GP-1108 - Gas Storage 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 Gas Storage 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.

On October 23, 2015, a leak was detected at Southern California Gas Company's (SoCal Gas) Aliso Canyon underground storage facility and was permanently plugged on February 18, 2016. During the leak on January 6, 2016, the California Governor issued a state of emergency through a proclamation with 14 directives. The Division of Oil, Gas, and Geothermal Resources (DOGGR) then issued Emergency Regulations (Requirements for Underground Gas Storage Projects, California Code of Regulations Title 14, Division 2, Chapter 4, Subchapter 1, Article 3, Section 1724.9) based on the Governor's Emergency Proclamation Directive #13 with an effective date of February 5, 2016. As of the writing of this Asset Management Plan, PG&E has completed five of the seven items included in the DOGGR Emergency Regulations. The pending two items on track for completion in August 2016 include developing supporting documentation for pressure limits and a risk management plan which incorporates PG&E's current risk and integrity management procedures and processes (refer to Appendix J for more details). Pending DOGGR permanent regulation and Senate Bill 887 are anticipated to be issued in the coming months which may impact operations. The consequences of the SoCal Gas incident led PG&E to update the impact scores of a loss of well integrity risk; however, has not changed PG&E's likelihood of risk.

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 including continued research and development of new technologies to mitigate and reduce these risks. Beyond the physical assets, the plan considers the impact on support areas such as training and guidance documents.

This asset management plan is consistent with the Strategic Asset Management Plan, the guidance document for the development of asset management plans.

1.1 Asset Overview

PG&E owns and operates the following three underground gas storage fields:

1. McDonald Island – San Joaquin County
2. Los Medanos – Contra Costa County
3. Pleasant Creek – Yolo County

The Gas Storage asset management plan looks at the following assets within these underground gas storage fields:

Table 1 - Primary Gas Storage Assets

Physical Asset	Quantity
Storage Wells*	117
Transmission Pipe (miles)**	14
Downhole Safety Valves	89
Uphole Safety Valves	217
Well Meters	191
Storage Reservoirs (Acres)	3,404

* Includes 200 miles of casing and tubing
** Includes 2.5 miles in High Consequence Areas (HCAs)

PG&E also has a 25% interest in the Gill Ranch Storage Field; however this plan does not assess these assets, but directs PG&E to continue to work with Gill Ranch Storage Limited to operate, assess and maintain the assets utilizing a risk-based asset management approach. The DOGGR Emergency Regulations set criteria and require each Storage operator to develop and submit a Risk Management Plan. PG&E has been benchmarking with Gill Ranch on these efforts.

The transmission pipe and surface equipment (including wellhead measurement and flow controls) included in this asset family are managed utilizing the Transmission Integrity Management Program (TIMP) and Facility Integrity Management Program (FIMP) like those assets in the Transmission Pipe, Compression & Processing, and Measurement & Control asset families. Detailed information about these programs is included in the respective asset management plans.

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. Alignment with LoS goals is presented in Section 4. After analyzing asset risk and condition within the LoS framework, a high-level Storage strategic objective is listed with more specific objectives related to different asset types as follows:

1. **Asset Management -** Effective and efficient asset management of gas storage facilities to identify the right work and to optimize the condition of our assets based on prioritization of risk.
    - Complete baseline well production casing assessments by 2025.
    - Evaluate Well Integrity Management Plan (WELL) enhancements and incorporate by 2017.
    - Assess work on transmission pipe through TIMP by 2017.
    - GPOM, FIMP, and Reservoir Engineering identify, prioritize, and develop a plan to complete open corrective work by 2017.
2. **Process Safety -** Ensure safe design, operations, maintenance, and execution of right work through the integration of process safety in the gas storage facilities.
    - Continue Process Hazard Analysis (PHA) and Pre-Startup Safety Reviews (PSSR) on all well, surface equipment, and pipeline in the storage asset family.

- Conduct annual emergency response drills which incorporate Well Control Tactical Considerations Plan in Gas Emergency Response Plan and participate in Gill Ranch emergency response drills by the end of 2017.

3. **Facility Performance -** Foster a culture of continuous improvement to optimize facility performance and risk reduction through design, operations, maintenance, and execution of the right work.
    - Gas Operations continue to evaluate proposed regulatory and legislative initiatives and its impact on facility performance and risk reduction mitigations.
4. **Capacity -** Meet system and customer storage capacity needs by optimizing short and long-term performance through the use of operational and maintenance procedures and workforce involvement.
    - Gas Operations continue to evaluate capacity requirements from storage to meet system needs and balancing risk reduction mitigations and reliable projects executed in 2017-2020.
    - Continue to conduct full field maximum flow tests annually and publish results.
    - Continue to conduct individual well flow tests annually and publish results.
5. **Compliance -** Satisfy commitments with regard to Integrity Management, Accounting and Environmental regulations by achieving no violations through auditing processes and procedures.
6. **Data -** Improve data quality, availability, and accessibility to enhance risk analyses and decision-making, moving from solely Subject Matter Expert input to more data informed.
    - Develop and implement Gas Storage Asset Management Systems (GSAMS) and Asset Health Scorecard (AHS) data to enhance risk analysis on well assets for 2019 Session D.
7. **Training** - Recruit, retain, and train a qualified and motivated workforce (employees and contractors) through identifying the needed training and developing line of progression for the operation and maintenance of the storage facilities.
    - Identify, analyze, and implement 5-year training/development profiles for Reservoir Engineering by 2016.
    - Review, revise, and develop operator training for storage well operations by 2018.

1.3 Asset and Data Condition

The current condition of Gas Storage assets has been qualitatively assessed by subject matter experts. One of the strategic goals is move toward more data informed assessment. A roadmap (Appendix K) has been developed to illustrate how data improvement programs and existing programs work towards utilizing more data informed decisions. Currently, data for this asset family is limited in terms of organization and accessibility to support quantitative analysis of asset condition and risk. Specific areas that have received focus include internal corrosion of the transmission pipe in the Storage asset family and internal/external corrosion of the storage well surface and production casing. Further, the ability to collect, organize, and monitor the impact on risk reduction and tracking metrics are part of the programs such as the Asset Health Scorecard (AHS) and Gas Storage Asset Management Systems (GSAMS). Enhancing data collection and accessibility is an area of focus in this plan to improve decision making going forward.

1.4 Key Risks

This asset management plan takes a risk-based approach to managing the asset to reduce risk. Proposed programs of work are risk scored with a process for prioritization across all asset families in an effort to implement programs that provide the greatest risk reduction

Gas Operations identifies risks for each asset family. For each threat (as defined in ANSI B31.8S), risk drivers and risks are identified for each asset family based on available data and SME input. The result of this process is a set of Gas Operations risks as shown 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 are defined as factor(s) that could cause risk to occur. These risks are defined with a significant degree of granularity. From an asset family basis, risks are defined and discussed in the Asset Management Plans based on the risks defined here.

PG&E also defines risks at the enterprise level. The enterprise level assessment ensures that all lines of business have risks defined at a consistent basis for enterprise level decision-making. For the enterprise assessment, the Gas Operations risks are consolidated or rolled-up to provide a higher level of risk definition consistent with all PG&E lines of business. The development of the Gas Operations enterprise risks is performed by treating the Gas Operations risks as "risk drivers" to develop higher level enterprise risks. Therefore, the enterprise risks incorporate many of the "risk drivers" (or risks from the Gas Operations histogram).

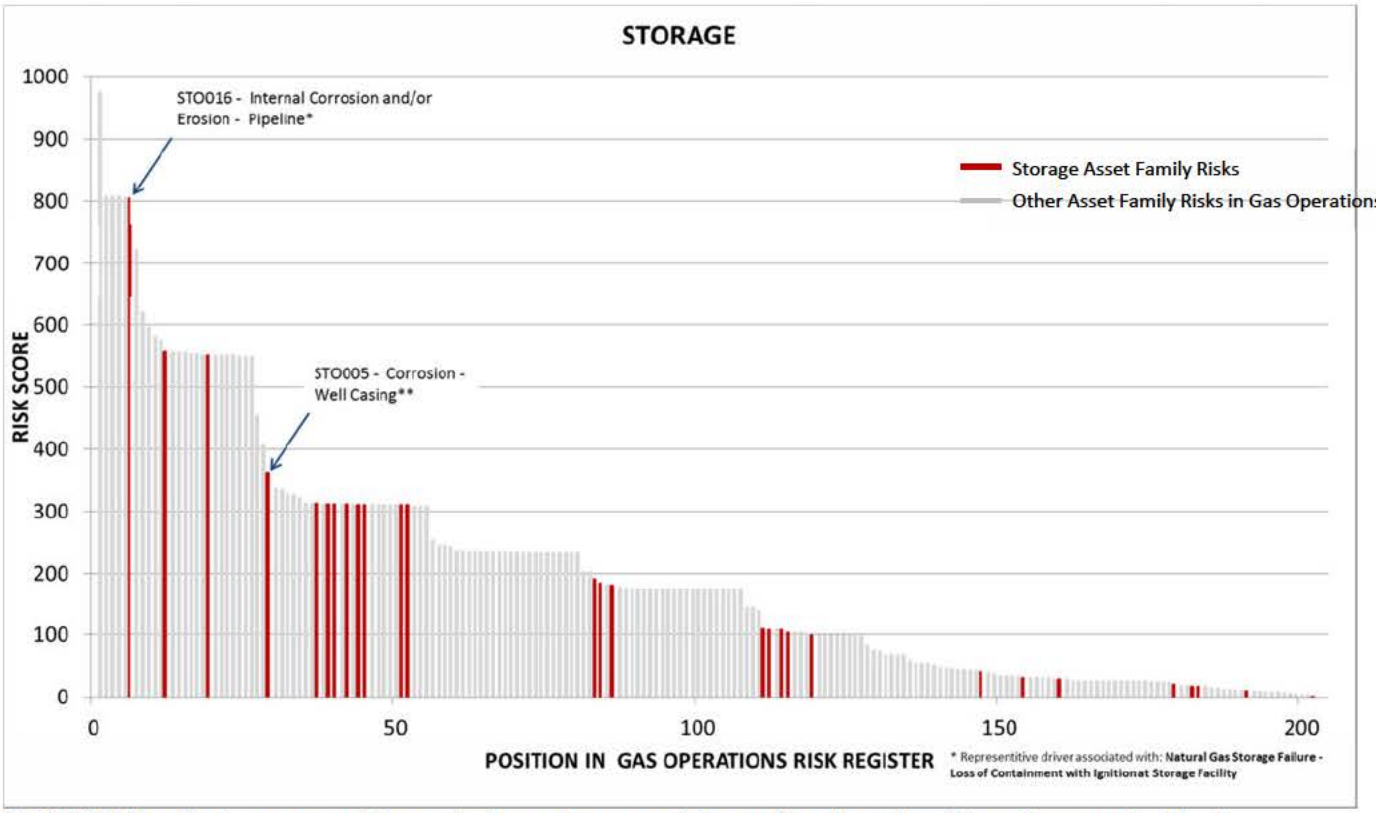
This asset management plan is based on the risks developed for Gas Operations. The enterprise risk and risk drivers for the Storage asset family are shown below:

Table 2 - Enterprise Risk for Storage Asset Family

Enterprise Risk	Risk Drivers
Natural Gas Storage Failure - Loss of Containment with Ignition at Storage Facility	STO016 – Internal Corrosion and/or Erosion – Pipeline
	STO017 – External Corrosion – Pipeline
	STO026 – Weather and Outside Forces – Seismic
	STO005 – Corrosion – Well Casing
	STO020 – Manufacturing – Pipeline
	STO015 – Erosion – Valves
	STO012 – Equipment – Meters
	STO018 – Fatigue – All Segments
	STO037 – Internal Corrosion and/or Erosion – Pressure Vessels
	STO030 – 1st, 2nd, 3rd Party Damage – All Segments
	STO003 – Construction by 1st & 2nd Party – Reservoir
	STO019 – Third Party Damage – Pipeline

The histogram below in Figure 1 displays the position of the Gas Storage asset family risks (red) within the Gas Operations risk register. Of the 204 Gas Operations Risks, the highest Storage risk (STO016) is ranked sixth.

Figure 1 - Gas Operations Risk Profile



** STO005 reflects rescored impacts based on new information from the Aliso Canyon incident.

The key identified Gas Storage risks, briefly described in Table 3, are derived based on a risk score that considers the likelihood and consequence of failure. The risks highlighted below are the highest among multiple threats that have been identified across the Gas Storage assets. The full extent of risks identified is addressed in detail in Appendix C.

1.5 High Level Program Overview

The asset management plan focuses on managing and reducing risk in the most efficient and effective manner possible. As the plan matures, focus on optimizing risks, performance and costs will continue to be strengthened. Proposed programs involve both capital and expense funding and in some cases address more than one area of risk. Detailed descriptions of the scope of each program are found in Section 4. The pace, trajectory, and scope for these proposed programs align with the submittals included in the Gas Transmission and Storage Rate Case.

The primary mitigations used to reduce risk are shown in Table 3 along with a metric to track progress.

Table 3 - Key Gas Storage Threats and Risks

Threat	Risk ID	Asset Type	Risk Description	Primary Mitigation	Mitigation Metric
Internal Corrosion and/or Erosion	STO016	Pipeline	Rupture of pipeline due to internal corrosion and/or erosion may result in loss of containment, and/or uncontrolled gas flow that may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage and/or environmental damage.	Internal Corrosion Site Specific Plan	Development of site specific internal corrosion and erosion monitoring and assessment plans and Storage 10 Year Pipe Plan
External Corrosion	STO017	Pipeline	Rupture due to external corrosion of the pipeline which may result in the loss of pipeline isolation and access as well as an uncontrolled flow or lost production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Assessment Pressure Test	Leaks on pipeline due to external corrosion and development of Storage 10 Year Pipe Plan
Weather and Outside Forces (Seismic)	STO026	All Segments	Loss of withdrawal platform, buildings and equipment due to seismic activity/earthquake that may result in the loss of containment or ability to provide storage service. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage.	Pilot Seismic Assessment Program Condition Assessment Program	Progress of Pilot Seismic Assessment Program

Threat	Risk ID	Asset Type	Risk Description	Primary Mitigation	Mitigation Metric
Corrosion	STO005	Well Casing	Loss of well integrity due to well casing corrosion (internal, external, or stress corrosion cracking) that may result in an uncontrolled flow of gas outside of well casing with ignition source, drinking water contamination, gas migration, or gas loss. This may lead to major impact on public or employee safety, facility outage or net replacement of supply, property damage and/or environmental damage.	Casing Inspections	% of completed vs. planned well baseline assessments by 2025
Manufacturing	STO020	Pipeline	Rupture of pipeline due to manufacturing may result in loss of containment, and/or uncontrolled gas flow that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Assessment Pressure Test	Development of Storage 10 Year Pipe Plan
Erosion	STO015	Valves	Erosion of valves may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Preventive Maintenance	Corrective vs. Preventive Maintenance
Equipment	STO012	Meters	Compromised measurement may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Preventive Maintenance	Corrective vs. Preventive Maintenance

Threat	Risk ID	Asset Type	Risk Description	Primary Mitigation	Mitigation Metric
Fatigue	STO018	All Segments	Failure of pipeline, equipment, and pipeline controls due to fatigue from internal pressure cycling or vibration may result in loss of containment. This may lead to significant impact on public or employee safety, outages, property damages and/or environmental damage.	Assessment Pressure Test	Development of Storage 10 Year Pipe Plan
Internal Corrosion and/or Erosion	STO037	Pressure Vessels	Through wall leaks in pressure vessels due to internal corrosion and/or erosion that may result in uncontrolled flow of gas. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or environmental damage.	Internal Corrosion Site Specific Plans	Development of site specific internal corrosion and erosion monitoring and assessment plans
1st, 2nd, 3rd Party Damage	STO030	All Segments	Rupture of belowground pipeline or uncontrolled flow from other storage assets due to 1st, 2nd, and 3rd Party damage caused by equipment/vehicles who may not have followed work procedures that may result in uncontrolled flow of gas, outages or replacement of gas supply. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or minor environmental damage.	Public Awareness & Damage Prevention	Dig-ins at Storage facilities

Threat	Risk ID	Asset Type	Risk Description	Primary Mitigation	Mitigation Metric
Construction by 1st & 2nd Party	STO003	Reservoir	Loss of reservoir integrity due to 1st and 2nd party drilling through storage field or reworking 1st and 2nd Party well that may result in an improper completion of the well or uncontrolled flow or loss containment with ignition source that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Guidance Documents (Drilling / Completion Design Standards and Process Safety Management)	PHAs conducted and PSSRs conducted
Third Party Damage	STO019	Pipeline	Rupture of pipeline due to mechanical damage by 3rd party may result in the loss of pipeline isolation and access as well as uncontrolled flow and loss in production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Public Awareness & Damage Prevention	Dig-ins at Storage facilities

2. Asset Inventory and Condition Overview

2.1 Asset Overview

The physical assets in the Storage asset family include all PG&E owned and operated underground gas storage fields and associated equipment installed system-wide. The different asset types that comprise the Storage asset family is listed in Table 4.

