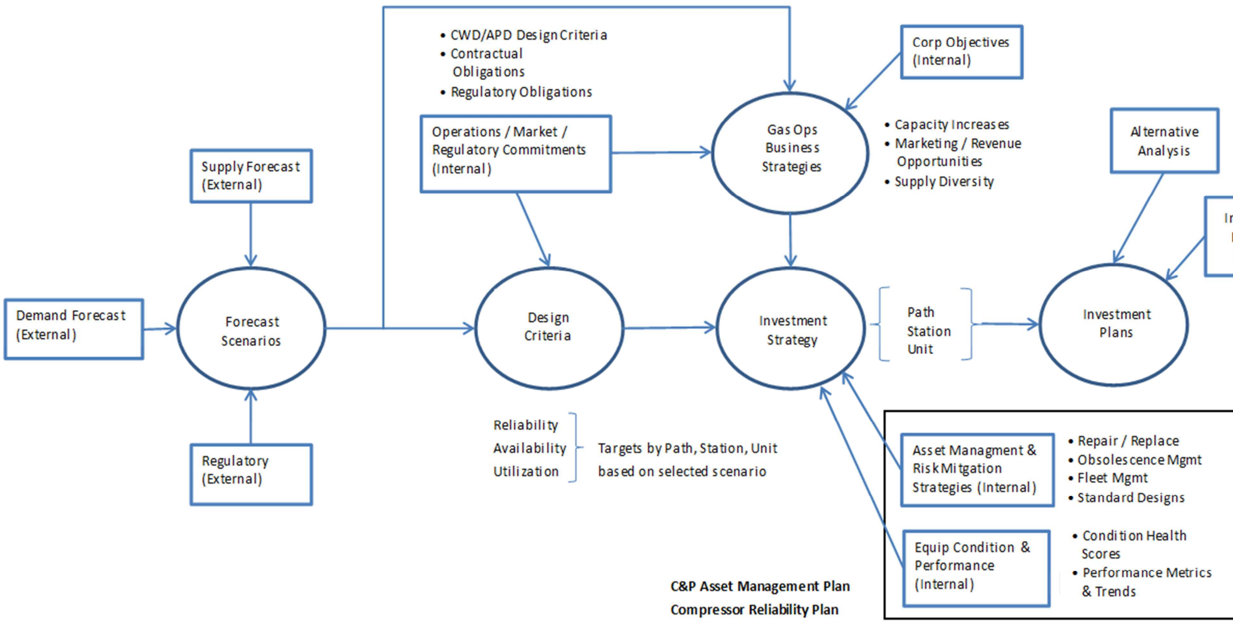
Figure 57 - Gas System Map

3. Plan Development Approach

3.1 Overview

The investment strategy for each path, compressor station, and compressor unit is based on design criteria which are used to define the levels of reliability, availability, and utilization that the compression assets must meet. The investment strategy and plan are designed to maintain these levels. The design criteria are shaped by various external and drivers which can change over time. External drivers are forecasts of future natural gas demand and supply. Additional influences may be exerted by future regulatory developments in both the pipeline safety and environmental areas. Internal drivers include Gas Operations business strategies, regulatory and market commitments, and asset and risk management strategies such as replacement versus rehabilitation and obsolescence management. Figure 58 below diagrams the inputs and outputs that inform the investment strategies and ultimately the investment plan.

Figure 58 - Investment Plan Development Approach



3.2 Forecast Scenarios

Forecast scenarios are foundational to creating an investment strategy and plan. They identify the range of possible future states for natural gas supplies and demand considering potential impacts resulting from current and future regulatory programs and initiatives. For the investment plan, the most likely forecast scenario is selected and used to inform the design criteria.

The forecast scenarios also inform Gas Operations business strategies. These business strategies align with corporate goals and objectives and are key inputs to the investment strategy. They guide investments around capacity increases or infrastructure to aid in positioning PG&E to quickly respond to changing supply and demand situations or to take advantage of marketing and revenue opportunities. A business strategy may have several scenarios or alternatives.

3.3 Investment Strategy and Plans

3.3.1 Investment Strategy

Once the selected forecast scenario, design criteria, and Gas Operations business strategies have been determined, an investment strategy is specified for each compressor unit and for each station system. The station systems listed below are utilized in the long term investment plan. These systems were originally identified for use in the compressor station condition assessment conducted in 2014. The systems and the components included in each system are listed in Appendix A.

- Civil/Structural
- Fire Detection/Suppression

- Compressed Air
- Controls
- Cooling Water
- Electrical
- Environmental
- Fuel Gas
- Gas System
- Lube Oil
- Power Gas
- Security

The investment strategy lays out the Near Term (Years 1 – 5), Mid-Term (Years 6 – 15), and Long Term (Years 16 – 30) investment strategy to be applied to each compressor unit and station system. The Near Term time frame is aligned with the S1/S2 budget cycle and the GT&S Rate Case cycle.

Investment strategy categories are:

- Replace: Compressor unit or system has reached or exceeded its expected service life and requires complete replacement
- Maintain: Continue current level of maintenance and targeted component replacement
- Increase or Decrease: Increase or Decrease current level of maintenance and targeted component replacement
- Retire: Station or system is no longer needed and can be retired and left in place or removed

For this initial issue of the long term plan, the determination of whether a compressor unit or station system replacement is forecast to occur in the Near Term, Mid-Term, or Long Term time frame is based solely on an estimate of its remaining service life. The remaining service life was estimated using the system "Component Age" parameter from the 2014 Compressor Station Condition Assessment. The Component Age parameter was one of approximately a dozen asset health parameters created and used in the condition assessment to develop unit and system health scores. The methodology for utilizing the Component Age parameter to determine the remaining service life for the investment strategy can be found in Appendix A.

Over time, the unit and station system replacement time frames may be adjusted to more closely reflect the actual life cycle of the assets. Continued improvement in the quantity, quality, and accessibility of asset condition and operating data will allow for more accurate estimates of remaining service life and enable better forecasts of investment timing.

3.3.2 Investment Plans

The investment plan forecasts the year by year capital and expense expenditures based on the investment strategy. The prioritization and scheduling of investments reflects the risk-based prioritization methodology used by Investment Planning, but does not consider any budget or resource constraints.

3.4 Investment Cost Estimate

The costs shown in the investment plan are order of magnitude costs and are used to show relative investment costs across stations. For the initial issue of the investment plan, the Year 1 (2016) costs are obtained from the approved S2 budget. Costs shown for the subsequent years are estimated for each of the investment strategy categories as follows:

- Replace category – Estimate of unit or system replacement cost based on actual costs of similar scope replacement projects or input from a subject matter expert (e.g., for station control system replacement).

- Maintain/Increase or Decrease – Estimate of annual routine expenditures obtained by trending recorded costs for routine capital and expense expenditures between 2011 and 2015 and allocating the costs equally between stations, compressor units, or systems, as appropriate.
- Retire – Show no expenditures for the unit or system beginning the year after retirement. No estimate is made of any associated retirement, removal, or salvage costs.

All costs are based on the "Old Cost Model" and include 3% escalation through 2030. Cost estimate accuracy falls in the range of a Class 5 estimate (Conceptual Engineering) as defined by the AACE, International Estimate Classification System.

3.5 Alternative Analysis

The investment strategy categories and estimated investment costs shown in the plan do not reflect any economic analysis of alternatives.

3.6 Data

Primary data sources used in development of the long term compression investment plan are listed in the table below.

Table 52 - Reference Documents

Source	Provides information on:
2014 California Gas Report	Long term supply, demand, and regulatory outlook – published biannually, 30-year outlook
2015 Compression & Processing Asset Management Plan GP-1105	Asset management and risk mitigation strategies Station condition assessment – updated annually
2014 Compressor Station Condition Assessment	Snap shot assessment of condition of compressor station systems and components (completed 2013/2014)
Compressor Reliability Plan (contained in the Compression & Processing Asset Management Plan)	Actions to address specific equipment performance and condition affecting reliability
Wholesale Marketing and Business Development, Gas Operations, Storage subject matter experts (SMEs)	• Current operating/marketing/regulatory commitments • Visibility into need for capacity increases, marketing/revenue opportunities • Storage services forecasts and scenarios

Part II – Investment Strategies

4. Backbone Transmission

The backbone transmission facilities are divided into northern facilities (Lines 2, 400 and 401) and southern facilities (Lines 300 and 319). The northern system known as the Redwood Path has five compressor stations located at Tionesta, Burney, Gerber, Delevan and Bethany. The northern system facilities interconnect with the Gas Transmission Northwest (GTN) pipeline near Malin, Oregon and the Ruby Pipeline at Onyx Hill Meter Station at the California/Oregon border. In addition, the northern system also delivers gas to and receives gas from third-party storage facilities, Lodi Gas Storage, Wild Goose Storage, and Central Valley Gas Storage.

The southern system known as the Baja Path extends from the California border near Topock to the Milpitas Terminal. It has three compressor stations located at Topock, Hinkley and Kettleman. The southern facilities interconnect with 1) Kinder Morgan and the Transwestern Pipeline Company near Topock, 2) Questar Southern Trails Pipeline Company at Essex, California, 3) Kern River Pipeline Company at Daggett, California, and 4) the Kern River High Desert Lateral near Kramer Junction, California. These interstate pipelines deliver gas from the southwest basins and the Rocky Mountain area to PG&E's southern system, which delivers gas to PG&E's load centers. The southern system can also receive gas from or deliver gas to SoCal Gas at Kern River Station. Kern River Station is connected to the SoCal Gas system by Line 319, a jointly owned PG&E-SoCal Gas pipeline. PG&E and SoCal Gas have other interconnections along Line 300 that are used for mutual operational assistance but not for commercial activity.

4.1 Forecast Scenarios

Gas supply and demand forecasts have the greatest influences on the development of forecast scenarios for backbone transmission. From a supply perspective, PG&E's gas system has access to gas supplies from the Southwest, Canada, and Rocky Mountain area. Current projections are that sufficient supplies will be available from a variety of sources to meet existing and future demands.

Gas demand over the next 30 years is projected to be essentially flat. In the 2014 California Gas Report, PG&E forecasted the overall gas demand by the residential, commercial, and industrial sectors to be flat or showing only slight growth, 0.1% per year through 2035. This is attributed to implementation of energy efficiency programs and effects of warmer temperatures due to climate change.

The gas demand by the electric generation (EG) sector which includes power plants and cogeneration is a more significant component of the total gas demand requirement. In the 2014 California Gas Report, PG&E estimated that EG demand would grow approximately 0.5% per year through 2035. Forecasting the gas demand for this sector, however, is highly uncertain and is affected by the following variables:

- Increase in renewable generation resources driven by California's Renewable Portfolio Standard program which has a goal of having 33% of energy retail sales coming from qualifying renewable resources by 2020.
- Location and type of new generation, particularly renewable energy
- Retirement of gas fired power plants having once-through water cooling systems. These systems are being phased out as part of California's implementation with the requirements in the federal Clean Water Act relating to power plant cooling. Compliance dates for individual power plants in California go out to 2029.
- Impact of policy and regulation around greenhouse gas emissions

The increased use of renewable generation resources in California like solar and wind energy may have the potential to displace energy that is currently being generated at natural gas power plants. This can reduce the overall demand on the gas system and lessen the need for capacity (and compression) on the backbone transmission system. In response PG&E contracted with McKinsey & Company (McKinsey) to develop a corporate strategy to address the impact of renewable energy on the electric and gas systems. McKinsey identified a number of EG scenarios that could result in reduced utilization at power plants on the PG&E gas system by the year 2030. The scenarios forecast a wide range of power plant fuel gas reductions based on the varying influence of drivers including technology advances, natural gas prices, incentives, and regulatory climate.

Based on the uncertainties associated with the EG demand forecast generally and renewables in particular, two EG forecast scenarios are analyzed for backbone transmission:

- Status Quo – This scenario assumes the EG demand forecast in the California Gas Report and is selected as the "most likely" scenario.
- High Renewables – This scenario assumes that renewable energy sources will have a measurable impact on EG gas demand by 2030 resulting in reduced need for compression assets on the backbone transmission system. This would be a "reduced investment" scenario.

4.1.1 Status Quo – Selected Scenario

- Low to flat load growth – assumes the "Average Day" demand forecasts in the 2014 California Gas Report

Core	0.1% per year
Non-Core	0.1% per year
EG	0.5% per year

- Increase in renewable generation produces no additional increase in EG demand
- No supply constraints
- No regulatory requirements impacting level of investment

4.1.2 High Renewables – Reduced Investment Scenario

With input from Wholesale Marketing and Business Development and Gas Planning, McKinsey EG scenario B1 was selected as a reasonable scenario for the reduced investment scenario analysis. This scenario assumes that evolving technology and regulatory climate will drive a moderate increase in renewables use by 2030. Since Redwood Path is projected by Wholesale Marketing and Business Development to remain the preferred pipeline for the foreseeable future, the reduced gas demand is subtracted entirely from the Baja Path for the analysis. See Section 4.2.2 for Design Criteria and Assumptions.

4.2 Baja Path

4.2.1 Design Criteria and Assumptions – Status Quo

- Baja Path remains as the swing pipeline
- No reduction in pipeline capacity
- No reduction in off-system deliveries
- No additional capacity required over the plan time frame, based on selected Forecast Scenario
- Existing peak-day planning standards and slack backbone criteria remain unchanged
- Retain all units and stations, no changes in operation

- Maintain current utilization, reliability, and availability levels

4.2.2 Design Criteria and Assumptions – High Renewables

Under the B1 EG scenario Baja firm capacity would be reduced to 564 MMCFD from the Status Quo firm capacity of 1010 MMCFD. This translates into the following compression requirements beginning 2030:

- Topock – 0 units
- Hinkley – 1 W330 unit and 4 GMW units
- Kettleman – 2 units

4.2.3 Investment Strategy – Status Quo

Table 53 - Kettleman Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Kettleman	K-1	Maintain	Maintain	Replace
	K-2	Maintain	Maintain	Replace
	K-3	Maintain	Maintain	Replace
	Civil/Structural	Maintain	Replace	Maintain
	Compressed Air	Maintain	Replace	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Maintain	Maintain	Replace
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Replace	Maintain	Maintain
	Fuel Gas	Replace	Maintain	Maintain
	Gas System	Maintain	Maintain	Replace
	Lube Oil	Maintain	Maintain	Replace
	Power Gas	Maintain	Replace	Maintain
	Security	Maintain	Maintain	Replace

Table 54 - Hinkley Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Hinkley	K-1 (Retrofit Unit)	Maintain	Replace	Maintain
	K-3 (Retrofit Unit)	Maintain	Replace	Maintain
	K-4 (Retrofit Unit)	Maintain	Replace	Maintain
	K-7 (Retrofit Unit)	Maintain	Replace	Maintain
	K-10 (Retrofit Unit)	Maintain	Replace	Maintain
	K-11 (Retrofit Unit)	Maintain	Replace	Maintain
	K-12 (Retrofit Unit)	Maintain	Replace	Maintain
	K-2	Maintain	Replace	Maintain

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
	K-5	Maintain	Replace	Maintain
	K-6	Maintain	Replace	Maintain
	K-8	Maintain	Replace	Maintain
	K-9	Maintain	Replace	Maintain
	P-Units	Maintain	Replace	Maintain
	Civil/Structural	Replace	Maintain	Maintain
	Compressed Air	Maintain	Replace	Maintain
	Controls	Maintain	Replace	Maintain
	Cooling Water	Replace	Maintain	Maintain
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Replace	Maintain	Maintain
	Fuel Gas	Maintain	Replace	Maintain
	Gas System	Replace	Maintain	Maintain
	Lube Oil	Replace	Maintain	Maintain
	Power Gas	Maintain	Replace	Maintain
	Security	Maintain	Replace	Maintain

Table 55 - Topock Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Topock	K-2	Maintain	Replace	Maintain
	K-3	Maintain	Replace	Maintain
	K-4	Maintain	Replace	Maintain
	K-5	Maintain	Replace	Maintain
	K-6	Maintain	Replace	Maintain
	K-7	Maintain	Replace	Maintain
	K-8	Maintain	Replace	Maintain
	K-9	Maintain	Replace	Maintain
	K-10	Maintain	Replace	Maintain
	P-Units	Maintain	Replace	Maintain
	Civil/Structural	Replace	Maintain	Maintain
	Compressed Air	Replace	Maintain	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	Replace	Maintain	Maintain
	Electrical	Replace	Maintain	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Replace	Maintain	Maintain
	Fuel Gas	Replace	Maintain	Maintain

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
	Gas System	Replace	Maintain	Maintain
	Lube Oil	Replace	Maintain	Maintain
	Power Gas	Maintain	Replace	Maintain
	Security	Maintain	Maintain	Replace