Table 4 - Asset Overview

Asset	Description
McDonald Island	- Storage Reservoirs - Storage Wells - Transmission Pipe - Surface Equipment
Los Medanos	
Pleasant Creek	
Gill Ranch	PG&E has a 25% interest stake and Gill Ranch Ltd owns the additional 75% and operates the field

The total design working gas capacity of the three PG&E-owned fields is 102 Bcf. They are designed for a maximum withdrawal capacity of 2,150 MMcf/D. The total design maximum injection capacity is 557 MMcf/D. The design maximum field pressure of the three fields ranges from 1,250 psig to 2,070 psig.

Assets within Gas Storage are grouped into four asset sub-categories:

1. Storage Reservoirs
2. Storage Wells
3. Transmission Pipe
4. Surface Equipment

A statistical summary of assets, broken down for each individual storage field can be seen in Table 5. This summary includes assets from other asset families in order to provide a complete view of the assets used by PG&E to provide storage services.

Regulations for the safety, construction, operations, and maintenance of the surface and pipeline up to the wellhead assets are under the jurisdiction of the California Public Utility Commission (CPUC). The reservoir and storage wells are under the California Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR). Many other federal, state, and local agencies also have authority to regulate.

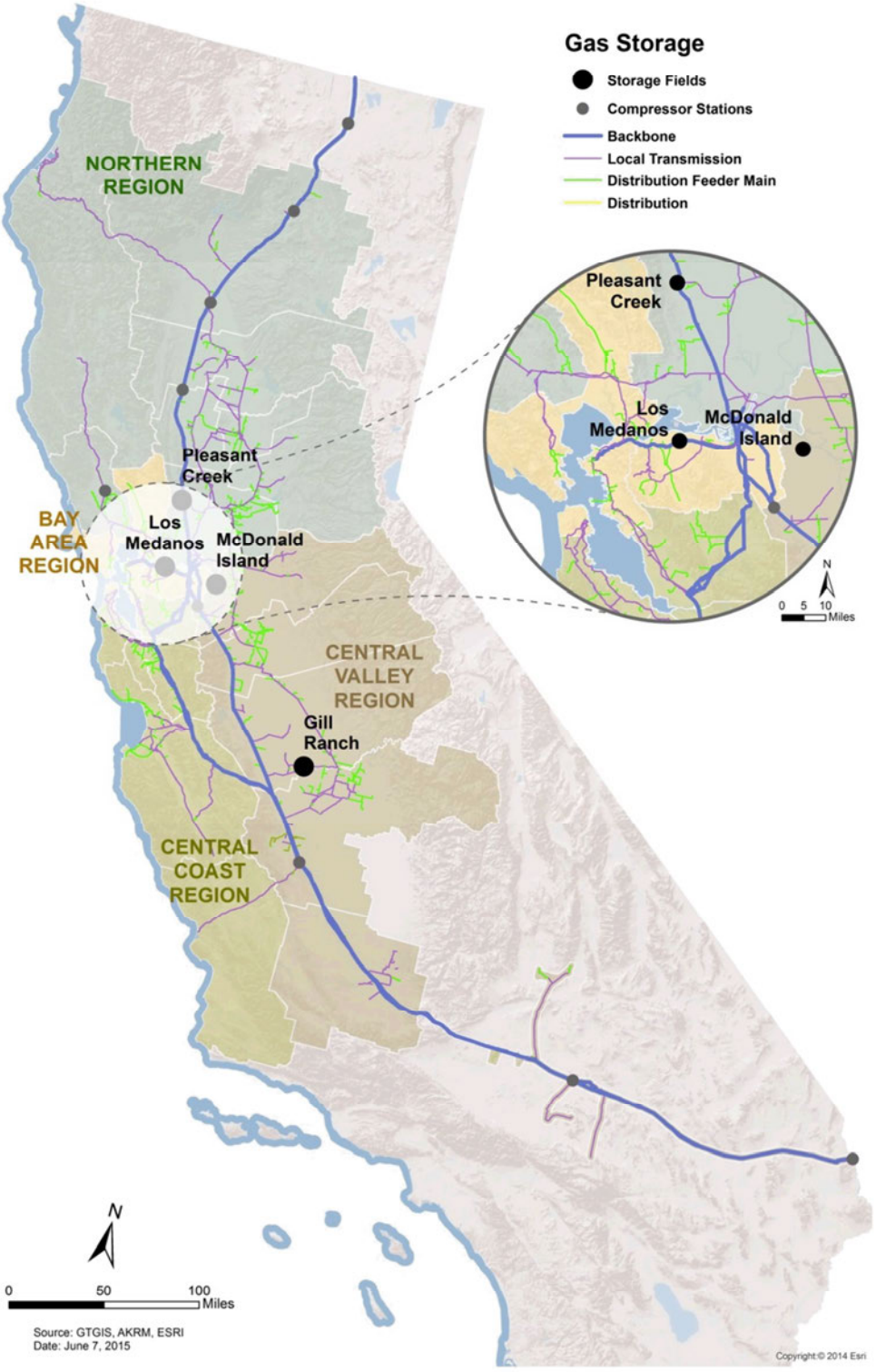
Table 5 - PG&E Storage Field Statistical Summary

Description of Statistic	McDonald Island (operated)	Los Medanos (operated)	Pleasant Creek (operated)	Gill Ranch (non-operated) [1]
Operator	PG&E	PG&E	PG&E	Gill Ranch
Location-County	San Joaquin	Contra Costa	Yolo	Madera/Fresno
Discovery Date	1936	1958	1948	1942/1957
Year Placed in Storage Service	1975	1973	1960	2010
Number of Injection and/or Withdrawal (I/W) Wells	81	21	7	12
Number of Observation Wells	7	1	-	7
Number of Salt Water Disposal (SWD) Wells	-	-	-	1
Compressor Units	5	1	1	5
Compression Horsepower (bhp)	12,256	3,733	749	45,000
Discovery Pressure-Wellhead (psig)	2,086	1,599	1,268	2,320 - 2,425
Discovery Pressure-Bottom Hole (psia)	2,365	1,774	1,367	2,610 - 2,777
Max Storage Pressure-Wellhead (psig)	2,070	1,600	1,250	3,179
Max Storage Pressure-Bottom Hole (psia)	2,365	1,774	1,353	3,655
Facility MAOP (psig)	2,160	1,800	1,300	3,150
Facility MOP (psig)	2,160	1,610	1,260	3,150
Cushion Gas (Bcf)	54.5	11.2	5.1	3.5
Working Gas (Bcf)	82	17.9	2.3	20
Total Inventory (Bcf)	136.5	29.1	7.4	23.5
Max Withdrawal (MMcf/d)	1,680	400	70	650
Max Injection (MMcf/d)	400	125	32	400
Reservoir Depth (feet)	5,200	4,100	2,800	5,700-6,300
Areal Extent (acres)	2,760	244	400	5,020
Number of Downhole Safety Valves (DHSV)	68	21	-	-
Number of Uphole Safety Valves (UHSV)	162	41	14	24
Miles of Production Casing / Production Liner/ Scab Liner	97.8	18.7	4.0	16.9
Miles of Production Tubing	90.5	17.5	4.2	14.7
Miles of Transmission Pipe in Storage Asset Family[2]	10	2	2	-
Miles of High Consequence Area (HCA) Transmission Pipe in Storage Asset Family[2]	2.5	-	-	-
Number of Well Meters	149	21	21	16

[1] Gill Ranch capacities listed are 100% of facility (PG&E owns 25%).
[2] Transmission pipe within the Storage asset family transport storage gas from storage wells, not production wells. Therefore there are no gathering lines within the Storage asset family.

A map of the four storage facilities is displayed in the figure below.

Figure 2 - Map of Gas Storage Asset Family



2.2 Asset Inventory and Condition

The availability of asset condition data varies across asset types within Gas Storage. An effort is underway to improve data collection and data accessibility via the Gas Storage Asset Management Systems (GSAMS) and the Asset Health Scorecard, which are discussed in further detail in Section 2. Section 4 contains details of programs and objectives that maintain and improve reservoir health. Asset inventory and condition is detailed by asset type in the following sections, including 2016 targets and 2015 results. A dashboard of condition from the Asset Health Scorecard with preliminary results can be found in Appendix H.

2.2.1 Storage Reservoirs

PG&E stores gas in storage reservoirs at McDonald Island, Los Medanos, and Pleasant Creek. Reservoir condition is assessed via percent gas migration, with an annual goal of 0% from the reservoirs ensuring that gas recorded as being in storage fields is confined to the storage reservoir (as shown in the table below).

Table 6 - Storage Reservoir Condition Data

Description	Gas Migration from Reservoirs
Assessment Method	Pressure Volume Hysteresis, Shut-In Testing
Frequency	Semi-Annually (Report issued annually in November)
2016 Target	0%
2015 Results	0%

Reservoirs are assessed using a combination of the storage well condition and operation data. The following assessments are used to determine the condition of storage well surface casing:

- **Well integrity:** Indicates if a storage well does not provide a conduit for gas loss or migration
- **Reservoir pressure, volume and fluid monitoring:** Provides an indication of gas loss, migration, and the influence operations have on the storage reservoir

2.2.2 Storage Wells

Storage well tubulars consist of production and surface casing on injection/withdraw and observation wells. PG&E operates 109 injection/withdrawal wells and 8 observation wells with wells having been in operation since 1936 through 2012. All 117 wells are equipped with steel casing. A list of storage fields and well-type are listed in Table 7.

Table 7 - Well Inventory by Storage Field

Field	Injection/Withdrawal Wells	Observation Wells
McDonald Island	81	7*
Los Medanos	21	1
Pleasant Creek	7	0
TOTAL	109	8

* 3 injection/withdrawal wells are planned to be converted to observation wells (refer to Section 2.2.3 for details)

Storage well condition is tracked by assessing the condition of surface casing and production casing. Surface casing is installed in each of the storage wells as a regulatory requirement to protect all freshwater zones. Storage well industry experience suggests the vintage of a well's tubulars should not be a factor in determining the well's integrity. The best in industry technology such as Magnetic Flux Leakage (MFL) tools, Ultrasonic Tools, Vertilog, or Casing Inspection Tools indicate that there is not a linkage between age and integrity.

Surface Casing

Surface casing is assessed using a combination of leak history and cement records. The following assessments are used to determine the condition of storage well surface casing:

- **Cement Records:** Indicate if a cement sheath is protecting the casing from external corrosion.
- **Production Casing Cementing:** Reduces threat of internal corrosion.
- **Annular pressure, volume and/or fluid monitoring:** Provides an indication of the surface casing condition. In 2016, PG&E began daily monitoring of the shut-in surface casing pressure.

An assessment of surface casing is in progress at this time and will be documented via an Asset Health Scorecard going forward. Current results for surface casing are listed in Table 8.

Table 8 - Storage Tubulars – Surface Casing Condition Data

Tubulars: Surface Casing Condition Data	
Description	Surface Casing Leak
Assessment Method	Pressure monitoring
Frequency	Daily
2016 Target	Tracking Only
2015 Results	0

Production Casing

Production casing is assessed for metal loss to determine condition. The following assessments are used to determine the condition of storage well production casing:

- **Noise & Temperature Logging:** Run annually on all wells to inspect for anomalies that may indicate wellbore tubular leak.
- **Magnetic Flux Leakage (MFL):** Used to evaluate casing for metal loss potentially related to internal corrosion, external corrosion, or cathodic protection. Approximately 6 - 8 rework wells are inspected using Vertilog annually.
- **Gamma Ray Neutron (GRN) Logs:** Identifies "gas behind pipe", or potential gas behind the well production casing and cement sheath. GRN was introduced in 2013 to set a baseline for wells at all storage fields.
- **Caliper Inspections:** Used to evaluate casing geometry and changes of internal diameter.
- **Ultrasonic Surveys:** Used to evaluate casing wall thickness which could be an indication of metal loss potentially related to internal corrosion, external corrosion, or cathodic protection.
- **Pressure tests:** Performed on approximately 6 - 8 wells during well reworks to ensure integrity of well.
- **Pressure, volume and fluid monitoring:** Provides an indication of the production casing condition.

Using these assessments, the targets and current conditions documented in Table 9 have been determined for PG&E storage field production casing.

Table 9 - Production Casing Condition Data

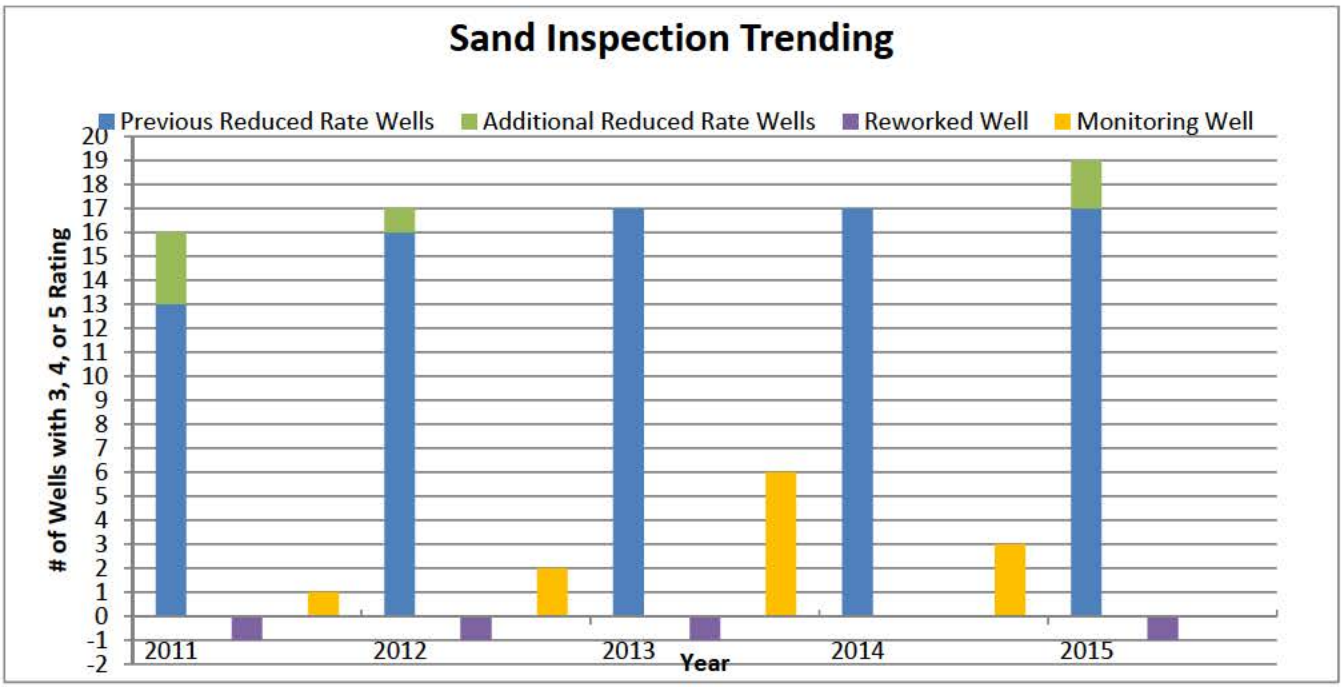
Production Casing Condition Data		
Description	Potential Casing Leak Path	Wall Thickness, Number of wells with Class 3 or greater apparent metal loss
Assessment Method	Noise & Temperature Logging	Magnetic Flux Leakage, Caliper, Ultrasonic
Frequency	Annually	Ranges from 1 to 15 years and risk based
2016 Target	0 wells	0 wells
Cumulative Results	2 wells – remediation not required	1 well – remediation not required

The noise and temperature logs have indicated potential anomalies on two wells (Los Medanos' Gino 3-7 and McDonald Island's WS-11W). The MFL indicated a Class 3 of greater apparent metal loss on one well (Los Medanos' 5B). All three wells do not currently require remediation; however, Reservoir Engineering will continue to monitor these wells and, if necessary, provide additional recommendations for evaluating the wells' integrity or remedial work.