4.2.4 *Investment Plan – Status Quo*

Figure 59 - Baja Capital Investment Plan

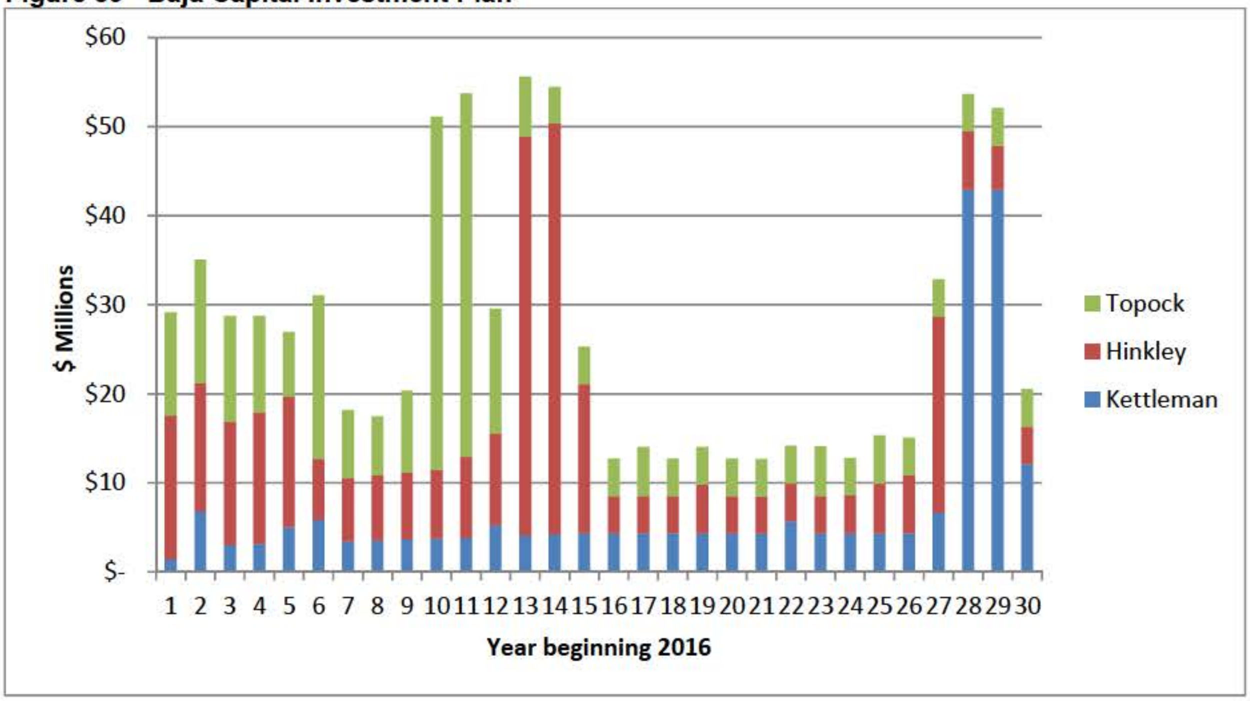
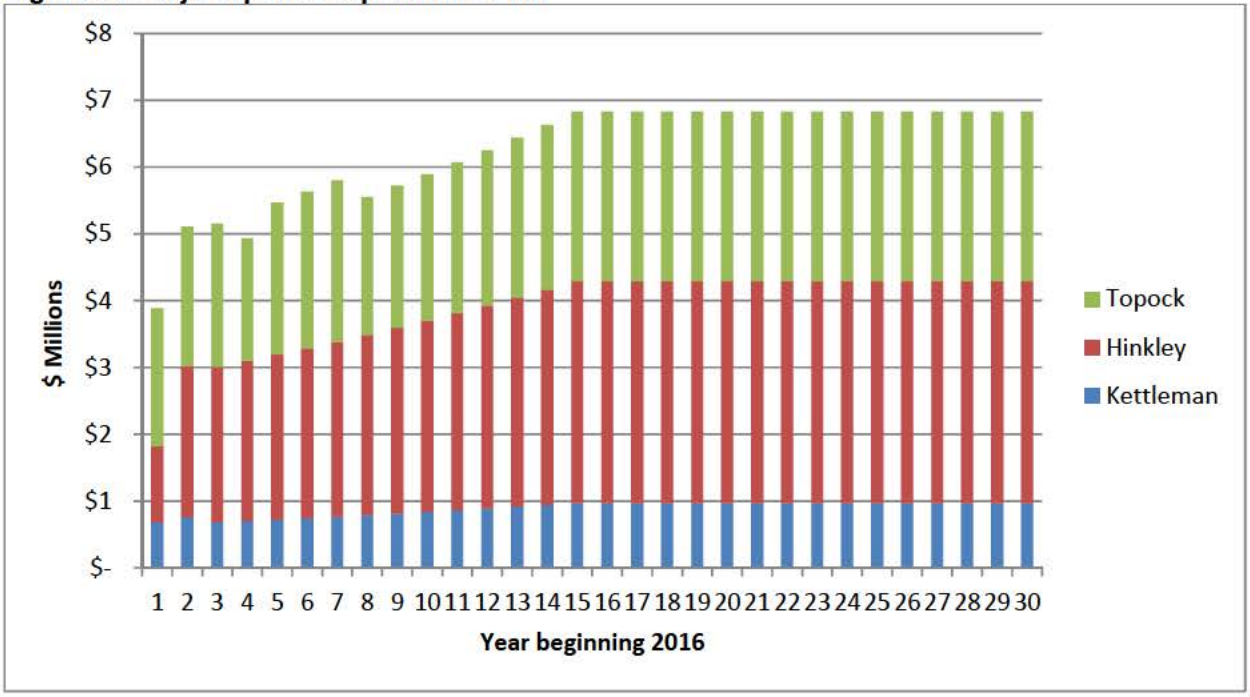


Figure 60 - Baja Expense Expenditure Plan



4.2.5 Investment Plan – High Renewables (McKinsey EG B1)

For the EG scenario analysis, the level of investment is determined simply by subtracting costs from the Baja Status Quo investment plan to match the reductions in the number of compressor units required and affected station systems for that scenario. The investment costs do not reflect any economic analysis of alternatives or additional work that may be required to implement the scenario. Savings may be reduced by any needed additional work. For example, construction of a pipeline to bypass Topock Compressor Station may be required. The cost for a bypass is not included in the costs shown.

Figures 61 and 62 below illustrate the capital investment and expense expenditure plans for the Baja High Renewables scenario. Gross reduction in capital investment spending for Baja Path over Status Quo is projected to be approximately $145 million over 30 years. Reductions are primarily due to not replacing the compressor units at Topock in years 10 through 12 (2025 – 2027) and reduced compressor unit replacement costs at Kettleman in years 27 through 30 (2042 – 2045). Gross reduction in expense expenditure over Status Quo is projected to be $15 million over 30 years due primarily to having fewer units to maintain.

Figure 61 - Baja High Renewables Capital Investment Plan

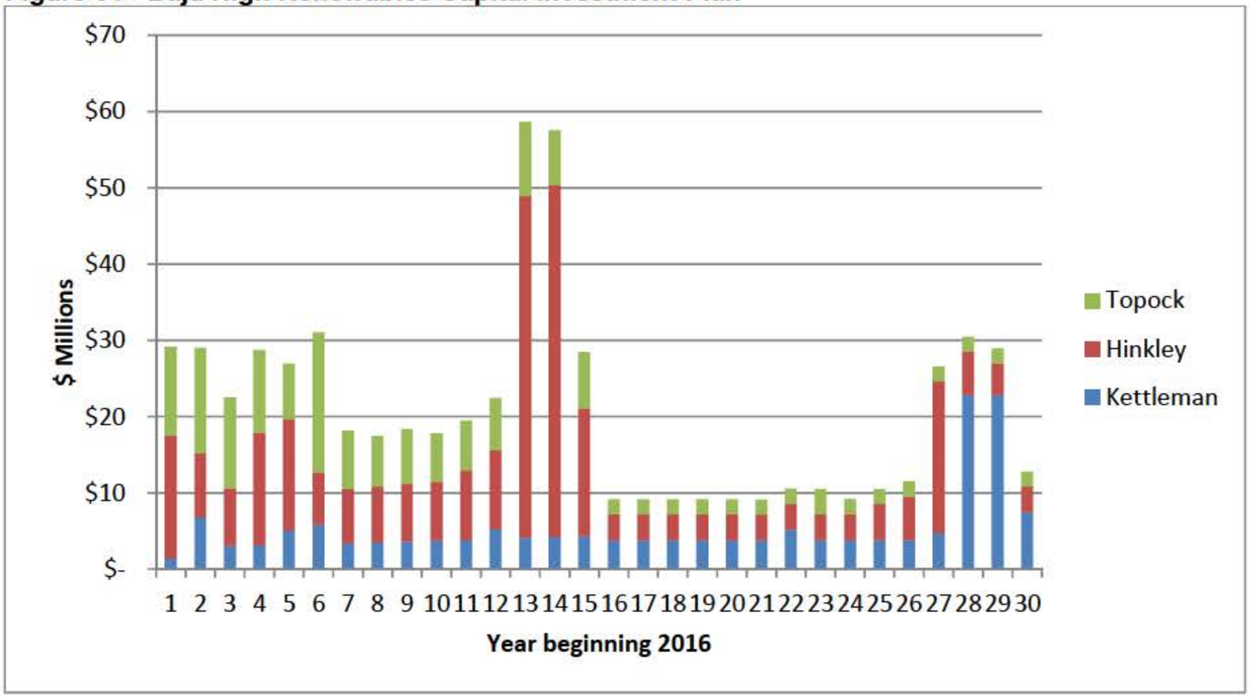
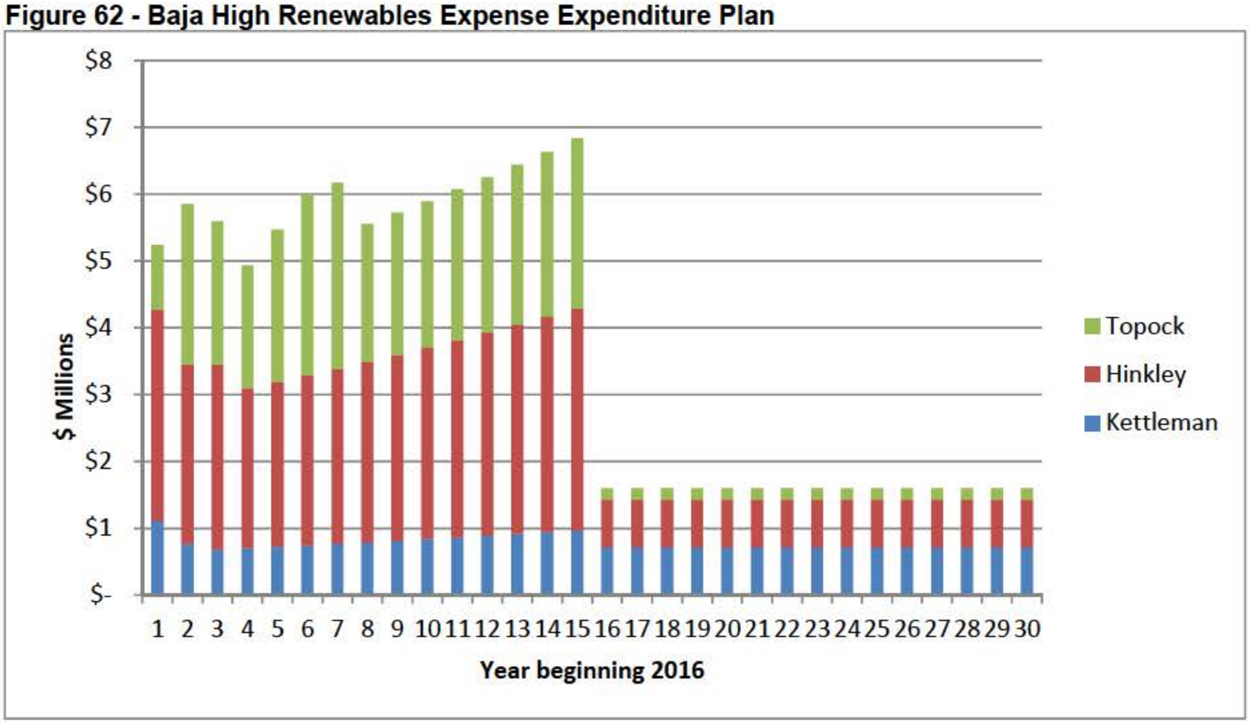


Figure 62 - Baja High Renewables Expense Expenditure Plan



4.3 Redwood Path

4.3.1 *Investment Design Criteria and Assumptions*

- Redwood Path remains the preferred pipeline
- No reduction in pipeline capacity
- No additional capacity required over the plan time frame based on selected forecast scenario
- Existing peak-day planning standards and slack backbone criteria remain unchanged
- Retain all units and stations; no changes in operation
- Maintain current utilization, reliability, and availability levels

4.3.2 *Redwood Path Investment Strategy – Status Quo*

Table 56 - Tionesta Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Tionesta	K-1	Maintain	Replace	Maintain
	Civil/Structural	Maintain	Replace	Maintain
	Compressed Air	Maintain	Replace	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Maintain	Replace	Maintain
	Fuel Gas	Maintain	Replace	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Replace	Maintain
	Power Gas	Maintain	Maintain	Replace
	Security	Maintain	Replace	Maintain

Table 57 - Burney Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Burney	K-2	Replace	Maintain	Maintain
	Civil/Structural	Replace	Maintain	Maintain
	Compressed Air	Replace	Maintain	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Replace	Maintain	Maintain
	Environmental	Replace	Maintain	Maintain
	Fire Detection/Suppression	Replace	Maintain	Replace

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
	Fuel Gas	Replace	Maintain	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Replace	Maintain	Maintain
	Power Gas	Maintain	Maintain	Replace
	Security	Maintain	Replace	Maintain

Table 58 - Gerber Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Gerber	K-1	Maintain	Maintain	Replace
	Civil/Structural	Maintain	Maintain	Replace
	Compressed Air	Replace	Maintain	Replace
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Maintain	Maintain	Replace
	Fuel Gas	Maintain	Replace	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Replace	Maintain
	Power Gas	Maintain	Maintain	Replace
	Security	Maintain	Replace	Maintain

Table 59 - Delevan Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Delevan	K-1	Maintain	Maintain	Maintain
	K-2	Maintain	Maintain	Maintain
	K-3	Maintain	Maintain	Replace
	Civil/Structural	Maintain	Maintain	Maintain
	Compressed Air	Maintain	Replace	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Maintain	Maintain	Replace
	Environmental	Maintain	Maintain	Maintain
	Fire Detection/Suppression	Maintain	Maintain	Replace
	Fuel Gas	Maintain	Maintain	Replace
	Gas System	Maintain	Maintain	Replace
	Lube Oil	Maintain	Maintain	Replace

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
	Power Gas	Maintain	Maintain	Maintain
	Security	Maintain	Maintain	Replace

Table 60 - Bethany Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Bethany	K-1	Maintain	Maintain	Replace
	K-2	Maintain	Maintain	Replace
	Civil/Structural	Maintain	Maintain	Maintain
	Compressed Air	Replace	Maintain	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	NA	NA	NA
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Maintain	Maintain	Replace
	Fuel Gas	Maintain	Replace	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Maintain	Replace
	Power Gas	Maintain	Maintain	Replace
	Security	Maintain	Replace	Maintain

4.3.3 Redwood Path Investment Plan – Status Quo

Figure 63 - Redwood Capital Investment Plan

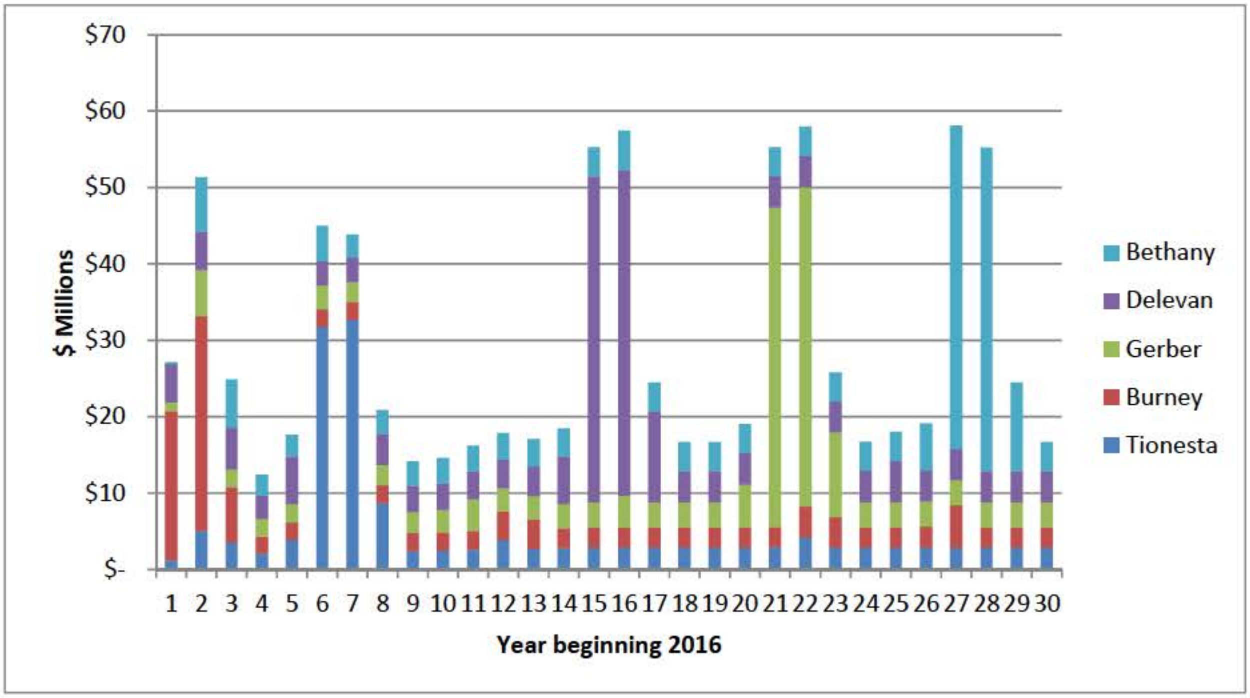
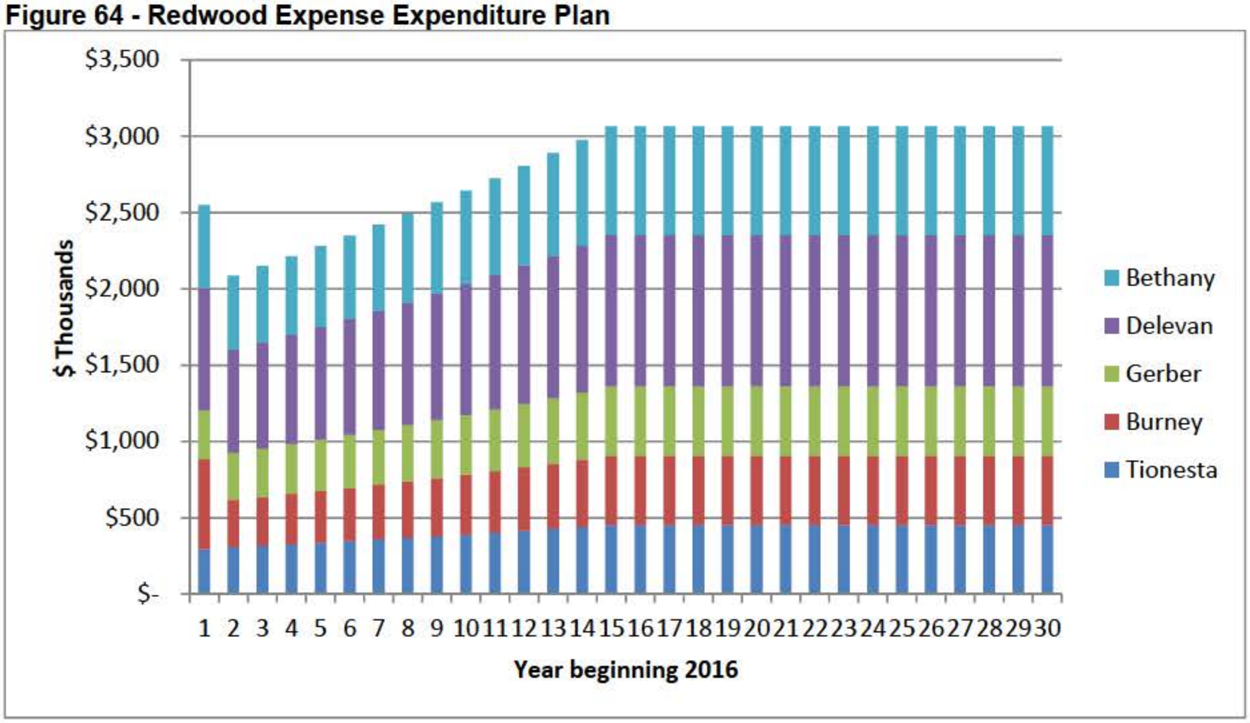


Figure 64 - Redwood Expense Expenditure Plan



5. Storage

PG&E owns and operates three underground storage fields: McDonald Island, Los Medanos and Pleasant Creek. The McDonald Island field, located near the city of Stockton, is the largest of PG&E's storage fields. The other two storage fields are smaller facilities. The Los Medanos facility is located near the city of Concord. The Pleasant Creek field is located near the city of Winters. Collectively, the storage facilities are known as Mission Path.

PG&E is also a minority partner (25 percent ownership) in the Gill Ranch Storage Facility. The facility is located near Fresno, California and is operated by Gill Ranch Storage Ltd. It was put into service in 2010 and connected to Line 401 approximately eight miles north of Panoche. The long term investment plan does not include forecasts of capital investments and expense expenditures for the Gill Ranch facility.