Sand Inspections

When gas wells produce gas at high velocities in the tubing or casing, any sand that is picked up in the flow stream becomes a potentially destructive element. Sand that is blasted against the piping, valves, chokes, or other parts of the system can destroy equipment in a very short time. Further, the presence of sand is an indicator of a potential failure of the wells gravel pack and screen liner to prevent sand production. The sand inspections occur twice during the winter withdrawal period. If sand is detected, Reservoir Engineering will evaluate whether to reduce rate, shut-in a well, or re-gravel pack and install a new liner. The sand inspection trending for the last five years is shown in Figure 3 below. The figure shows the total number of wells with a 3, 4, or 5 sand production rating. The blue bar represents the number of wells with reduced rates prior to that particular year whereas the green bar shows the number of wells with rates reduced in that particular year. The purple bar represents the number of reworked wells due to sand production and lastly the orange bar shows wells which sand production that are continuing to be monitored.

Figure 3 - Sand Inspection Trending



2.2.3 Transmission Pipe

PG&E's gas storage fields include transmission pipe between the wells and compression and processing equipment. Within the three storage fields there are approximately 14 miles of transmission pipe, including 2.5 miles in High Consequence Areas (HCA). All 2.5 miles of HCA transmission pipe are located at McDonald Island.

This asset management plan provides a general condition assessment of the transmission pipe in the Gas Storage asset family. There is evidence that internal/external corrosion and erosion exists within the transmission pipe but a complete assessment is still in progress. Pipe within the Storage asset family has more potential for moisture and corrosive agents. There were indications of microbiologically

induced corrosion (MIC) found during 2013 McDonald Island Whiskey Slough rebuild project with wall loss on the majority of pipe between wells and processing equipment. Site-specific Internal Metal Loss Action Plans (IMLAP) are currently being developed for all the storage fields and further detailed in Section 4. Results from 2014 and 2015 baseline investigations being used to develop the Site-specific plans show multiple indications of wall loss. As a result, several Ultrasonic Thickness (UT) probes have been installed and utilized to determine corrosion growth rate changes.

At McDonald Island a non-traditional in-line inspection (ILI) was performed on a segment of L57A-MD1 in August 2015. A significant number of anomalies and one dent were found. The affected portion is currently shut-in with a project in progress to permanently deactivate then retire the segment between valve V-11 and injection/withdrawal wells Tilden 1, Roberts 1, and Roberts 2. The three injection/withdrawal wells will then be converted to observation wells.

At Los Medanos, an external corrosion leak was found near well LM-18D in late 2015. Pipe coating was found to be disbonded on segments of pipe nearby. A project is in progress to replace the affected pipe.

Out of the 10 miles of Storage Asset Family pipe reviewed in the 2015 ILI Piggability Study, 6.5 miles are identified as potentially non-traditional ILI and 3.5 miles as not piggable.

2.2.4 Surface Equipment

Surface equipment includes but is not limited to safety and isolation valves, well flow measurement, and controls.

Most injection and withdrawal wells also have “downhole” safety valves (DHSV), installed approximately 250 feet below ground level. All injection and withdraw wells have safety valves installed “uphole” (UHSV) at the wellhead for the casing and tubing flow to provide emergency shutdown. The inventory of wells with DHSV and UHSV are shown in Table 10.

Table 10 - Number of Wells with DHSV and UHSV

Valve Type	Number of Wells
Downhole Safety Valves (DHSV)	89 (77% of wells)
Uphole Safety Valves (UHSV)	109 (94% wells)

Pressure tests have been conducted on all UHSVs and all DHSVs based on criteria established with the California Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR) prior to the DOGGR Emergency Regulations effective on February 5, 2016. Based on tests in 2016, all safety valves were functional except valves on 5 wells that were either not functional or unavailable for testing. PG&E submitted a letter to DOGGR in May 2016 with a plan to replace the valves during the 2016 rework program. To mitigate nonfunctional valves, PG&E has a replacement program to replace 6 - 8 DHSVs annually as part of the well rework program. Beginning in 2015 a program has been developed to repair/replace UHSV of reworked wells and other non-functioning valves as identified. Safety valves are rated on the scales indicated in Table 11.

The previous year’s DHSV and UHSV testing results and this year’s targets are shown in Table 12. Trends from the past five years of safety valve testing can be seen in Figures 4 and 5.

The DHSV 5-year condition trend shows a decrease in wells with a “4” rating in 2015. The DHSV 5-year condition trend shows an increase in wells with a “4” rating in 2014. The increase in the number of wells

having an increased rating was at McDonald Island Whiskey Slough Station. The potential reason for the increase is that the DHSVs were not exercised monthly due to the DHSV hydraulic control system being taken out of service for more than 9 months as a result of the Whiskey Slough production measurement and controls and piping system upgrade in 2013. Of note, the DHSV manufacturer recommends functionally exercising the DHSVs at a minimum once a month to keep the DHSVs working properly and reliably. Additionally, the Storage asset family is working with PG&E's Applied Technology Services (ATS) and the valve vendor to assess the DHSV design and improve valve performance.

The trending for UHSV with a "4" rating at McDonald Island is gradually increasing. Los Medanos trending has decreased over the five years; however, due to obsolescence, repairing valves is no longer an option. A program has been developed at Los Medanos to phase the replacement of the obsolete UHSVs and repair/replace McDonald Island nonfunctional UHSV. Pleasant Creek has remained flat at zero valves with a "4" rating following valve testing since all UHSVs were replaced in 2011.

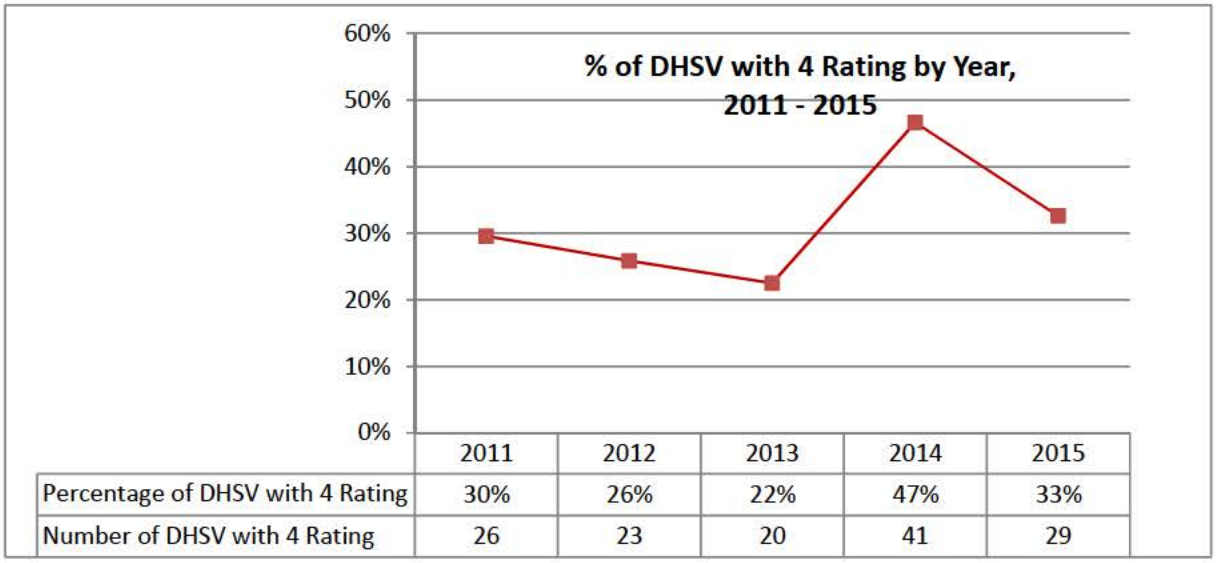
Table 11 - DHSV and UHSV Condition Key

Rating	Condition
0	No Leakage
1	1 - 100 psig
2	101 - 200 psig
3	201 - 300 psig
4	300 psig or higher

Table 12 - 2015 Year End DHSV and UHSV Condition Summary

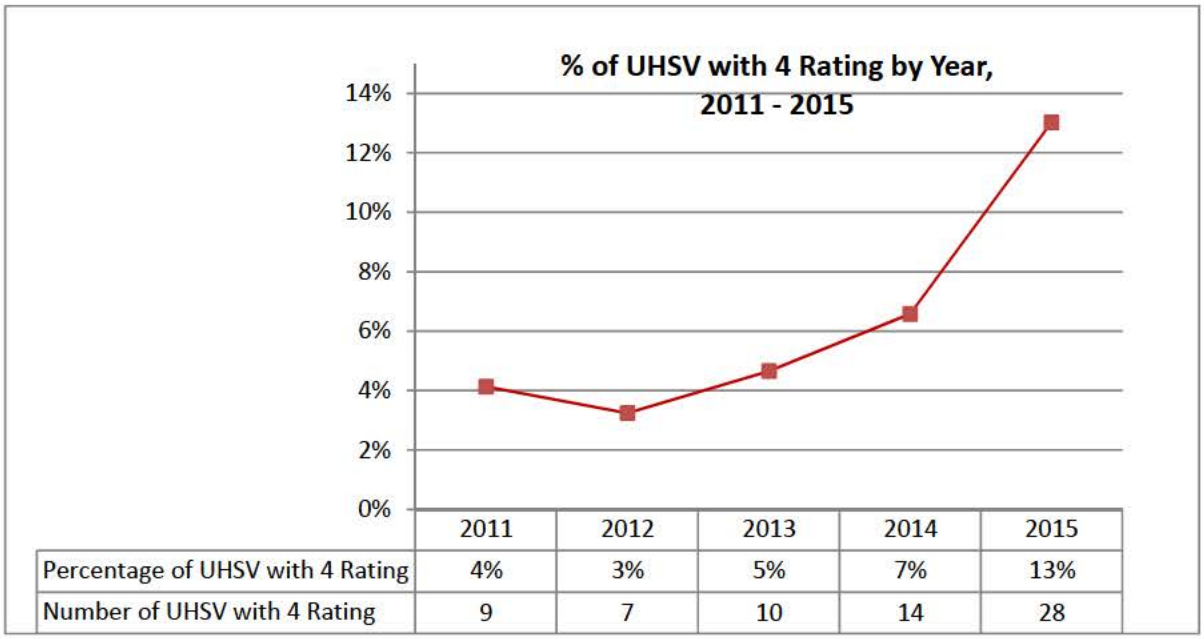
2015 Year-End Safety Valve Condition Results							
	DHSV			UHSV			
	MI	LM	Total	MI	LM	PC	Total
# Valves Available for Testing	68	21	89	160	41	14	215
4 Rating	21	8	29	25	3	0	28
% of Total	31%	38%	33%	16%	7%	0%	13%
# Replacing in 2016	4	2	6	8	8	0	16
2016 Target (% of 4 Rating to Total # of Valves)	25%	29%	26%	11%	0%	0%	6%

Figure 4 - DHSV 5-Year Condition Trend



	2011	2012	2013	2014	2015
Percentage of DHSV with 4 Rating	30%	26%	22%	47%	33%
Number of DHSV with 4 Rating	26	23	20	41	29

Figure 5 - UHSV 5-Year Condition Trend



	2011	2012	2013	2014	2015
Percentage of UHSV with 4 Rating	4%	3%	5%	7%	13%
Number of UHSV with 4 Rating	9	7	10	14	28

Further details of condition assessments of other surface equipment are contained within the Measurement & Control and Compression & Processing Asset Management Plans. *Please refer to documents GP-1104: Measurement & Control Asset Management Plan and GP-1105: Compression & Processing Asset Management Plans for more details.*

2.2.5 Leak Survey

In response to the CPUC's January 2016, directive to California owners and operators of underground gas storage facilities, PG&E performed a leak survey and submitted a report with the number of leaks repaired and the number of leaks scheduled for repair at McDonald Island, Los Medanos, and Pleasant Creek summarized in the tables below. PG&E will provide an additional update(s) to the CPUC when these repairs are completed. Of note, PG&E is continuing to conduct daily inspections and leak surveys on the wellheads for the three storage fields owned and operated by PG&E.

Leaks were identified during condition baseline assessments (performed January 15-21, 2016), daily inspections (performed January 22-26, 2016), and the SED Directive Leak Survey (performed January 26- February 1, 2016). All identified leaks were located on fittings, valves, or flanges. No leaks were identified on well production casings or the transmission pipe body and were also not located in close proximity to any buildings intended for human occupancy or found migrating to a confined space.

Table 13 - 2016 Leak Survey Results

Leak Survey Results	PG&E Underground Storage Facilities			Total
	Los Medanos	Pleasant Creek	McDonald Island	
Leaks Identified	23	29	32	84
Storage Well Production Casing Leaks	0	0	0	0
Above Ground - Wellhead Equipment	6	4	8	18
Above Ground - Other	17	25	23	65
Below Ground	0	0	1	1

Leak Repair/Mitigation	PG&E Underground Storage Facilities			Total
	Los Medanos	Pleasant Creek	McDonald Island	
Repaired/Mitigated Leaks	23	28	26	77
Above Ground - Wellhead Equipment	6	4	3	13
Above Ground - Other	17	24	22	63
Below Ground	0	0	1	1
Pending Repair/Mitigation	0	1	6	7
Above Ground - Wellhead Equipment	0	0	5	5
Above Ground - Other	0	1	1	2
Below Ground	0	0	0	0

Of the seven reported leaks pending repair as of June 2016, they are isolated and scheduled for repairs with vendor support in 2016. One leak at McDonald Island is on an observation well, so Reservoir Engineering is currently evaluating it for a potential rework.

On June 16, 2016, a PG&E employee identified gas bubbling in a well cellar. PG&E quickly took action and isolated the well to ensure safe operations of the McDonald Island Storage Facility. In the subsequent days, PG&E observed gas bubbling in additional well cellars. There is no public safety, health, environmental or reliability risk. PG&E is utilizing a number of new techniques and technologies to monitor the leak and identify its source. PG&E experts and engineers have been working with DOGGR and industry experts to determine what's causing the minor leaks. PG&E has created a repair

plan to address what is found and has shared that with DOGGR. As soon as the leak source is confirmed, PG&E will initiate the final stages of the repair plan and continue outreach to local, state and federal regulators.

2.2.6 Data

Data for the storage wells and reservoirs is currently maintained and stored either as a hardcopy (Well File) or a scanned version in the Reservoir Engineering Department's shared drive. Data includes spot temperature, pressure, rate readings collected during inspections and testing, well logs, well files that contain the physical characteristics of the storage well, wellhead, permits, and operational histories. A summary of the data source, availability and quality of asset data is summarized in Table 14. This asset data can be used in developing performance indicators and desired metrics for tracking performance in managing threats.