5.1 Forecast Scenario

There is currently an over-abundance of storage capacity in Northern California. In addition to storage services offered by PG&E and Gill Ranch Storage, LLC, there are three other storage providers in northern California – Wild Goose Storage, Inc.; Central Valley Gas Storage, LLC; and Lodi Gas Storage, LLC. The abundance of storage capacity coupled with the projected excess of natural gas supplies have contributed to a decline in the value of market storage services since 2010. Up until then, incremental investments in PG&E's gas storage facilities were made primarily to increase market storage service offerings.

In response, PG&E is currently evaluating a number of storage scenarios as a part of its 2018 Gas Transmission & Storage Rate Case filing. Some of the scenarios would require investment to improve injection capability, while others would entail decommissioning or selling existing storage assets. Until a business strategy for storage is finalized, the investment strategy developed for storage compression and used in this plan is focused on maintaining current levels of reliability of the compression assets used for injection and does not include investments to improve reliability or to increase injection capacity.

5.2 Investment Design Criteria and Assumptions

- No additional capacity required over the plan time frame
- Existing peak-day planning standards remain unchanged
- Retain all units, including leased units, at McDonald Island and Los Medanos
- Retire Pleasant Creek Station in 2042
- No changes in injection operations or requirements
- Maintain current utilization, reliability, and availability levels

5.3 Investment Strategy – Status Quo

Table 61 - McDonald Island Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
McDonald Island	K-1	Maintain	Replace	Maintain
	K-2	Maintain	Replace	Maintain
	K-7 (Leased Unit)	Maintain	Maintain	NA
	K-8 (Leased Unit)	Maintain	Maintain	NA
	K-9 (Leased Unit)	Maintain	Maintain	NA
	Civil/Structural	Maintain	Replace	Maintain

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
	Compressed Air	Replace	Maintain	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	Maintain	Replace	Maintain
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Replace	Maintain	Maintain
	Fuel Gas	Replace	Maintain	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Replace	Maintain
	Power Gas	Maintain	Replace	Maintain
	Security	Replace	Maintain	Maintain

Table 62 - Los Medanos Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Los Medanos	K-1	Maintain	Replace	Maintain
	Civil/Structural	Maintain	Maintain	Replace
	Compressed Air	Maintain	Replace	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	Maintain	Replace	Maintain
	Electrical	Maintain	Replace	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Maintain	Replace	Maintain
	Fuel Gas	Replace	Maintain	Maintain
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Replace	Maintain
	Power Gas	Maintain	Replace	Maintain
	Security	Maintain	Replace	Maintain

Table 63 - Pleasant Creek Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Pleasant Creek	K-1	Maintain	Maintain	Retire
	Civil/Structural	Maintain	Maintain	Retire
	Compressed Air	Maintain	Replace	Retire
	Controls	Replace	Maintain	Retire
	Cooling Water	Maintain	Maintain	Retire
	Electrical	Maintain	Maintain	Retire
	Environmental	Maintain	Replace	Retire
	Fire Detection/Suppression	Maintain	Maintain	Retire
	Fuel Gas	Maintain	Replace	Retire
	Gas System	Maintain	Maintain	Retire
	Lube Oil	Maintain	Maintain	Retire
	Power Gas	Maintain	Maintain	Retire
	Security	Replace	Maintain	Retire

5.4 Investment Plan – Status Quo

Figure 65 - Storage Compression Capital Investment Plan

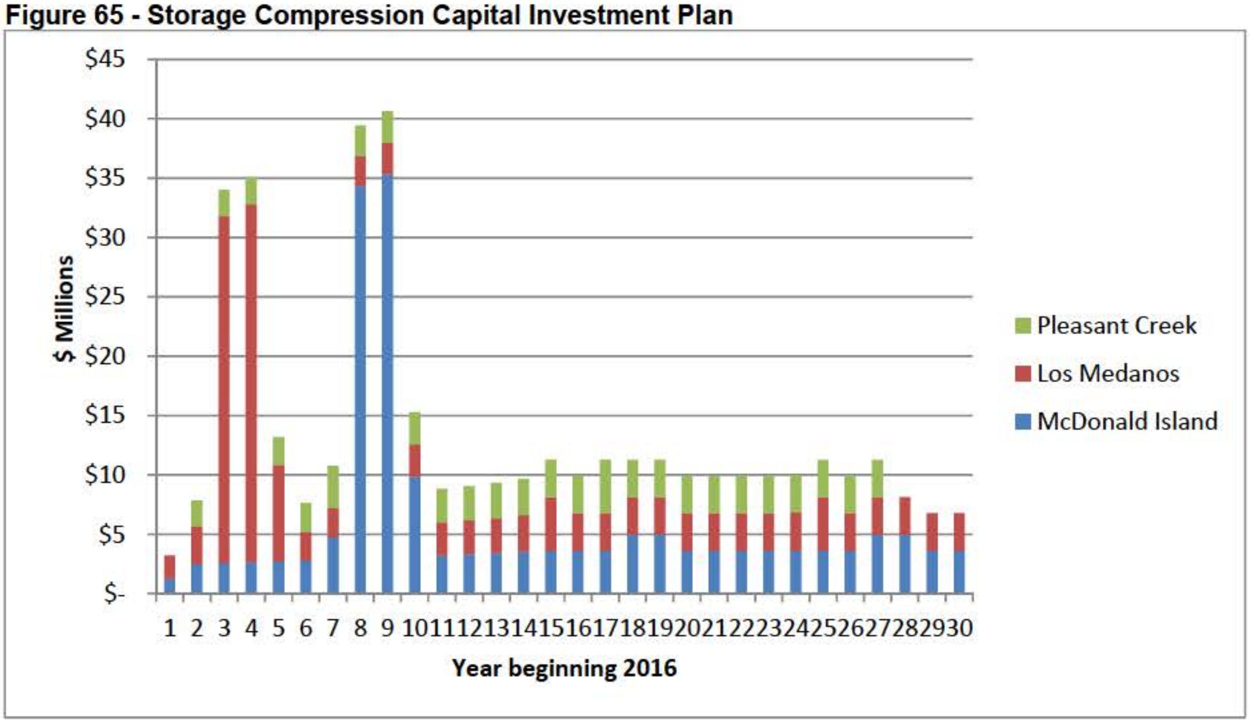
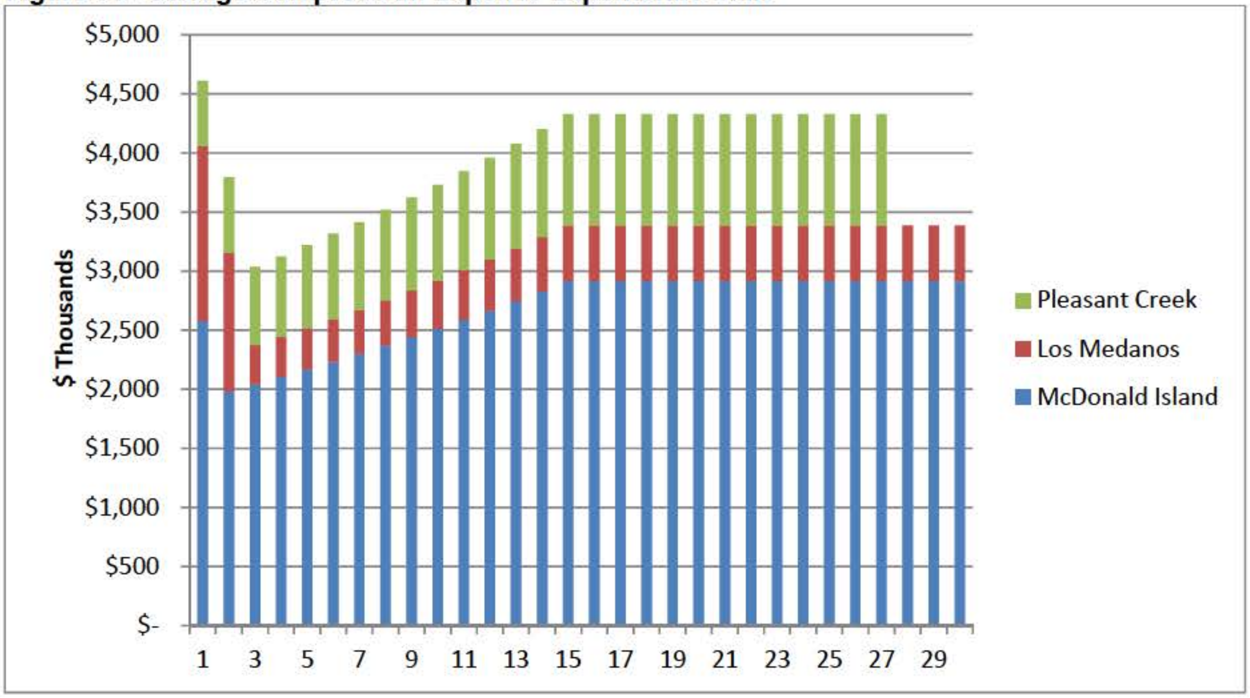


Figure 66 - Storage Compression Expense Expenditure Plan



6. Local Transmission – Santa Rosa Compressor Station

PG&E's local transmission system consists of non-backbone facilities with design operating pressure greater than 60 psig. The local transmission facilities include PG&E's non-backbone numbered transmission lines, distribution feeder mains and PG&E's six-sevenths interest in the Standard Pacific Gas Line (Stanpac), which PG&E owns jointly with Chevron Pipe Line Company. Currently Santa Rosa Compressor Station is the only local transmission station with compression assets. The station compresses gas from Line 21 and sends it north to supply the towns of Ukiah and Willits and other communities located at the northern extremity of Line 21. The station operates primarily during the winter months to help meet Cold Winter Day (CWD) gas demands.

6.1 Forecast Scenarios

Assume Status Quo scenario for Backbone Transmission. Gas Planning forecasts that this station will be required for the foreseeable future.

6.2 Investment Design Criteria and Assumption

- Existing peak-day planning standards remain unchanged over the plan time frame
- Station will continue to be required for CWD support
- Maintain current utilization, reliability, and availability levels

6.3 Investment Strategy – Status Quo

Table 64 - Santa Rosa Investment Strategy

Station	Unit / System	Near Term (2016 – 2020)	Mid-Term (2021 – 2030)	Long Term (2031 – 2045)
Santa Rosa	K-1	Maintain	Maintain	Replace
	K-2	Maintain	Maintain	Replace
	Civil/Structural	Maintain	Replace	Maintain
	Compressed Air	Replace	Maintain	Maintain
	Controls	Replace	Maintain	Replace
	Cooling Water	Maintain	Replace	Maintain
	Electrical	Replace	Maintain	Maintain
	Environmental	Maintain	Replace	Maintain
	Fire Detection/Suppression	Replace	Maintain	Maintain
	Fuel Gas	NA	NA	NA
	Gas System	Maintain	Replace	Maintain
	Lube Oil	Maintain	Maintain	Replace
	Power Gas	Replace	Maintain	Maintain
	Security	Replace	Maintain	Maintain

6.4 Investment Plan – Status Quo

Figure 67 - Santa Rosa Compressor Station Capital Investment Plan

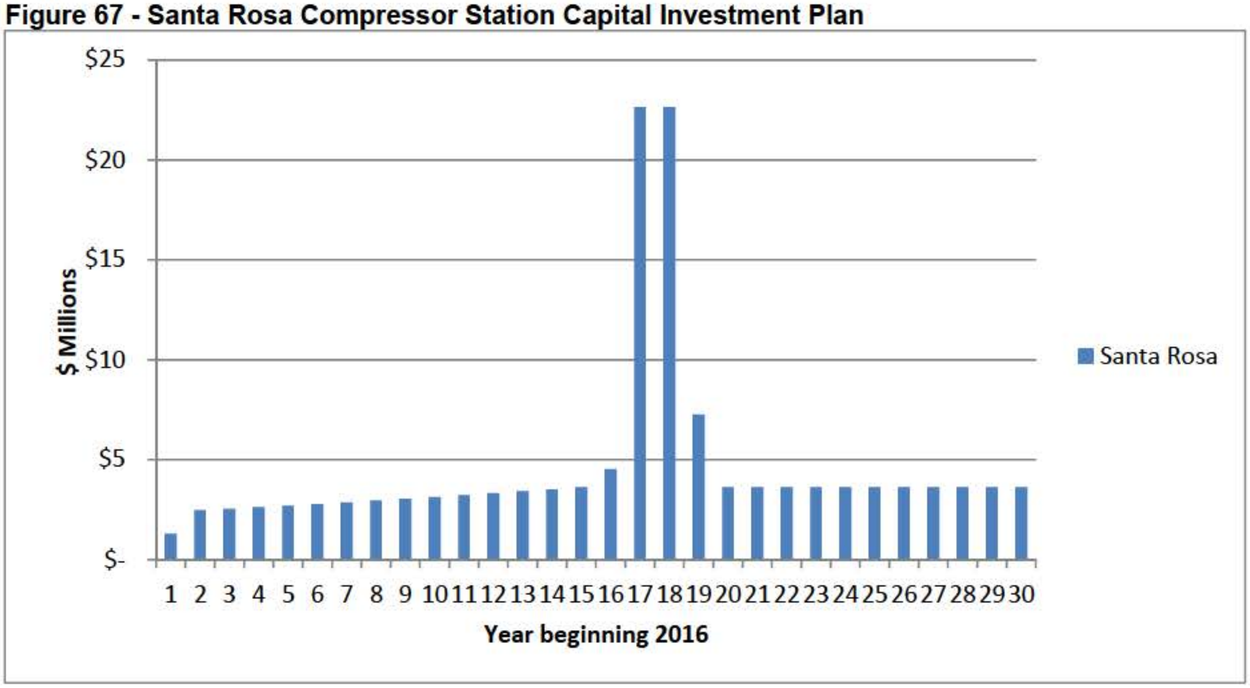
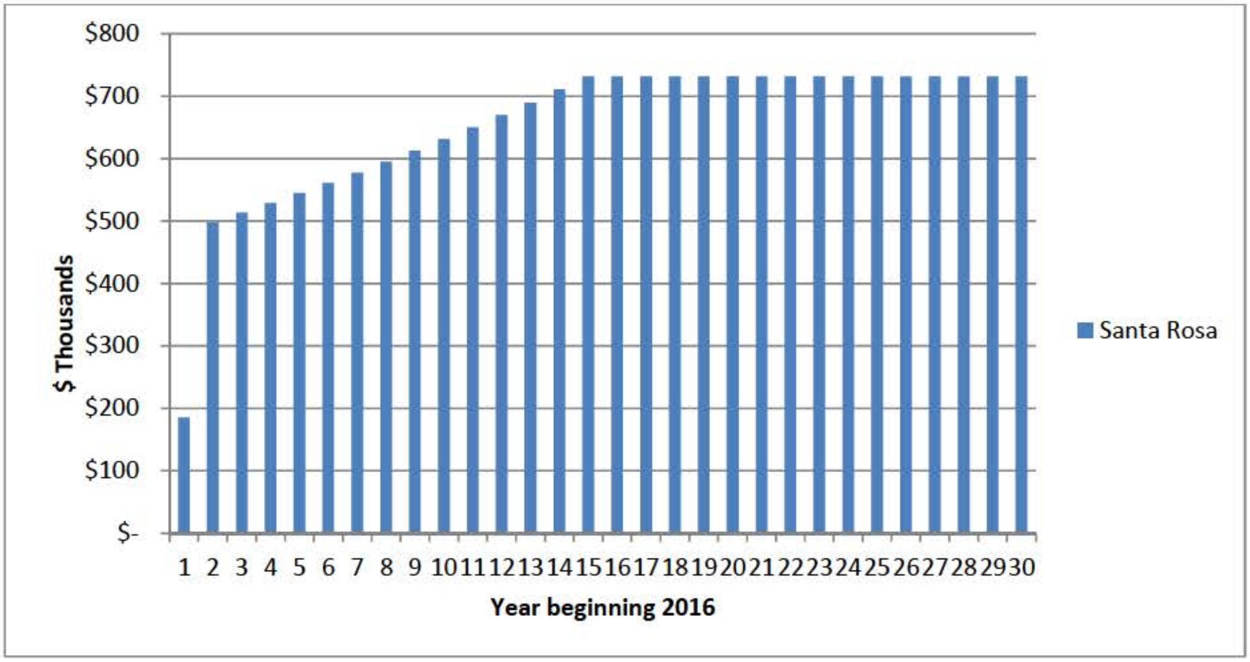


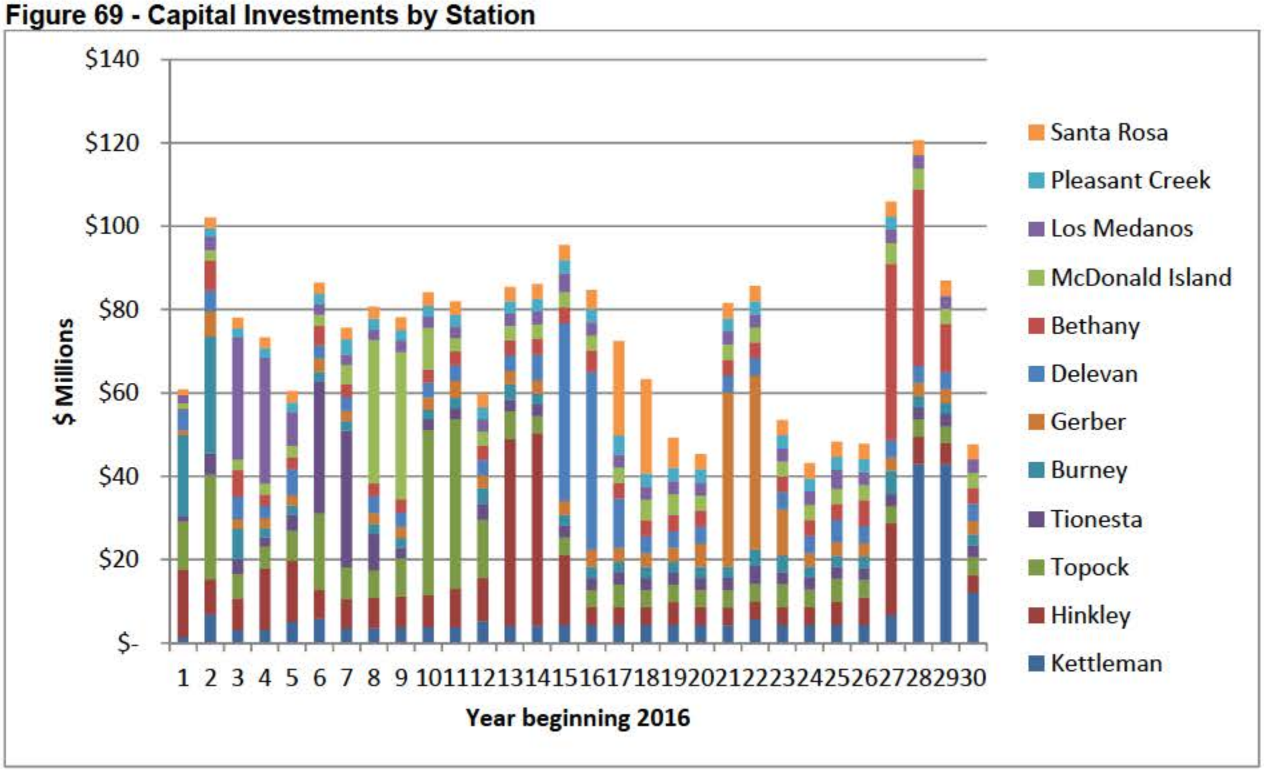
Figure 68 - Santa Rosa Compressor Station Expense Expenditure Plan