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. Data quality is evaluated on the following scale:

- **Good** – Meets most data availability and quality requirements. Nearly all data available, some data quality issues, but minimal impact on data reliability for asset management purposes
- **Fair** – Meets some data availability and quality requirements. Some data missing, known data quality issues, but available data is valuable for asset management purposes
- **Poor** – Meets few, if any, data availability and quality requirements. Significant amounts of data missing or data quality is too problematic to be useful for asset management purposes
- **N/A** – Not available at present

Table 14 - Data Summary

Data Sources	Availability and Quality	Comments
Equipment Type & Installation		
• Site specific documentation (record drawings, field photographs, job files, well files)	Good	• Well Shared Drive specific documentation varies by storage field • Reservoir Shared Drive specific documentation varies by storage field
Maintenance and Condition		
• Computer based maintenance management – PLM transitioning to SAP • Results, trends from predictive tests, inspections, investigations, and analyses • Station log books • Well Files (inspection data, casing inspection logs, etc.)	Fair	• Maintenance records documented in PLM / SAP, corrective maintenance data is limited and difficult to extract • Documents are partially centrally maintained and there is no index to aid in finding a report • Results or trends from predictive tests, inspections, investigation and analysis

Data Sources	Availability and Quality	Comments
Operating and Performance		
• Process Hazard Analyses (PHAs) • SCADA • Unit and station PLCs • Data historians • Event tracking databases (Overpressure Event Report, CAP) • Project tracking – PSRS • Well Files (pressure/volume monitoring data)	Fair	• Not all well flowrates/pressures available via SCADA • Paper and Shared Drive data is consolidated into spreadsheets. Gas Storage Database (GSDB) resulted in digitized and centralized records. • Assigned facility and reservoir engineers tracking asset condition & performance issues

While the accessibility of the data varies by type and source, the data sources listed in the table are adequate to support threat assessment and trending and reporting of the metrics for Storage assets.

The transmission pipe, wellhead measurement, auxiliary equipment, and flow controls included in this asset family are assessed primarily by the Transmission and Facility Integrity Management teams. An objective of this plan is to utilize the framework of these teams to assess the data sources' condition and move toward more data informed assessment. A roadmap (Appendix K) has been developed to illustrate how data improvement programs and existing programs work towards utilizing more data informed decisions. Further details on pipe and surface equipment data availability and quality can be found in the Transmission Pipe, Measurement & Control, and Compression & Processing Asset Management Plans.

Currently, data for this asset family is limited in terms of organization and accessibility to support quantitative analysis of asset condition and risk. Specific areas of data that have received focus over the past year include internal corrosion of the transmission pipe in the Storage asset family and internal/external corrosion of the storage well surface and production casing. Further, the ability to collect, organize, and monitor the impact on risk reduction and tracking metrics, are part of the programs such as the Asset Health Scorecard (AHS) and Gas Storage Asset Management Systems (GSAMS). Enhancing data collection and accessibility is an area of focus in this plan to improve decision making going forward.

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) 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.

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, as seen in Table 15. In addition, the Storage Asset Family Owner has included threats as identified in American Petroleum Institute's Recommended Practice 1171.

Table 15 - Storage 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 recognizes risks 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 risks posed by an inadequate response to and recovery from emergencies.

Threats are identified through available data sources including the Corrective Action Program (CAP), Process Hazard Analyses (PHAs), Pre-Startup Safety Reviews (PSSRs), 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, including impact and frequency levels, associated with each threat. Gas Storage 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 Gas Storage asset family. The discussion below highlights the key reason for the threat and primary mitigation measures. These threats guide the identification of the risks contained in the Storage Risk Register.

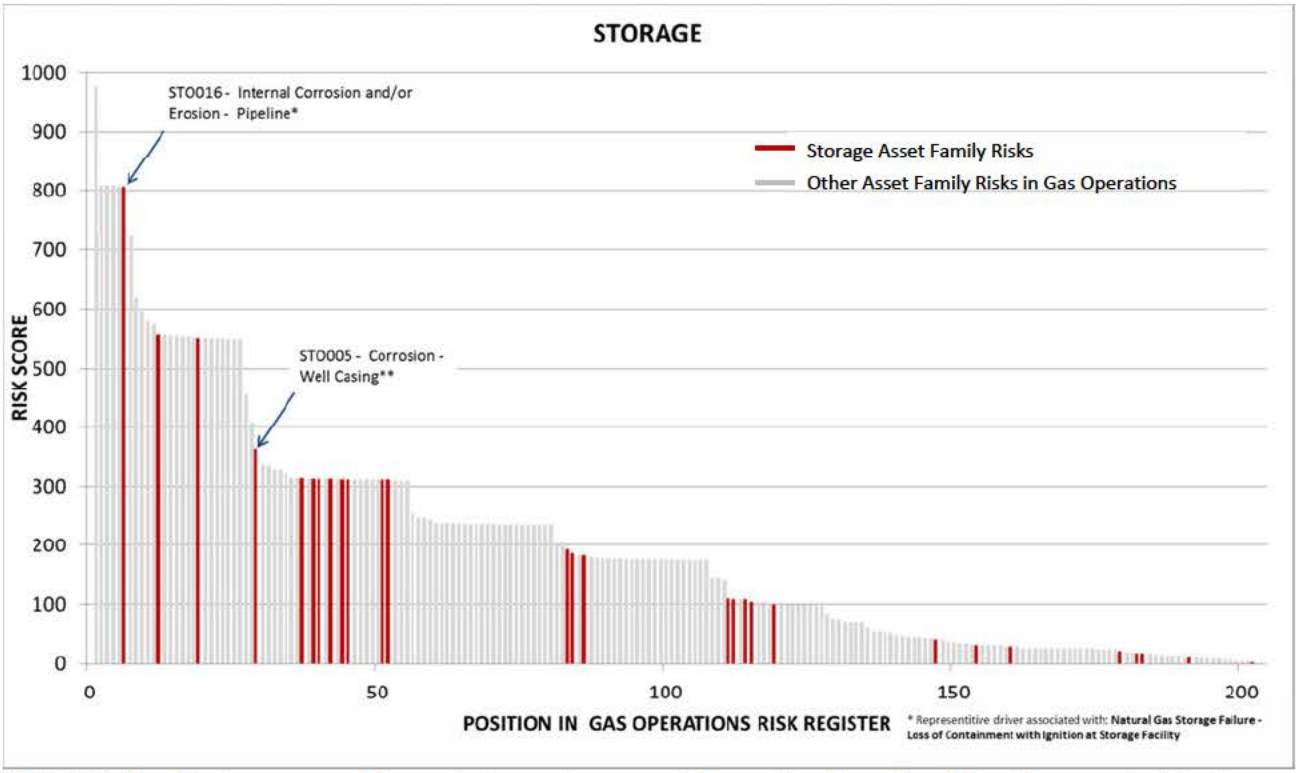
3.1.2 Key Gas Storage Risks

Using the identified threats from the threat matrix, risks have been identified and annually updated for the storage 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 Storage asset family identified 36 risks in 2016. Of the 36 Storage asset family risks, one risk was introduced in 2016 related to internal corrosion and/or erosion of pressure vessels (STO037). Two Storage risks were retired including the records management risk (STO032) and the employee qualifications risk (STO036) since they're both covered by cross-cutting Gas Operations risks. Two risks were rescored due to new information including increasing impact scores for the corrosion of well casing risk (STO005) based on SoCal Gas' Aliso Canyon well leak incident and increasing the frequency score for the external corrosion of pipeline risk (STO017) based on recent evidence of external corrosion at Los Medanos. The highest Storage risk (STO016) ranked sixth among the 204 risks in Gas Operations.

Below is a histogram that displays the position of the Storage asset family risks within the Gas Operations risk register.

Figure 6 - Gas Operations Risk Profile



** STO005 reflects rescored impacts based on new information from the Aliso Canyon incident.

The key risks for the storage asset family are detailed in the table below.

Table 16 - Key Gas Storage Risks

Risk ID	Asset Type	Threat	Risk Description
STO016	Pipeline	Internal Corrosion and/or Erosion	Rupture of pipeline due to internal corrosion and/or erosion may result in loss of containment, and/or uncontrolled gas flow that may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage and/or environmental damage.
STO017	Pipeline	External Corrosion	Rupture due to external corrosion of the pipeline which may result in the loss of pipeline isolation and access as well as an uncontrolled flow or lost production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.
STO026	All Segments	Weather and Outside Forces (Seismic)	Loss of withdrawal platform, buildings and equipment due to seismic activity/earthquake that may result in the loss of containment or ability to provide storage service. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage.
STO005	Well Casing	Corrosion	Loss of well integrity due to well casing corrosion (internal, external, or stress corrosion cracking) that may result in an uncontrolled flow of gas outside of well casing with ignition source, drinking water contamination, gas migration, or gas loss. This may lead to major impact on public or employee safety, facility outage or net replacement of supply, property damage and/or environmental damage.
STO020	Pipeline	Manufacturing	Rupture of pipeline due to manufacturing may result in loss of containment, and/or uncontrolled gas flow that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.
STO015	Valves	Erosion	Erosion of valves may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.
STO012	Meters	Equipment	Compromised measurement may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.
STO018	All Segments	Fatigue	Failure of pipeline, equipment, and pipeline controls due to fatigue from internal pressure cycling or vibration may result in loss of containment. This may lead to significant impact on public or employee safety, outages, property damages and/or environmental damage.

Risk ID	Asset Type	Threat	Risk Description
STO037	Pressure Vessels	Internal Corrosion and/or Erosion	Through wall leaks in pressure vessels due to internal corrosion and/or erosion that may result in uncontrolled flow of gas. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or environmental damage.
STO030	All Segments	1st, 2nd, 3rd Party Damage	Rupture of belowground pipeline or uncontrolled flow from other storage assets due to 1st, 2nd, and 3rd Party damage caused by equipment/vehicles who may not have followed work procedures that may result in uncontrolled flow of gas, outages or replacement of gas supply. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or minor environmental damage.
STO003	Reservoir	Construction by 1st & 2nd Party	Loss of reservoir integrity due to 1st and 2nd party drilling through storage field or reworking 1st and 2nd Party well that may result in an improper completion of the well or uncontrolled flow or loss containment with ignition source that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.
STO019	Pipeline	Third Party Damage	Rupture of pipeline due to mechanical damage by 3rd party may result in the loss of pipeline isolation and access as well as uncontrolled flow and loss in production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.

**For all Storage risks see Appendix C

3.2 Integrity Management Programs

In addition to the EORM process to identify scenario based risks, some asset families leverage information from related integrity management programs to identify asset level risks.

Based on the components in the storage asset family, the following integrity management programs apply:

Well Integrity Management Program (WELL)
This program is used to assess the risk related to the storage wells and recommend actions to prevent or mitigate these risks. While the WELL risk management process contains elements that overlap with risk assessment processes within the risk register, it is a separate process that considers threats to individual wells. The risk process for this program gathers, reviews, and integrates data to prioritize preventive and mitigative measures, and monitor for operational changes that may require additional actions.

PG&E's storage wells are constructed and operated according to the regulations of California's Division of Oil, Gas, and Geothermal Resources (DOGGR) that were in effect at the time the storage wells were constructed. These regulations require storage wells to demonstrate integrity and can be considered as a lagging indicator. The program includes both leading and lagging indicators. The

leading indicators are designed to assess the condition and take preventive steps prior to failure. The lagging indicators are designed to identify potential failure and steps to mitigate the failure. WELL draws on industry best practices given the absence of industry standards on the functional integrity of natural gas wells and fields. In 2012, the industry recognized that this gap existed. Through the efforts of storage operators and regulators, American Petroleum Institute (API) agreed to establish a task team to develop API Recommended Practice 1171 that addresses the functional integrity of natural gas storage wells and fields. A current PG&E employee participated on the API task team. This guidance document was published in 2015. On February 5, 2016 DOGGR implemented Emergency Regulations to develop and submit a Risk Management Plan by August 5, 2016. One of the 2015 Storage Asset Management Plan's strategic objectives was to conduct an analysis of API RP 1171: Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs in 2016 to identify enhancements to its current operating practices. PG&E is currently conducting the analysis and enhancing a well integrity management plan prior to the effective date of the DOGGR Emergency Regulations.

While WELL focuses on storage reservoirs and wells, other storage assets such as transmission pipe and surface equipment fall under other integrity management programs as described below.

Transmission Integrity Management Program (TIMP)
The transmission pipe in this asset family is assessed primarily by the 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.

Facility Integrity Management Program (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 will be 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 Compression & Processing Asset Management plan will become a part of the FIMP. This plan will also apply to the Storage Asset Family surface equipment. *Please refer to document GP-1105: Compression & Processing Asset Management Plan for more details.*

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

The Storage asset family's strategic objectives are developed to optimize asset life cycle by maintaining and improving asset condition and adequately mitigating risks and threats. These strategic objectives, which support Gas Operation's Line of Sight (LoS) goals, have been established to align investment in the asset family with the Asset Management Strategy, reduce risks and ultimately realize PG&E's corporate vision.

Using these inputs, a long-term plan has been defined to meet Storage Asset Management and corporate objectives. An underlying assumption in the development of these strategic objectives is current regulations remain static. For example, currently proposed regulation changes following SoCal Gas' Aliso Canyon well incident and proposed regulation for air quality (e.g. methane emission reduction) will potentially impact operations and investments of the storage asset family's wells and surface equipment.

Three key programs, including WELL, TIMP, and FIMP, lay out the long-term vision for the Storage asset family. The desired state for Storage well assets is carried out by the development and implementation of a robust Well Integrity Management Program (WELL). The WELL defines the long-term desired state for the condition and the management of the Storage well assets. For Storage pipe assets, Transmission Integrity Management Program (TIMP) is developing a long-term strategy to hydrotest, assess, or replace the Storage asset family's 10 miles of transmission pipe. As for Storage surface equipment assets, a robust Facility Integrity Management Program (FIMP) which is still under development will define the desired state for asset condition and management.

Also, research and development efforts will enhance the desired state of safer and more reliable gas storage assets. Completed and pending projects can improve well and pipe integrity assessments and methane emissions detection. The outcomes from these projects can have long-term benefits which improve integrity management through WELL, TIMP, and FIMP. Please refer to Appendix I for more details.

4.1 Strategic Objectives, Programs and Mitigations Alignment

The Storage strategic asset objectives and associated metrics as they correspond to Gas Operations' LoS goals are detailed in the table below. A high-level strategic objective is listed with more specific objectives related to different asset types.

Table 17 - Storage Strategic Objectives

Gas Operations LoS Goals	Strategic Objective	Metric
Safe	**Asset Management** - Effective and efficient asset management of gas storage facilities to identify the right work and to optimize the condition of our assets based on prioritization of risk. • Complete baseline well production casing assessments by 2025. • Evaluate Well Integrity Management Plan (WELL) enhancements and incorporate by 2017. • Assess work on transmission pipe through TIMP by 2017. • GPOM, FIMP, and Reservoir Engineering identify, prioritize, and develop a plan to complete open corrective work by 2017.	• % Complete • % Complete • % Complete • % Complete
Safe	**Process Safety** - Ensure safe design, operations, maintenance, and execution of right work through the integration of process safety in the gas storage facilities. • Continue Process Hazard Analysis (PHA) and Pre-Startup Safety Reviews (PSSR) on all well, surface equipment, and pipeline in the storage asset family. • Conduct annual emergency response drills which incorporate Well Control Tactical Considerations Plan in Gas Emergency Response Plan and participate in Gill Ranch emergency response drills by the end of 2017.	• # of PHA and # of PSSR • Annual drill complete
Affordable	**Facility Performance** - Foster a culture of continuous improvement to optimize facility performance and risk reduction through design, operations, maintenance, and execution of the right work. • Gas Operations continue to evaluate proposed regulatory and legislative initiatives and its impact on facility performance and risk reduction mitigations.	• % Complete
Reliable / Customer	**Capacity** - Meet system and customer storage capacity needs by optimizing short and long-term performance through the use of management of change, operational and maintenance procedures, and workforce involvement. • Gas Operations continue to evaluate capacity requirements from storage to meet system needs and balancing risk reduction mitigations and reliable projects executed in 2017-2020. • Continue to conduct full field maximum flow tests annually and publish results. • Continue to conduct individual well flow tests annually and publish results.	• % Complete • % Complete • % Complete

Gas Operations LoS Goals	Strategic Objective	Metric
Compliance	**Compliance** - Satisfy commitments with regard to Integrity Management, Accounting and Environmental regulations by achieving no violations through auditing processes and procedures.	• # of Notice of Violations (NOVs)
Safe	**Data** - Improve data quality, availability, and accessibility to enhance risk analyses and decision-making, moving from solely Subject Matter Expert input to more data informed. • Develop and implement Gas Storage Asset Management Systems (GSAMS) and Asset Health Scorecard (AHS) data to enhance risk analysis on well assets for 2019 Session D.	• % Complete
Safe / People	**Training** - Recruit, retain, and train a qualified and motivated workforce (employees and contractors) through identifying the needed training and developing line of progression for the operation and maintenance of the storage facilities. • Identify, analyze, and implement 5-year training/development profiles for Reservoir Engineering by 2016. • Review, revise, and develop operator training for storage well operations by 2018.	• % Complete • % Complete

PG&E has developed the following programs to meet these strategic objectives, using the aforementioned risk-based investment strategy to address both enterprise and asset level risks, meet compliance requirements and maintain asset condition. An overview of the storage multi-year plan, or roadmap, can be seen below in its entirety in Appendix K. Detailed program plans and timeframes follow in Section 4.2.

The programs and mitigations related to the Storage asset family are shown in Table 18 along with linkage to the strategic objectives identified in Table 17. The timeframes for the following programs and mitigations are based on the proposed rate case targets as of the publish date of this Asset Management Plan and detailed in Tables 19 through 22.

Table 18 - Programs, Mitigations, and Strategic Objectives

Programs & Mitigations	Asset Family Strategic Objectives						
	Asset Management	Process Safety	Facility Performance	Capacity	Compliance	Data	Training
WELL – Integrity Assessments	X	X	X	X	X	X	
WELL – Remediation and Conditioning	X	X	X	X	X		

Programs & Mitigations	Asset Family Strategic Objectives						
	Asset Management	Process Safety	Facility Performance	Capacity	Compliance	Data	Training
WELL – Controls and Continuous Monitoring	X	X	X	X	X	X	
WELL – Repair and Replace	X	X	X	X	X		
WELL – Other	X	X	X	X		X	
Asset Health Scorecard	X	X	X			X	
Gas Storage Asset Management Systems (GSAMS) and Gas Storage Database (GSDB)	X	X				X	
Asset Management Backbone and Stations (AMBBS)	X	X	X			X	
Internal Metal Loss Action Plans (IMLAP)	X	X	X		X	X	
Corrosion Control	X	X	X		X	X	
Patrolling / Continuing Surveillance	X	X	X		X		
In-Line Inspection (ILI)	X	X	X		X	X	
Direct Assessment (DA)	X	X	X		X	X	
Pressure Test	X	X	X		X	X	
Leak Survey & Repair	X	X	X		X	X	
Public Awareness / Damage Prevention	X	X	X		X		
Vintage Pipe Replacement	X	X	X				
Locate & Mark	X	X	X		X		
Shallow Pipe Program	X	X	X		X		
Cathodic Protection	X	X	X		X	X	
Atmospheric Corrosion Inspection Program	X	X	X		X	X	
Supervisory Control and Data Acquisition (SCADA) / Network Visibility	X	X	X		X	X	

Programs & Mitigations	Asset Family Strategic Objectives						
	Asset Management	Process Safety	Facility Performance	Capacity	Compliance	Data	Training
Fault Crossing	X	X	X				
Geotechnical Hazard Monitoring	X	X	X				
Water & Levee Crossing	X	X	X		X		
Engineering Critical Assessment (ECA) Phase 1	X	X	X		X	X	
Engineering Critical Assessment (ECA) Phase 2	X	X	X		X	X	
Hydrostatic Testing Station Facilities	X	X	X		X		
Critical Documents	X	X	X		X	X	
Physical Security	X	X	X				
Routine Expense and Routine Capital Spend	X	X	X				
Emergency Shutdown (ESD) System Upgrades	X	X	X		X		
Install Active Fire Suppression Systems	X	X	X		X		
Hard to Turn Valve Replacement Program	X	X	X		X		
Preventive Maintenance	X	X	X		X		
Guidance Documents	X	X	X		X	X	X
Cyber Security Measures	X	X	X			X	
Station Design Standardization	X	X	X			X	X
Training	X	X	X		X	X	X
External Corrosion Control	X	X	X		X	X	
Process Safety	X	X	X		X		X
Emergency Response	X	X			X		X
Research Projects	X	X	X	X	X	X	

4.2 Programs and Mitigations Overview

Table 19 - Program Summary - Storage Reservoirs & Wells

Program:	WELL – Integrity Assessments
Scope: This includes storage well survey and data logging to assess and inspect well casing pipe integrity for all 117 wells by 2025. Well integrity inspections may include Temperature and Noise surveys, Magnetic Flux Leakage (MFL), Gamma Ray/Neutron logs, Cement Bond Logging (CBL), Ultrasonic Surveys, and caliper inspections.	
Desired State:	Assess and inspect well casing pipe integrity.
Risks Addressed:	STO005, STO005.1, STO011
Timeframe:	Baseline from 2013 – 2025; Reevaluations on-going beyond 2026
Responsibilities:	Reservoir Engineering
Program:	WELL – Remediation and Conditioning
Scope: This includes: 1) assessment of the storage wells' condition, and additional remedial work for mitigating any potential risks/threats. Of note, the existing Downhole Safety Valves (DHSVs) in wells have to be pulled in order for the well casing pipe to be inspected and remedial work and new DHSVs are to be installed.; 2) Replacement of DHSVs in wells that are identified as not functionally holding pressure or the leak rate being above the API standards based on the annual test results; and 3) if necessary, installation of gravel pack to restore well deliverability due to natural degradation from cyclical injection and withdrawal operations and fouling of the gravel pack.	
Desired State:	Replace downhole safety valves which are unable to isolate storage gas and restore well deliverability.
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO015, STO016, STO016.1
Timeframe:	On-going
Responsibilities:	Reservoir Engineering
Program:	WELL – Controls and Continuous Monitoring
Scope: This includes the projects that are to install 1) transducers at the well heads to remotely and continuously monitor the pressures in the well surface casing annuli (SCA) and tubing and casing annulus (TCA); 2) flow measurements in the injection flow stream (McDonald Island only), and 3) replacement of obsolete or outdated field well flow controls to prevent overflowing of the wells to minimize sand production.	
Desired State:	Enhance monitoring and protect wells from overflowing.
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO015, STO016, STO016.1
Timeframe:	2016 – 2018
Responsibilities:	Reservoir Engineering, Operations & Maintenance, Facility Integrity Management Program
Program:	WELL – Repair and Replace
Scope: This program includes Uphole Safety Valve (UHSV) replacements, pipeline replacements, and sand inspection valve replacements.	
Desired State:	Replace pipeline due to corrosion. Repair safety valves and sand inspection valves to improve reliability
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO015, STO016, STO016.1, STO017, STO17.1, STO031, STO031.1
Timeframe:	On-going
Responsibilities:	Reservoir Engineering, Operations & Maintenance, Facility Integrity Management Program
Program:	WELL – Other
Scope: This includes engineering support and data analysis software.	
Desired State:	Improve analytical capabilities

Risks Addressed:	STO005, STO005.1
Timeframe:	On-going
Responsibilities:	Reservoir Engineering
Program:	Asset Health Scorecard (AHS)
Scope: The Asset Health Scorecard will summarize the physical and operational condition of assets based on health properties identified and developed by the Storage asset family. These scorecards enable fact based decisions making for long term investment planning and emergent work. Scorecard output can provide high level analysis for asset management planning. The asset health scorecard timeline for the Storage asset family is as follows: • Developed asset health scoring business process requirements (2014) • Implement asset health scoring process (2015) • Automate asset health scoring process (2015 - 2017)	
Desired State:	Condition data is collected and analyzed with scoring methodology.
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO014, STO015, STO016, STO016.1
Timeframe:	2014-2018
Responsibilities:	Business Technology, Reservoir Engineering
Program:	Gas Storage Asset Management Systems (GSAMS) and Gas Storage Database (GSDB)
Scope: Reservoir Engineering and Records & Information Management (RIM) have identified the need to consolidate and secure the paper and electronic records for the reservoirs and 117 storage wells. The scope of the project includes: • Consolidation of records • Determination of the applicable systems (PLM, SAP, Documentum, etc.) to be used • Development of processes to access and track the condition/health of the storage well assets with the data.	
Desired State:	Records are consolidated in centralized repository and system of record.
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO014, STO015, STO016, STO016.1
Timeframe:	2014-2019
Responsibilities:	Business Technology, Reservoir Engineering
Program:	Asset Management Backbone & Stations (AMBBS)
Scope: Migrate the Backbone, Stations, and Storage asset information from multiple systems and platforms into SAP, as a single system of record. By employing emerging mobile technologies, the project will be enhancing management of Transmission preventive and corrective maintenance, enabling mobile device to capture maintenance information, and provide greatly enhanced access and retrieval of storage asset information.	
Desired State:	Ensure one source of asset and maintenance related data and for use in ongoing health determination.
Risks Addressed:	STO005, STO005.1, STO011, STO012, STO014, STO015, STO016, STO016.1
Timeframe:	2015-2019
Responsibilities:	Work Management Solutions, Reservoir Engineering
Program:	Internal Metal Loss Action Plans (IMLAP)
Scope: PG&E is improving the internal corrosion control program with more prescriptive standards and procedures which include the development of site-specific Internal Metal Loss Action Plans (IMLAP). Each IMLAP will contain internal corrosion control monitoring, testing and inspection requirements. Site-specific plans include key points where liquids are most likely to accumulate based on operating and design characteristics such as hydraulic flow rates, operating pressures, and topography. The plans document type and frequency of tasks (e.g., Non Destructive Examinations (NDE), liquid sampling and testing, drip blowing and assessments, operational pigging, corrosion monitoring coupons).	

Desired State:	Site specific internal corrosion control plans for each gas storage field.
Risks Addressed:	STO016, STO016.1, STO037
Timeframe:	Develop baseline 2014-2015; Develop plan 2016; Implement recommendations starting mid-2016 and continue on-going assessments.
Responsibilities:	Corrosion Engineering

The pipe and surface equipment (including wellhead measurement and flow controls) included in this asset family are managed utilizing the Transmission Integrity Management Program (TIMP) and Facility Integrity Management Program (FIMP) like those assets in the Transmission Pipe, Compression & Processing, and Measurement & Control asset families. Detailed information about these programs is included in the respective asset management plans (refer to Appendix A for links).

In the table below, Transmission Pipe asset family programs and mitigations that also apply to the transmission pipe within the Storage asset family are listed. In addition to these programs aligning with Transmission Pipe strategic objectives, they also tie to Storage asset family strategic objectives as shown in Table 17. Please refer to Appendix A for a link to the Transmission Pipe asset family Asset Management Plan.

Table 20 - Program Summary - Transmission Pipe

Program:	Corrosion Control
Scope: Corrosion is a threat that adversely affects the longevity and reliability of natural gas pipelines, valves, pressure vessels, and other pipeline appurtenances. There are several types of corrosion threats to pipelines: external, internal, atmospheric, and stress corrosion cracking. To protect against external corrosion, pipelines are well coated and have adequate cathodic protection (CP). Some of the mitigation programs in place to reduce the risk of external corrosion include: • Electrical Interference Monitoring – Alternating Current (AC) and Direct Current (DC) • Casing Monitoring • Atmospheric Corrosion Inspection To protect against internal corrosion, the quality of the gas is monitored for certain constituents, including oxygen, hydrogen sulfide, and/or carbon dioxide. One of the mitigation programs in place to reduce the risk of internal corrosion includes: • Internal Corrosion Site Specific Plans To protect against stress corrosion cracking, pipelines are well coated and have adequate cathodic protection (CP). Some of the mitigation activities in place to reduce the risk of stress corrosion cracking includes: • Monitoring and control of compressor station discharge temperature • Close Interval Survey • Magnetic Particle Inspection during H-Form Inspections	
Desired State:	Protect assets against internal corrosion, external corrosion, and stress corrosion cracking
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO031, STO031.1
Timeframe:	Ongoing
Responsibilities:	Gas Operations*

Program:	Patrolling / Continuing Surveillance
Scope: The Pipeline Patrol Program is a means of preemptive threat identification and can observe a myriad of potential threats ranging from construction activity, landslides, ground movement, vegetation encroachments, right-of-way (ROW) encroachments, leaks, corrosion, missing markers, etc. If left identified and unmitigated, many of these threats could result in a failure/rupture of company assets. These patrols are conducted to achieve compliance with 49 CFR Part 192.705 and to fulfill commitments to the CPUC.	
Desired State:	• Increased patrolling of areas with high risk of dig-ins, such as agricultural areas, HCA's, Class 3 locations, and targeted distribution pipelines • Acquire seven (7) additional centralized ground patrol personnel to assist with vegetative cover patrols, landslide patrols, and ground investigations • LiDAR technology under consideration for patrolling vegetative cover areas, identification of new construction, and historic earth disturbance change detection
Risks Addressed:	STO017, STO017.1, STO019, STO022, STO023, STO029, STO030, STO030.1
Timeframe:	Ongoing
Responsibilities:	Gas Operations*
Program:	In-Line Inspection (ILI)
Scope: ILI is the most reliable pipeline integrity assessment tool currently available to natural gas pipeline operators to assess the internal and external condition of transmission line pipe. ILI enables a pipeline operator to learn about the condition of its pipelines and to predict the integrity of those pipelines into the future to address time dependent as well as other threats to pipeline integrity. It involves running technologically advanced inspection tools, often called "smart pigs," through the inside of the pipeline to collect data about the pipe, and then using that data to identify anomalies that may require further investigation or repair.	
Desired State:	• Targeting 65 percent system piggable by 2026 • Apply both short and long-term recommendations from the McKinsey Capital Productivity Effort • Complete development and testing of custom ILI tools from ROSEN including 12"x16", 10"x12", and 24"x30", including full API 1163 qualification for each • Improve ILI run success rate to 90% for first-time ILI and 95% for ILI re-inspections
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO019, STO021, STO022, STO023, STO030, STO030.1
Timeframe:	2026; Ongoing
Responsibilities:	Transmission Integrity Management
Program:	Direct Assessment (DA)
Scope: DA is used to evaluate the possibility of time dependent threats of external corrosion, internal corrosion, and stress corrosion cracking. Each evaluation methodology is designed to proactively address the pipeline threat of corrosion and is meant to discover and prevent anomalies from growing to a size that affects the structural integrity of the pipeline. Application of DA involves applying a four-step process consisting of: (1) Pre-Assessment; (2) Indirect Inspection; (3) Direct Examination; and (4) Post Assessment.	
Desired State:	Proactively address the threat of corrosion
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO031, STO031.1

Timeframe:	Ongoing
Responsibilities:	Transmission Integrity Management
Program:	Pressure Test
Scope: The objective of the Pressure Test program is to validate the integrity and assure a margin of safety for those gas transmission pipelines that lack a documented strength test record. This program identifies stable/resident threats by evaluating the yield strength of segments of pipe for the presence of manufacturing defects, which is then followed by implementation of mitigation measures.	
Desired State:	All pipe with traceable, verifiable, and complete pressure test records
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO020, STO020.1
Timeframe:	2023; Ongoing
Responsibilities:	Transmission Integrity Management
Program:	Leak Survey & Repair
Scope: PG&E conducts leak surveys on the gas transmission pipeline system by implementing foot, mobile, and aerial leak surveys. 1) **Foot survey:** Foot survey is the most common method to conduct leak survey and requires personnel to carry a portable gas leak detector in close proximity to the pipeline route. 2) **Aerial survey:** Aerial leak surveys using Light Detection and Ranging Infra-Red (IR) technology are being used more frequently, and are typically transported by helicopter along the pipeline right-of-way. 3) **Mobile survey:** Ground-based mobile technology is a portable gas detector transported on all-terrain vehicles (or possibly cars or trucks) along the pipeline right-of-way. For each case, leaks are detected and recorded on the instrument before being downloaded to a database for repair.	
Desired State:	Identify, prioritize, monitor and repair leaks
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO031, STO031.1
Timeframe:	Ongoing
Responsibilities:	Gas Operations*
Program:	Public Awareness / Damage Prevention
Scope: The Public Awareness Program informs people living in proximity to transmission pipelines of the risks associated with natural gas pipelines and what actions to take in the event of an emergency. In an effort to continuously promote safety and awareness, PG&E has sent informational letters and safety brochures to homeowners and businesses located within about 2,000 feet of a natural gas transmission pipeline, and provided useful gas safety information online. The Damage Prevention Program identifies excavation companies that consistently adhere to safe excavation practices by recognizing them through PG&E's Gold Shovel program. In addition, the Damage Prevention Program identifies excavation companies that do not adhere to safe excavation practices and works with these companies to reduce damage to our pipeline systems.	