7. System Investment Plans – Status Quo

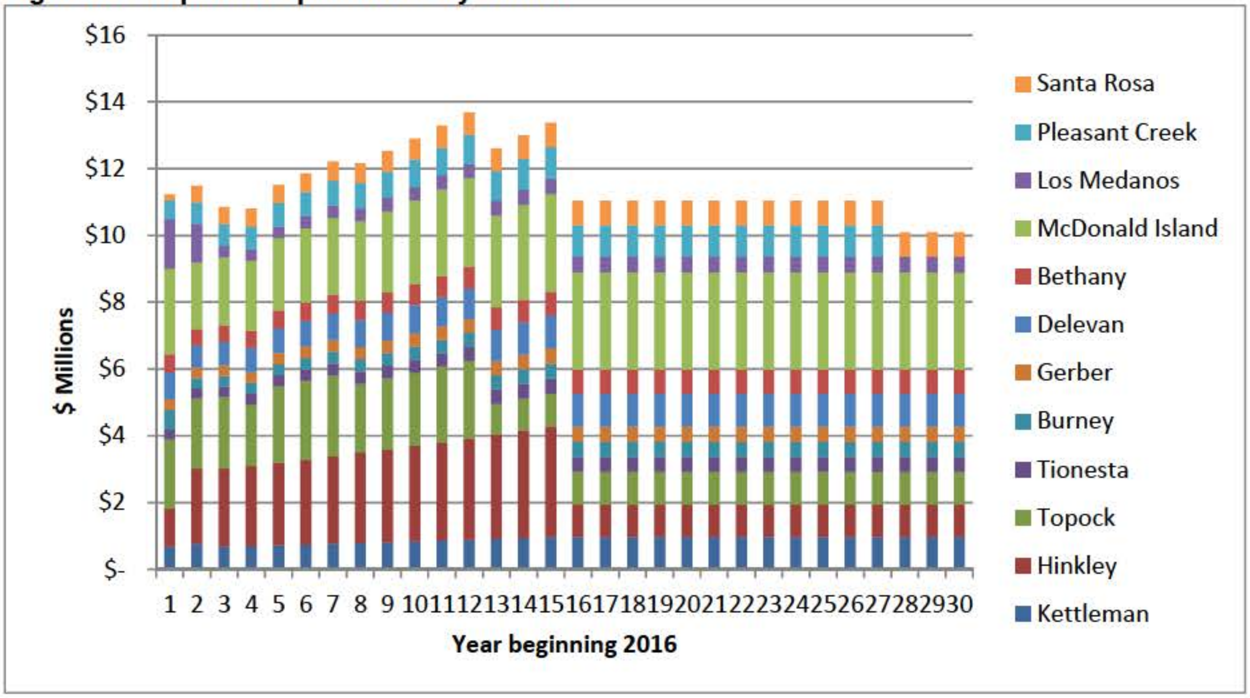
7.1 Capital Investment Plan

Figure 69 - Capital Investments by Station



7.2 Expense Expenditure Plan

Figure 70 - Expense Expenditures by Station



Part III – Plan Administration

8. Investment Strategy Review and Update

To ensure that the long term investment plan continually reflects best estimates of the future operating and business requirements for the compression assets, the forecasts and design criteria on which the investment strategy is reviewed annually and reaffirmed or adjusted if there are significant changes.

Review Team

- Facility Integrity Management Program & Technical Services (Plan Owner)
- Wholesale Marketing
- Gas Operations/Gas Planning
- Storage

Required Data

- Updated equipment/station condition health scores – FIMP&TS
- Equipment performance metrics – FIMP&TS
- Updated storage forecast – Storage/Wholesale Marketing and Business Development
- Updated planning studies or forecasts – Gas Planning
- New or changes in existing regulations that affect equipment – FIMP&TS
- Potential revenue opportunities – Wholesale Marketing and Business Development

Process Steps

- Review selected forecast scenario. Is it still the right scenario to use?
- Review individual path design criteria and assumptions – Reaffirm or adjust
- Update the Near Term strategy (1 – 5 years) to reflect outcome of completed work, budget decisions, resource constraints, etc.
- Reaffirm inputs. Look for:
    - Any significant shifts in asset management or risk mitigation strategies
    - Any significant shifts in the way paths or storage will be operated
    - Any major infrastructure or equipment installations proposed or completed
    - Any significant change in asset condition or health – catastrophic failure
    - Any new regulation or significant change in existing regulations
    - Any new revenue or business opportunities
- Make adjustments to Mid-Term and Long Term strategies as needed to reflect changes in inputs
- Make adjustments to the costs or timing of expenditures in the individual investment plans as needed

APPENDICES

Appendix	Title
A	Remaining Service Life Determination

Appendix A – Remaining Service Life Determination

Average System Age Scores by Compressor Station

To arrive at an average system age score for each compressor station, the 2014 Condition Assessment utilized a component age metric to first determine the expected life of major components making up the system. The component age metric represents the ratio of component age to its intended life expectancy. The metric is measured as shown below in the table below.

Table 65 - Component Age Scoring Criteria

Metric	Definition	Metric Score (1=good; 10=poor)				
		1	3	5	7	10
Component Age	Percent of component age vs. expected life of component	0-20%	21-40%	41-60%	61-80%	>80%

For the 2014 Condition Assessment, the determination of expected component life was based on the experience of various stakeholders and experts for various component types. The table below provides the list of expected life by component for the various components included in the condition assessment.

Table 66 - Component Expected Life

Component Type	System[1]	Lifespan[2]	Weighting Factor[3]	Class[4]	Class Large[5]	System Factor[6]
BOILER	Civil/Structural	20	0	1	3	0.5
CIVIL-BUILDING	Civil/Structural	60	0	1	3	0.5
FAN - CIVIL-BUILDING	Civil/Structural	60	0	1	3	0.5
FOUNDATION	Civil/Structural	60	0	1	2	1
HVAC	Civil/Structural	30	0	1	3	0.5
SUPPORTS	Civil/Structural	60	0	1	3	0.5
AIR RECEIVER	Compressed Air	50	0	1	3	0.5
COMPRESSOR	Compressed Air	20	0	1	2	1
DRYER	Compressed Air	20	0	1	2	1
FILTER	Compressed Air	30	0	1	3	0.5
SWITCH	Compressed Air	20	0	1	2	1
ANALYZER	Compressors	10	0	1	1	1.5
BLOWER	Compressors	30	0	1	2	1
COMPRESSOR	Compressors	60	0	1	1	1.5
ENGINE	Compressors	60	0	1	1	1.5
FAN	Compressors	30	0	1	3	0.5
FILTER	Compressors	30	0	1	3	0.5
MOTOR	Compressors	60	0	1	1	1.5
TURBINE	Compressors	40	0	1	1	1.5

Component Type	System[1]	Lifespan[2]	Weighting Factor[3]	Class[4]	Class Large[5]	System Factor[6]
TURBINE - PWR	Compressors	40	0	1	2	1
VFD	Compressors	20	0	1	1	1.5
COOLER	Compressors	50	0	1	3	0.5
ESD	Control	20	0	1	2	1
RTU / PLC	Control	15	0	3	1	1.5
SWITCH	Control	20	0	1	2	1
TRANSMITTER	Control	15	0	3	3	0.5
COOLER	Cooling Water	50	0	1	3	0.5
COOLING TOWER	Cooling Water	50	0	1	3	0.5
FILTER	Cooling Water	30	0	1	3	0.5
HEAT EXCHANGER	Cooling Water	50	0	1	3	0.5
PUMP	Cooling Water	40	0	1	2	1
TANK	Cooling Water	60	0	1	4	0
VALVE - ACTUATED	Cooling Water	30	0	1	3	0.5
ATS	Electrical	20	0	1	2	1
BATTERY	Electrical	10	0	3	2	1
COOLER	Electrical	50	0	1	3	0.5
GENERATOR	Electrical	40	0	3	1	1.5
RELAY	Electrical	10	0	1	1	1.5
SWITCHGEAR / MCC	Electrical	30	0	1	2	1
TRANSFORMER	Electrical	30	0	1	2	1
UPS	Electrical	10	0	3	2	1
WIRING / CABLE	Electrical	60	0	1	3	0.5
CIVIL-BUILDING	Environmental	60	0	1	1	0
CIVIL-OTHER	Environmental	60	0	1	1	0
HAZMAT-LABEL	Environmental	10	0	1	1	0
HAZMAT-STORAGE	Environmental	20	0	1	1	0
DETECTOR	Fire Detection / Suppression	20	0	1	1	0
EXTINGUISHER	Fire Detection / Suppression	40	0	1	1	0
FOAM	Fire Detection / Suppression	40	0	1	1	0
PUMP	Fire Detection / Suppression	40	0	1	1	0
TANK	Fire Detection / Suppression	60	0	1	1	0
DEHYDRATOR	Fuel Gas	40	0	1	3	0.5
FILTER	Fuel Gas	30	0	1	3	0.5
HEATER	Fuel Gas	30	0	1	3	0.5
METER - ORIFICE	Fuel Gas	30	0	1	3	0.5
METER - TURBINE	Fuel Gas	20	0	1	3	0.5