Desired State:	Enhance public safety, emergency preparedness and environmental protection through increased public awareness and knowledge
Risks Addressed:	STO017, STO017.1, STO019, STO030, STO030.1
Timeframe:	Ongoing
Responsibilities:	Gas Operations*
Program:	Vintage Pipe Replacement
Scope: PG&E considers vintage construction and fabrication threats interacting with land movement as one of the top risks facing the transmission pipe asset and the Vintage Pipe Replacement Program will significantly reduce that risk. PG&E's vision for its Vintage Pipe Replacement Program is to replace all known pipe segments containing vintage fabrication and construction threats that are subject to the threat of land movement that are in proximity to population by the end of 2030.	
Desired State:	• Targeting reducing risk to the population toward the 90% goal as soon as possible (2025). • Expected Completion Date – Based off remaining miles from program snapshot from current year if 15 miles/year is the execution rate. • Primary focus is to reduce the risk to the impacted population (that is within the vicinity of our pipelines) by 2030. • Incorporate LiDAR data to improve identification of land movement threats as managed through the geo-hazard identification program. • Incorporate IMU data from ILI to determine bending stresses in the pipeline, verifying land movement concerns.
Risks Addressed:	STO021
Timeframe:	2025
Responsibilities:	Transmission Integrity Management
Program:	Locate & Mark
Scope: This program is intended to prevent excavation damages to PG&E's transmission pipeline assets by third-party contractors, PG&E construction crews, or others by accurately locating and marking transmission assets and returning to the site when excavation activities are occurring near or over these assets. Activities under this program include responding to notifications in a timely manner and physically locating PG&E transmission pipelines near the proposed excavations. To properly respond to excavation notifications, transmission work crews have personnel assigned to monitor the regional one-call notifications from "811 – Call Before You Dig" systems.	
Desired State:	Prevent excavation damage
Risks Addressed:	STO019, STO029, STO030, STO030.1
Timeframe:	Ongoing
Responsibilities:	Gas Operations*
Program:	Shallow Pipe Program

Scope: The purpose of this program is to identify, prioritize and mitigate locations that have insufficient cover and are vulnerable to exposure from third parties. Capital remediation options include: replacement or relocation of the pipeline at an acceptable depth of cover in parallel, or along an alternate route and retirement of the shallow location and retirement of those shallow pipelines not necessary for operations. Expense remediation options include: excavation along the length of the pipeline to allow lowering to an acceptable depth of cover (only an option if the required depth of cover can be met without adding excessive external stresses to the pipeline) and protection of the pipeline by installing additional cover, concrete cap, or permanent bridging structure over the shallow location.	
Desired State:	• 3 year cyclical monitoring plan for continual surveillance established. • Primary focus is to reduce the risks at locations of agriculture/farming, external loading concerns on pipe, and erosion leading to exposure of pipeline. • Continued performance of public awareness.
Risks Addressed:	STO019, STO022, STO023, STO029, STO030, STO030.1
Timeframe:	2017; Ongoing
Responsibilities:	Transmission Integrity Management
Program:	Cathodic Protection
Scope: As part of this program, PG&E plans to enhance cathodic protection levels by adopting a more conservative protection criterion of -850 mV "off" as described in the NACE Standard Practice 0169-2007, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems." PG&E currently uses the -850 mV "on" criteria and transitioning to the "off" criteria will provide a more accurate indicator of system protection levels because it considers the soil IR voltage drop between pipe and reference cell when recording a pipe-to-soil potential. Including voltage drop can yield less conservative pipe-to-soil readings and potentially mask areas with inadequate levels of CP.	
Desired State:	• Establish internal engineering team including expert corrosion engineer, program manager, associate engineers, and data analyst to develop a program methodology, manage the program and provide engineering analysis and remedial CP System designs and upgrades to achieve 850 Off transmission pipeline CP levels. • Establish team of field engineers to survey the 6,750 miles of transmission pipeline within a 4 year period for CP status and collect the data necessary to support the Engineering recommendations to meet 850 Off criteria for all transmission pipeline. • Eliminated notifications and NOVs for inadequate CP • Improved compliance for bi-monthly and annual CP reads
Risks Addressed:	STO017, STO017.1
Timeframe:	2019; Ongoing
Responsibilities:	Corrosion Engineering
Program:	Atmospheric Corrosion Inspection Program

Scope: Two major aspects of the program are: • Improve current procedures and training to ensure atmospheric corrosion inspections are performed correctly and uniformly throughout the company. As well as create new automated processes and procedures for when remediation are required to ensure they are completed within the compliance window. • Review existing records and to find existing deficiencies and prioritize the remediation based risk. This includes a review of all systems of record (PLM, SAP, and paper), inspecting for issues, and creating remediation projects.	
Desired State:	• Developed new inspection procedures and training, reduce and simplify forms. • Improved system of record across different asset types (spans, vaulted assets, etc.) • Implemented mobile solution to facilitate quicker turn-around of field inspection results. • Over two thirds of station projects completed. • Over two thirds of span projects completed.
Risks Addressed:	STO017, STO017.1
Timeframe:	2021; Ongoing
Responsibilities:	Corrosion Engineering
Program:	Supervisory Control and Data Acquisition (SCADA) / Network Visibility
Scope: The Gas Transmission Control Center (GTCC) SCADA system is designed to provide greater visibility to the gas system operators and increased situational awareness, which means faster detection of abnormal conditions, and more robust response. The system can accommodate advanced applications such as the real-time line break detection application, improved control room management including improved audit documentation, emergency response tools, and other applications	
Desired State:	Provide visibility into gas system operations and increase situational awareness
Risks Addressed:	STO027, Major Emergency or Disaster
Timeframe:	2013-2021
Responsibilities:	Gas Operations*
Program:	Fault Crossing
Scope: The Fault Crossings program serves to address and mitigate the specific threat of land movement strains on transmission pipe that results from seismic activity. By conducting detailed studies that focus on geologic movement as well as the pipeline's mechanical properties, PG&E is able to gather critical information to determine how best to manage the integrity of these segments of pipe. In order to improve the margin of safety at each fault crossing, this program implements mitigation measures such as modified trench designs, trench adjustment, pipe replacement, or the installation of automated isolation valves.	
Desired State:	Mitigate threat of land movement strains resulting from seismic activity
Risks Addressed:	STO026
Timeframe:	2012-2018
Responsibilities:	Gas Operations*

Program:	Geotechnical Hazard Monitoring
Scope: The Geotechnical Hazard Monitoring Program supplements PG&E's Vintage Pipeline Replacement Program by refining data that will help it more effectively address the interactive threats caused by land movement. There are currently gaps in knowledge that inhibit PG&E from adequately mitigating for this threat. To address this issue, the geo-hazard identification and mitigation program provides more granular, site-specific information where slow land movement or subsidence may be straining our pipelines. By building upon this current basis of information, PG&E can enhance its risk evaluation of this threat.	
Desired State:	Address interactive threats caused by land movement
Risks Addressed:	STO022, STO023, STO026
Timeframe:	2014-2016
Responsibilities:	Gas Operations*
Program:	Water & Levee Crossing
Scope: The Water and Levee Crossing Program improves system safety and reliability by identifying and evaluating erosion, third-party damage threats, and other hazards to trenched-in pipeline installations located under waterways and within levee structures. This program has three components related to transmission pipeline installations: jurisdictional water crossing, jurisdictional levee crossing and the non-jurisdictional water crossing.	
Desired State:	Identify and evaluate hazards to pipeline located under waterways and within levee structures
Risks Addressed:	STO024
Timeframe:	Ongoing
Responsibilities:	Gas Operations*

* Stakeholders for these programs are as shown in Appendix D

In the table below, C&P and M&C asset families' programs and mitigations that also apply to the Storage asset family are listed. In addition to these programs aligning with C&P and M&C strategic objectives, they also tie to Storage asset family strategic objectives as shown in Table 17. Please refer to Appendix A for links to the other asset family Asset Management Plans

Table 21 - Program Summary - Surface Equipment

Program:	Engineering Critical Assessment (ECA) Phase 1
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.	
Desired State:	Identification of discrepancies that require mitigation
Risks Addressed:	Gas Operations Records Management Risk
Timeframe:	2014 – 2019

Responsibilities:	Facility Integrity Management Program
Program:	Engineering Critical Assessment (ECA) Phase 2
Scope: The scope of this program will mitigate discrepancies identified during the ECA Phase 1 program. This program begun in 2015 and continues 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 is more favorable than the cost and/or operational impact created by station hydrostatic testing.	
Desired State:	Minimize the number of discrepancies that must be mitigated through pressure testing
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO018, STO020, STO020.1
Timeframe:	2015 – 2019
Responsibilities:	Gas Operations*
Program:	Hydrostatic Testing Station Facilities
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.	
Desired State:	Mitigate discrepancies remaining after completion of ECA Phase 1 and Phase 2 work
Risks Addressed:	STO016, STO016.1, STO017, STO017.1, STO018, STO020, STO020.1
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:	STO010, STO013, Records Management Risk
Timeframe:	2012 – 2019
Responsibilities:	Gas Operations*
Program:	Physical Security

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:	STO029
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 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:	Ongoing
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:	All
Timeframe:	2015 – 2025
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:	All
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:	STO014
Timeframe:	Ongoing
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:	STO012, STO014, STO015
Timeframe:	Ongoing
Responsibilities:	Gas Operations*
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. 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:	STO004, STO010, STO013, STO027, Records Management Risk

Timeframe:	Ongoing
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:	STO029, Enterprise Cyber Security Risk
Timeframe:	Ongoing
Responsibilities:	Enterprise Cyber Security organization
Program:	Station Design Standardization
Scope: This program has been developed to ensure consistency between 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:	STO010, STO013, Records Management 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:	STO004, STO010, STO013, STO027, Gas Operations Records Management Risk
Timeframe:	Ongoing
Responsibilities:	Gas Operations*

Program:	External Corrosion Control (such as Coatings, Cathodic Protection, External Corrosion Direct Assessment)
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 facilities
Risks Addressed:	STO017, STO017.1
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. 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:	All
Timeframe:	Ongoing
Responsibilities:	Gas Operations*

* Stakeholders for these programs are as shown in Appendix D

The following table describes emergency response and research projects applicable to all assets in the Storage asset family.

Table 22 - Program Summary Emergency Response and Research Projects - All assets

Program:	Emergency Response
Scope: An annual update of the Storage Well Emergency Response Plan should be completed along with an exercise of the Well Plan and Gas Emergency Response Plan (GERP). Develop site specific plans to enhance response times in the event of a storage well blowout.	
Desired State:	Enhance emergency response related to storage well blowout
Risks Addressed:	All
Timeframe:	2016 – 2018
Responsibilities:	Reservoir Engineering, Emergency Preparedness
Program:	Research Projects
Scope: Develop technology to reduce risks to the storage asset family. Appendix I contains a list of projects completed or in development that address various risks in the asset family.	

Desired State:	Develop and implement technology to reduce risks to storage asset family
Risks Addressed:	STO005, STO005.1, STO016, STO016.1, STO017, STO017.1, STO018, STO020, STO020.1, STO022, STO023, STO024, STO026, STO031, STO031.1
Timeframe:	On-going
Responsibilities:	Research & Development

The latest program investment plan information can be found at the following links:

- Transmission S1: 2015 GT S1
- Transmission S2: 2015 GT S2

5. Areas for Continuous Improvement

There are some areas in the asset management plans that have not been fully built out at this stage; these are highlighted in the table 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 23 - Areas for Continuous Improvement

Areas for Continuous Improvement
Repair vs. Replace • Documented criteria and decision-marking when repairing vs. replacing a component
Asset Criticality • Improved understanding of critical component assets – To be developed through Asset Health Scorecard • Collaborate with Gill Ranch on risk and asset management • Evaluate long-term plan for storage capacity needs
Data • Refinement of leading and lagging performance indicators in order to measure, monitor and report on asset performance and condition • More comprehensive data assessment and identification of gaps in existing data (if any) • Develop programs/processes to address data organization, accessibility, and identified gaps (if any) • Analyze trends from data
Asset Management Plan • Continue to work with other asset families to develop consistency in plan content • Ensure asset management plans are the primary source of asset family information and incorporates information from the Threat Matrices, Risk & Compliance Committee meetings, Session D, S1, and S2 • Continue to refine mitigation program “Desired State” and develop metric to measure progress toward the desired state • Improve criteria for identifying mitigation program status, including benchmarking criteria, program effectiveness metrics, and funding fulfillment • Work toward distinguishing assets between asset families to obtain granularity into trends
Personnel Implications • Additional or supplemental personnel in supporting Storage to perform proactive risk, asset, and process safety management activities. • Additional resources to develop and implement data organization and accessibility 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 Asset Management Principals and begin skill/expertise development for succession • Continue developing skills of Asset Family Owner and Asset Management Principals

APPENDICES

A. Related Documents

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

Table 24 - Related Documents

Related Document	Document Number / Description	Link
Storage Asset Family Video	Asset Family Owner introduces the Gas Storage Asset Family and how what you do every day makes a difference in how we are managing and maintaining the health of our assets.	GAS-T759 Gas Storage
Gas Storage 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.	2015 GT S1 2015 GT S2
Enterprise and Operational Risk Management Standard and Procedure	RISK-5001S, RISK-5001P-01	http://pgeatwork/Guidance/RiskCompliance/Pages/default.aspx
Gas Asset Management Policy	TD-01	TD-01
Gas Operations Asset Management System Risk Management Standard	TD-4011S	TD-4011S
Gas Operations Risk and Compliance Committee Charter	GOV-1021S	http://pgeatwork/Guidance/Governance/Pages/default.aspx
Strategic Asset Management Plan	GP-1100	Gas Safety Plans / Asset Management
Transmission Pipe 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	
Compression and Processing Asset Management Plan	GP-1105	
LNG/CNG Portable Supplies Asset Management Plan	GP-1106	
CNG Station Asset Management Plan	GP-1107	

Related Document	Document Number / Description	Link
Gas Storage Asset Management Plan	GP-1108	

B. Threat Matrices and Key Threats

The threat matrices below display 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 7 - Storage – Diagram for Threat Matrices

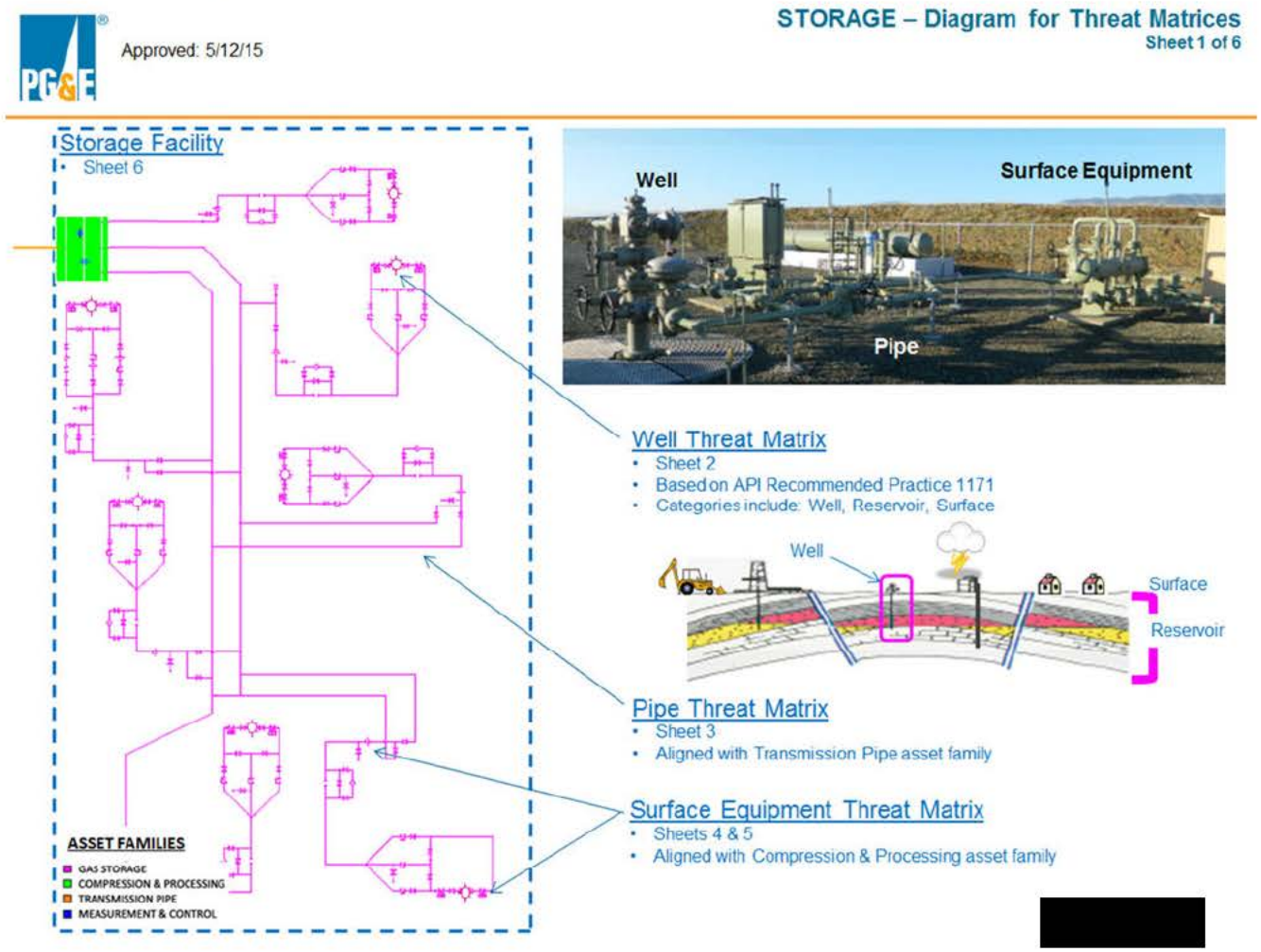


Figure 8 - Threat Matrix (Storage – Well)

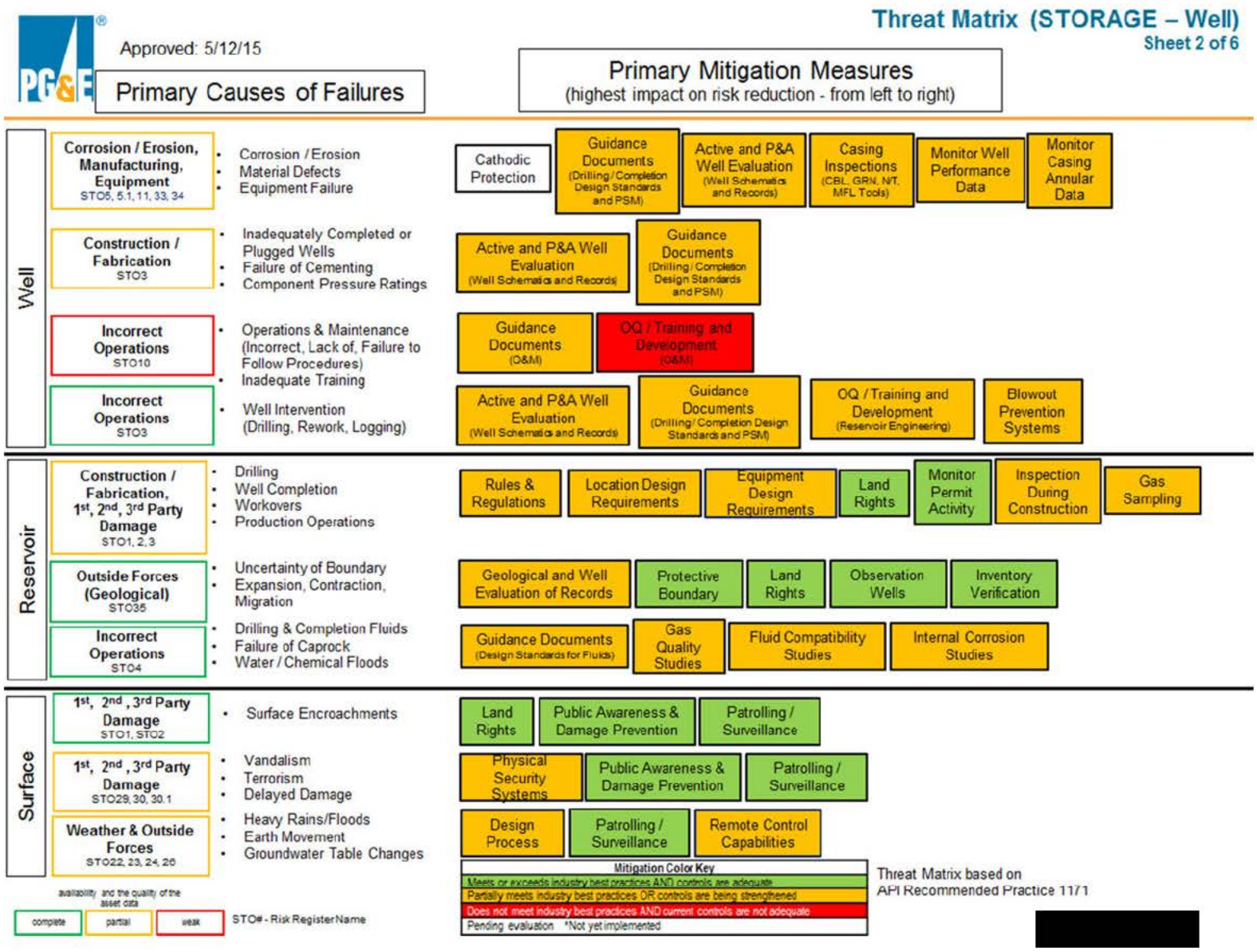


Figure 9 - Threat Matrix (Storage – Pipe)

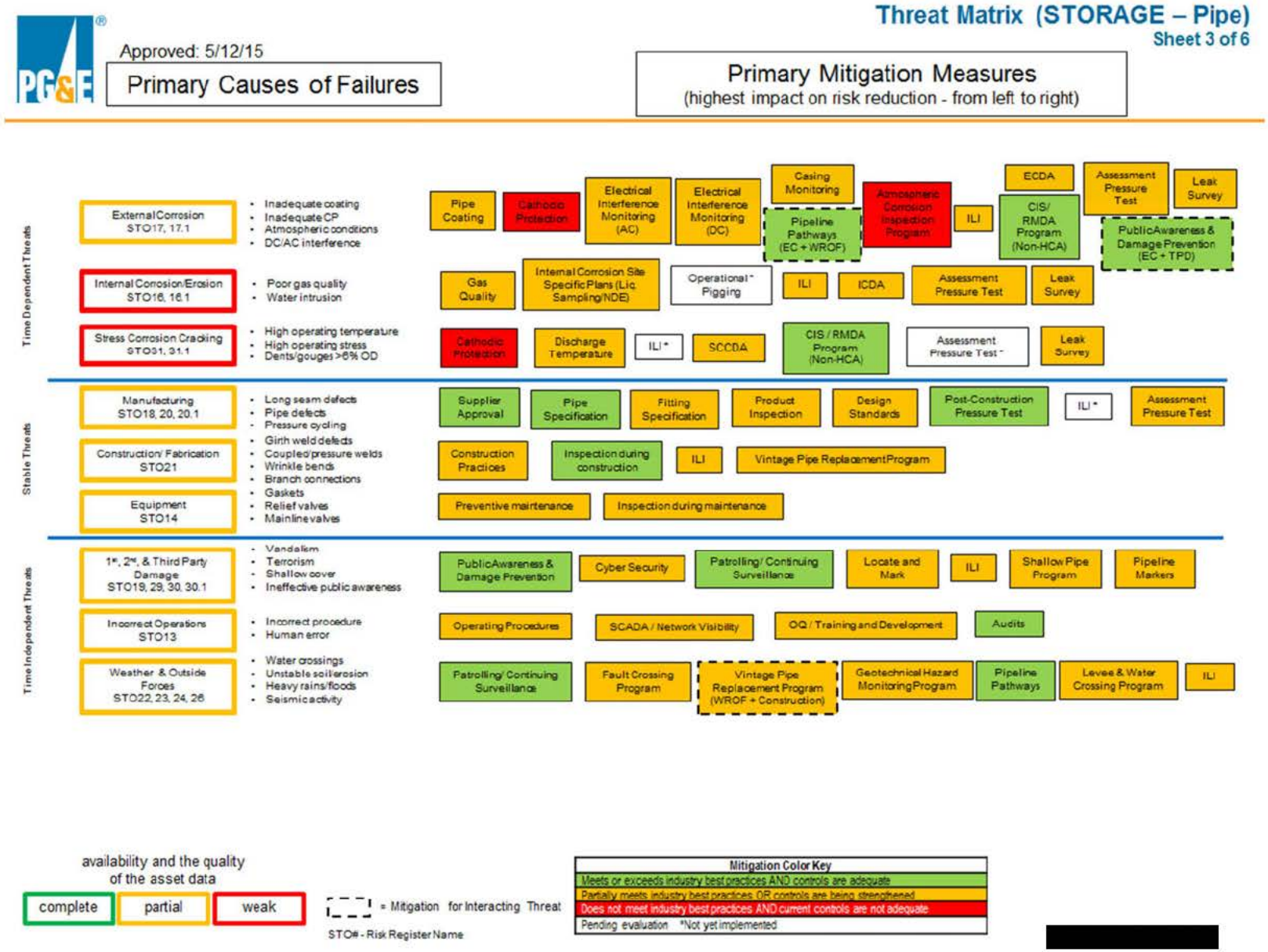
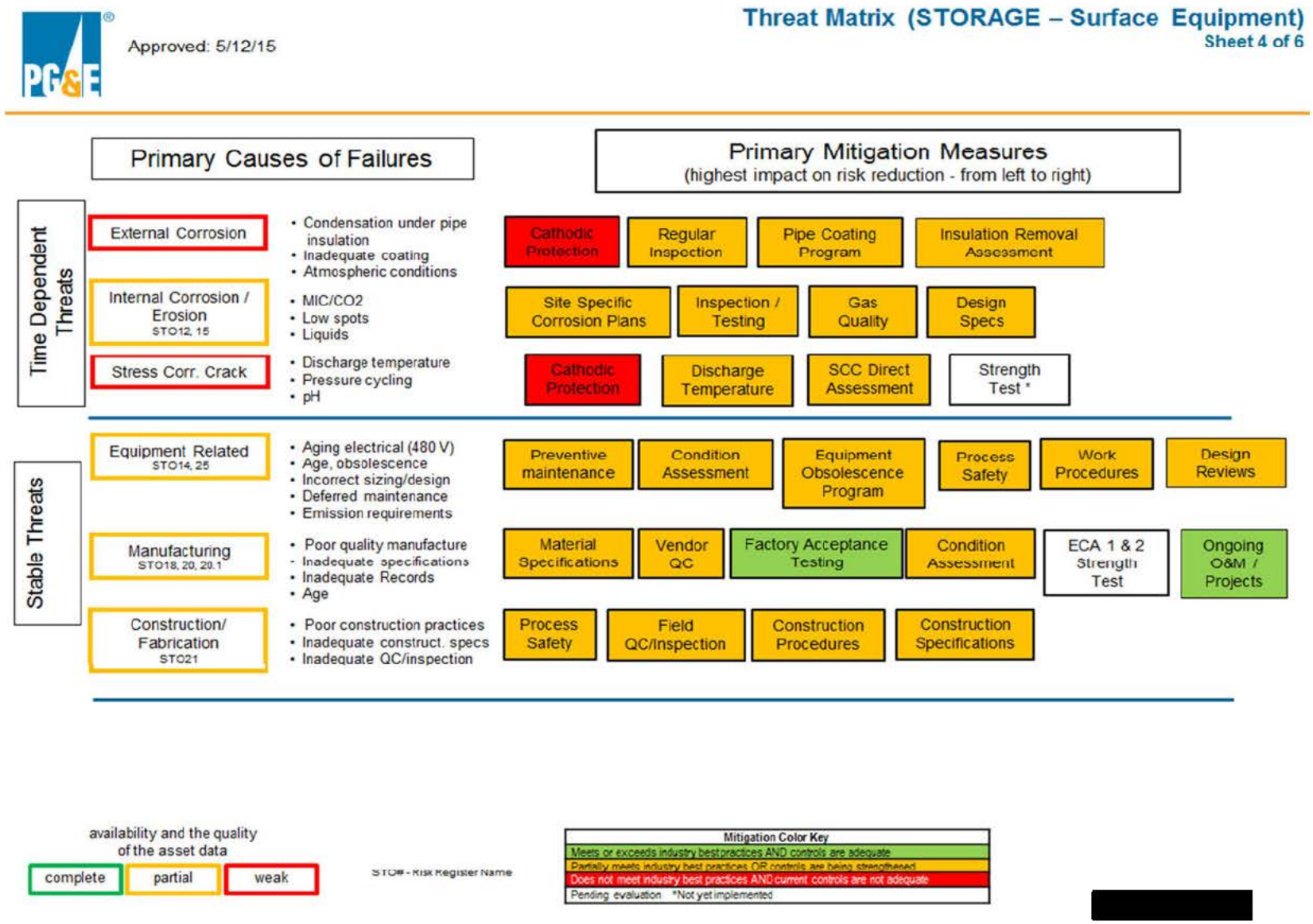


Figure 10 - Threat Matrix (Storage – Surface Equipment)

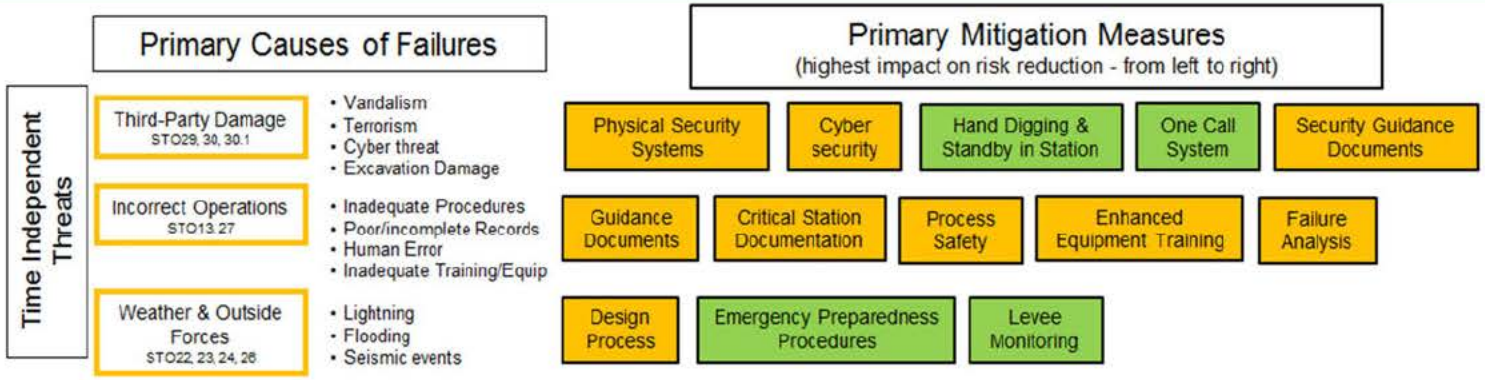


Below is a continuation of the Threat Matrix for Storage – Surface Equipment.