Component Type	System[1]	Lifespan[2]	Weighting Factor[3]	Class[4]	Class Large[5]	System Factor[6]
REGULATOR	Fuel Gas	30	0	1	2	1
SEPARATOR	Fuel Gas	30	0	1	3	0.5
VALVE	Fuel Gas	60	0	1	3	0.5
VALVE - ACTUATED	Fuel Gas	30	0	1	2	1
VALVE - RELIEF	Fuel Gas	30	0	1	3	0.5
ANALYZER	Gas	10	0	3	4	0
BOTTLE	Gas	60	0	3	4	0
COOLER	Gas	50	0	1	3	0.5
DEHYDRATOR	Gas	40	0.5	2	3	0.5
FAN	Gas	40	0	1	3	0.5
FILTER	Gas	30	0.5	2	3	0.5
HEATER	Gas	40	0	1	4	0
METER	Gas	30	0.5	2	3	0.5
METER - INSERTION	Gas	60	0.5	2	3	0.5
METER - ORIFICE	Gas	30	0.5	2	3	0.5
METER - ROTARY	Gas	20	0.5	2	3	0.5
METER - TURBINE	Gas	20	0.5	2	3	0.5
METER - ULTRASONIC	Gas	20	0.5	2	3	0.5
MONITOR	Gas	30	1	1	2	1
ODORIZER	Gas	20	0.5	2	2	1
PIPING	Gas	60	0	3	4	0
REGULATOR	Gas	30	1	1	2	1
SAMPLER	Gas	10	0	3	4	0
SEPARATOR	Gas	30	0.5	2	3	0.5
SUPPRESSOR - NOISE	Gas	60	0	3	4	0
VALVE	Gas	60	0	3	4	0
VALVE - ACTUATED	Gas	30	1	1	2	1
VALVE - CHECK	Gas	60	0	1	4	0
VALVE - RELIEF	Gas	30	0.5	2	3	0.5
COOLER	Lube Oil	50	0	1	2	1
FILTER	Lube Oil	30	0	1	2	1
HEATER	Lube Oil	30	0	1	2	1
LUBE SYS	Lube Oil	40	0	1	2	1
PUMP	Lube Oil	40	0	1	2	1
TANK	Lube Oil	60	0	1	3	0.5
DETECTOR	Security	20	0	1	1	0
FENCE	Security	30	0	1	1	0
GATE	Security	30	0	1	1	0

Component Type	System[1]	Lifespan[2]	Weighting Factor[3]	Class[4]	Class Large[5]	System Factor[6]
SIGN	Security	30	0	1	1	0
HYDRAULIC SYS	Storage	40	0	1	2	1
METER - ORIFICE	Storage	30	0	1	3	0.5
METHANOL SYS	Storage	40	0	1	2	1
REGULATOR	Storage	30	0	1	2	1
VALVE	Storage	60	0	1	4	0
VALVE - ACTUATED	Storage	30	0	1	2	1

Notes:

1. *System that a component is assigned to for scoring purposes*
2. *Lifespan is the expected component life used for the age metric.*
3. *Weighting factor applied to components at M&C facilities for station score*
4. *Class factor assigned to components for M&C stations for use in station score.*
5. *Class factor assigned to components for C&P facilities for system score.*
6. *Weighting factor applied to components at C&P facilities for system score.*

Applying the component metric and component life expectancies information, an average system score was developed for each system. Tables 67 through 70 below list the component age metric score for associated systems at each compressor station. The higher the score, the closer the system is to the end of its expected service life. A score of 1 indicates that the system has consumed 0 – 20% of its expected service life; a score of 10 indicates that it has consumed over 80% of its expected service life.

Table 67 - Average System Age Scores - Baja Path

Station / System	Kettleman	Hinkley	Topock
Gas System	9.7	10.0	9.6
Compressors	2.3	9.5	6.5
Compressed Air	10.0	10.0	10.0
Lube Oil	10.0	10.0	10.0
Fuel Gas	9.5	10.0	10.0
Power Gas	10.0	10.0	10.0
Cooling Water	N.A.	9.5	9.1
Control	9.5	10.0	10.0
Electrical	10.0	7.2	8.2
Fire Detection / Suppression	10.0	10.0	8.0
Civil / Structural	10.0	10.0	10.0
Security	10.0	10.0	8.8
Environmental	10.0	10.0	10.0

Table 68 - Average System Age Scores - Redwood Path

Station / System	Tionesta	Burney	Gerber	Delevan	Bethany
Gas System	4.6	4.8	5.1	1.8	4.5
Compressors	9.0	9.0	3.0	2.3	3.0
Compressed Air	8.8	8.8	8.8	2.7	8.8
Lube Oil	5.7	5.5	5.7	4.7	4.5
Fuel Gas	5.9	6.3	5.7	2.0	5.7
Power Gas	5.0	5.0	5.0	1.0	5.0
Cooling Water	N.A.	N.A.	N.A.	1.0	N.A.
Control	9.1	8.8	10.0	3.0	9.2
Electrical	7.2	6.9	7.7	3.6	7.4
Fire Detection / Suppression	4.6	4.3	3.4	3.0	4.3
Civil / Structural	3.0	7.0	3.0	1.0	3.0
Security	6.5	7.8	7.8	1.5	7.8
Environmental	7.7	7.7	7.7	3.0	7.7

Table 69 - Average System Age Scores - Storage

Station / System	Pleasant Creek	Los Medanos	McDonald Island
Gas System	3.9	7.1	8.3
Compressors	1.0	5.0	10.0
Compressed Air	4.6	5.5	10.0
Lube Oil	3.0	8.5	9.6
Fuel Gas	4.7	9.2	10.0
Power Gas	3.0	7.0	10.0
Cooling Water	3.0	8.0	9.4
Control	9.3	10.0	10.0
Electrical	3.0	7.7	9.7
Fire Detection / Suppression	N.A	6.7	10.0
Civil / Structural	3.0	5.0	7.0
Security	5.5	10.0	10.0
Environmental	6.7	8.3	9.0

Table 70 - Average System Age Scores - Santa Rosa

Station / System	Santa Rosa
Gas System	7.8
Compressors	7.0
Compressed Air	8.2
Lube Oil	1.0
Fuel Gas	10.0
Power Gas	N.A.
Cooling Water	9.2
Control	10.0
Electrical	9.7
Fire Detection / Suppression	10.0
Civil / Structural	7.0
Security	10.0
Environmental	9.0

Remaining Service Life

The average system age scores were next converted to years of remaining life by subtracting the expended life percentage based on the age metric (Table 65) from the expected life of the system. The expected life of the system is based on the expected life of the components making up that system (Lifespan column in Table 66). Where major components making up a system have different lifespans, the expected life of the system is based on the component with the largest system factor (System Factor column in Table 66). The remaining life for each of the compressor stations is provided in Tables 71 through 74 below.

Table 71 - Remaining Life (Years) - Baja Path

Station / System	Kettleman	Hinkley	Topock
Civil / Structural	6.0	6.0	6.0
Compressed Air	2.0	2.0	2.0
Compressors	26.8	4.7	10.0
Control	1.8	1.5	1.5
Cooling Water	N.A.	4.7	5.2
Electrical	4.0	7.7	6.4
Environmental	6.0	6.0	6.0
Fire Detection / Suppression	4.0	4.0	6.7
Fuel Gas	3.5	3.0	3.0
Gas System	17.1	3.0	3.5
Lube Oil	4.0	4.0	4.0

Station System	Kettleman	Hinkley	Topock
Power Gas	5.0	5.0	5.0
Security	3.0	3.0	4.2

Table 72 - Remaining Life (Years) - Redwood Path

Station System	Tionesta	Burney	Gerber	Delevan	Bethany
Civil / Structural	36.0	12.0	36.0	48.0	36.0
Compressed Air	2.8	2.8	2.8	12.6	2.8
Compressors	5.3	5.3	24.0	26.8	24.0
Control	2.0	2.1	1.5	3.0	1.9
Cooling Water	N.A.	N.A.	N.A.	32.0	N.A.
Electrical	7.7	8.4	7.1	21.6	7.5
Environmental	10.6	10.6	10.6	36.0	10.6
Fire Detection / Suppression	17.6	18.8	22.4	24.0	18.8
Fuel Gas	9.3	8.1	9.9	21.0	9.9
Gas System	13.2	12.6	11.7	21.6	13.5
Lube Oil	13.2	10.5	13.2	17.2	18.0
Power Gas	20.0	20.0	20.0	40.0	20.0
Security	7.5	5.2	5.2	22.5	5.2

Table 73 - Remaining Life (Years) - Storage

Station System	Pleasant Creek	Los Medanos	McDonald Island
Civil / Structural	36.0	24.0	12.0
Compressed Air	8.8	7.0	2.0
Compressors	32.0	16.0	4.0
Control	1.9	1.5	1.5
Cooling Water	24.0	6.7	4.8
Electrical	24.0	7.1	4.4
Environmental	13.8	9.4	8.0
Fire Detection / Suppression	N.A	9.2	4.0
Fuel Gas	12.9	3.8	3.0
Gas System	15.3	5.9	4.7
Lube Oil	23.6	6.0	4.5
Power Gas	30.0	10.0	5.0

Station / System	Pleasant Creek	Los Medanos	McDonald Island
Security	10.5	3.0	3.0

Table 74 - Remaining Life (Years) - Santa Rosa

Station / System	Santa Rosa
Civil / Structural	12.0
Compressed Air	3.2
Compressors	8.0
Control	1.5
Cooling Water	5.1
Electrical	4.4
Environmental	8.0
Fire Detection / Suppression	4.0
Fuel Gas	3.0
Gas System	5.2
Lube Oil	32.0
Power Gas	N.A.
Security	3.0