Approved: 5/12/15

Threat Matrix (STORAGE – Surface Equipment)

Sheet 5 of 6



availability and the quality of the asset data

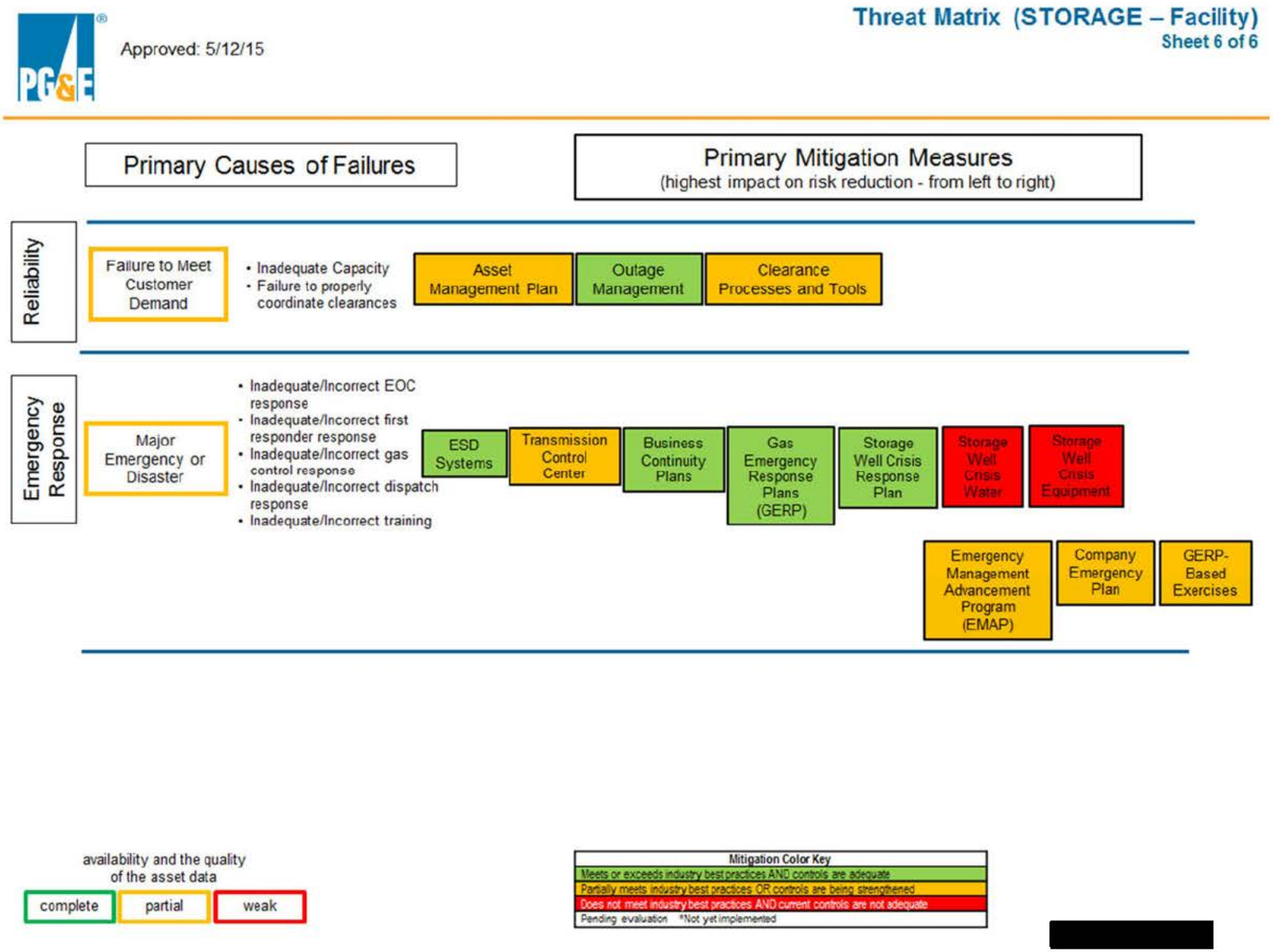
complete	partial	weak

STO# - Risk Register Name

Mitigation Color Key
Meets or exceeds industry best practices AND controls are adequate
Partially meets industry best practices OR controls are being strengthened
Does not meet industry best practices AND current controls are not adequate
Pending evaluation *Not yet implemented

[redacted]

Figure 11 - Threat Matrix (Storage – Facility)



Key Threats and Risks

The key threats and risks associated with the Gas Storage asset family, identifies the causes, inspection methods, primary preventative actions and mitigative actions taken as part of the ongoing management of the assets. The risk maybe triggered by a number of threats requiring identification, prevention and mitigation which is paramount to risk management.

The discussion below highlights the reason for the threat, possible consequences, and likelihood of failure. These threats guided the identification of the risks contained in the Storage Risk Register. The risks (labeled by Risk ID) associated with the threats are shown in Appendix C.

Internal Corrosion and Erosion (All Components Including Well Tubulars)

Internal corrosion and erosion are threats to all components of the storage asset. The associated risks are the loss of integrity of the component which may result in loss of containment of the storage gas with pressures ranging from 600 psig to 2,160 psig. This is a high risk to the Gas Storage asset family due to the gas quality of the storage gas being withdrawn from the storage formation. In storage operations the gas withdrawn from the storage formation and moved through the storage asset generally contains water, sand, and other gas components (e.g. CO2, H2S) that can cause either corrosion or erosion of the internal components. Due to the geological nature and completion of PG&E's storage fields and wells, the high potential to produce sand increases the likelihood of a risk of erosion at the impingement points (e.g. valves, elbows, tees) within the surface components.

Internal corrosion may also impact assets downstream of the Storage asset family. Whenever there is gas storage of natural gas delivered directly into the system there is the potential for moisture and corrosive agents to be introduced into the gas stream creating the potential for internal corrosion. This can happen, for instance, if dehydration or separation equipment does not function properly. Moreover, Microbiologically Induced Corrosion (MIC) is a threat to PG&E's storage assets which can also become a threat to PG&E's transmission pipe assets since MIC can travel via the gas stream to other parts of the system.

External Corrosion (All Components Including Well Tubulars)

External corrosion is a threat to transmission pipelines in the storage asset family and the risk associated with this threat is the loss of integrity of the component which may result in the loss of containment of storage gas with pressure ranges of 600 psig up to 2,160 psig. This risk is also applicable to the surface and production casings in the storage wells as the likelihood of failure due to external corrosion can be found where the cement sheath surrounding the tubulars is not present. The consequences of failure due to external corrosion can result in a loss of isolation and access to the storage service, uncontrolled flow or lost production from a storage well which could have multiple impacts such as: employee/public health and safety, regulatory non-compliance, fluids potentially entering the surface and groundwater or other environmentally sensitive areas, reduction of service to PG&E's customers, financial impacts to the public/company, and trust in PG&E. An event involving storage wells may also require a prolonged response to bring the well under control.

Stress Corrosion Cracking (SCC)

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. The risk associated with the threat of stress corrosion cracking is the loss of integrity of the component as the components experience pressure ranges of 600 psig to 2160 psig as gas is injected and withdrawn

from the facility. In the development of the risk register for the asset family the risk of stress corrosion cracking was not perceived as a high likelihood of failure based on the Stress Corrosion Cracking Direct Assessments (SCCDA) conducted on approximately 2.5 miles of HCA pipe within the Gas Storage asset family.

The risk associated of SCC for storage is considered a known unknown as there is no documented case of failure per the subject matter experts whom reviewed the Risk Register.

Manufacturing

Manufacturing issues related to long seam and pipe defects of the storage asset can result in risk such as the loss in integrity of the component as the components experience pressure that ranges of 600 psig to 2,160 psig as gas is injected and withdrawn from the facility. In the development of the risk register for the asset family the risk of manufacturing threats was not perceived as a high likelihood of failure based on the judgment of the subject matter experts and the existing GIS and storage well file records.

Construction/Fabrication

Construction/fabrication threat from a Third Party or PG&E drilling through and/or into the storage reservoir, and/or reworking storage wells can result in an improperly completed and poorly constructed well. The risk associated with improper connection of the tubulars and/or a bad cement job is the loss of integrity of the well or storage caprock to contain the storage gas.

Risks associated with poor construction of girth welds, coupled/pressure welds, wrinkle bends, and branch connections include a loss of integrity of the component as the components experience pressure ranges of 600 psig to 2,160 psig as gas is injected and withdrawn from the facility. In the development of the risk register for the asset family the risk of manufacturing threats was not perceived as a high likelihood of failure risk based on the judgment of the subject matter experts and the existing GIS and storage well file records.

Equipment

The safety valves, surface flow control valves, and well measurement for the storage wells have been automated at Los Medanos and McDonald Island. As gas is injected and withdrawn from the facility, the risk of automation controls failing could result in either a loss in integrity of the transmission pipe or damage of the storage well gravel pack. The subject matter experts perceive there is a moderate likelihood of failure risk and a full assessment is in progress.

An event with a storage well may also require a prolonged response to bring the well under control. Overflow of a storage well can also result in the gravel pack being damaged resulting in a reduction in performance and any associated sand being produced has the potential to erode impingement points in the storage piping and wellhead.

Third Party Damage or Cyber Threats

Third party threats and the risks associated with vandalism, immediate hits, and delayed damage could result in either a loss in integrity of the transmission pipe as gas is injected and withdrawn from the facility. In addition, there is a risk that third parties drill into the storage field because PG&E does not have all the licenses / rights to storage gas. This would allow the third party to produce storage gas. PG&E has completed annual assessment of its gas storage rights. The assessment indicates there is a low likelihood of failure at McDonald Island, Los Medanos, and Pleasant Creek as PG&E has the

necessary rights to store gas in the fields. A risk does exist as PG&E must meet the terms of the agreements (e.g. rentals and royalties).

PG&E has historically implemented mitigation measures to improve physical security at critical gas transmission facilities including compressor stations and gas storage 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 Supervisory Control and Data Acquisition (SCADA) and process control, the threat of third party damage is 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

The threat of incorrect operations can lead to the risk of incorrect procedures of all asset components and human error that could result in a loss in integrity of the transmission pipe as gas is injected and withdrawn from the facility. There is a risk of over-pressurization during injection of fluids by a third party or PG&E that results in the caprock integrity becoming compromised which leads to the migration, loss of gas, or need to abandon the storage field indefinitely. Storage fields are designed not to exceed the lowest of the three pressures of the storage formation and caprock:

1) Fracture gradient pressure that causes the formation to separate (frac)

2) Threshold pressure in which fluid can be displaced from the pore space of the caprock

3) Original reservoir pressure of the storage formation

The mitigation measures that are available to PG&E to reduce the risks include correct operating procedures, visibility of the operating pressures and volumes on a real-time basis, having a well trained staff, and audits of the operations. Storage reservoir integrity risk is not visible and not easily recognizable as these tend to be small leakages and require extensive reservoir studies to identify.

The reservoir composition is a threat for the storage asset family as each gas storage reservoir is unique when examining the petrophysics, mineralogy, and cementation of the rock within the storage reservoir. Without understanding the rock of the reservoir there is a threat that utilizing the incorrect fluids could result in clay swelling or participating solids into the pore throats of the rock which impedes the flow of the storage gas.

Industry research has demonstrated that most chemicals utilized to treat the surface pipes for hydrates and corrosion have potential to damage the storage reservoirs. The consequences of failure due to not having an understanding of the storage reservoir could result in a reduction in field production capability.

Weather and Outside Forces

The threat of outside forces is associated with the risk of cold weather, lightening, heavy rains/flooding, and earth movement that could result in a loss in integrity of the transmission pipe as gas is injected and withdrawn from the facility or access to the asset. Further evaluation shows that PG&E participates in the Reclamation District which maintains the McDonald Island levee. The Reclamation District maintenance of the levee system is directed by 1985 study that set out priorities of maintenance and repair. The District is in the process of evaluating the need to update the 1985 study to consider

sea level rising and impact of climate change and need to develop GIS based databases. The facility is located in a flood plain in the Delta region and is vulnerable to flooding. The PG&E-owned compression and processing equipment are installed on platforms that elevate the piping and equipment above the flood plain, enabling the facility to operate in the event of a levee break. However, prolonged flooding would increase the risk of failure of transmission pipelines due to corrosion, potential collision of debris into the storage wellheads resulting in a loss of well containment, or well controls failing at those locations that are not located on the platforms.

Additionally, subsidence (i.e. 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 gas lines running from the wellheads to the flow meter runs. Subsidence at McDonald Island is a known threat and requires continuous monitoring and mitigation such as was relieving the stress in the connected pipe to the McDonald 5A well. There is a risk of loss of service and safety impacts due to possible loss of containment.

Other – Completion and Reservoir Geological Characteristics

The reservoir petrophysical and geological characteristics are a threat for the storage asset family as each gas storage reservoir is unique when examining the petrophysics, mineralogy, and cementation of the rock within the storage reservoir. Without understanding the rock of the reservoir there is a threat in utilizing the incorrect fluids could result in clay swelling or participating solids into the pore throats of the rock which impedes the flow of the storage gas. Industry research has demonstrated that most chemicals utilized to treat the surface pipes for hydrates and corrosion will damage the storage reservoirs. Additionally, poor cementation of the reservoir will allow for the migration of reservoir particulates and fines to reduce the pore throats size within the gravel pack.

C. Asset Family Risks

The Storage asset family risks below are sorted below by risk ranking. Also, related risks are listed for Storage (STO), Transmission Pipe (TRA), Compression & Processing (CP), and Measurement & Control (MC) asset family risks.

Table 25 - Storage Risks and Related Risks

Risk ID	Asset Type	Threat	Risk	Related Risks
STO016	Pipeline	Internal corrosion and/or Erosion	Rupture of pipeline due to internal corrosion and/or erosion may result in loss of containment, and/or uncontrolled gas flow that may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage and/or environmental damage.	Calibrated with TRA008 Related to STO016.1
STO017	Pipeline	External Corrosion	Rupture due to external corrosion of the pipeline which may result in the loss of pipeline isolation and access as well as an uncontrolled flow or lost production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Calibrated with TRA001 Related to STO017.1
STO026	All Segments	Weather and Outside Forces (Seismic)	Loss of withdrawal platform, buildings and equipment due to seismic activity/earthquake that may result in the loss of containment or ability to provide storage service. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage.	N/A
STO005	Well Casing	Corrosion	Loss of well integrity due to well casing corrosion (internal or external, or stress corrosion cracking) that may result in an uncontrolled flow of gas outside of well casing with ignition source, drinking water contamination, gas migration, or gas loss. This may lead to major impact on public or employee safety, facility outage or net replacement of supply, property damage and/or environmental damage.	Related to STO005.1
STO020	Pipeline	Manufacturing	Rupture of pipeline due to manufacturing may result in loss of containment, and/or uncontrolled gas flow that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Calibrated with TRA004 Related to STO020.1

Risk ID	Asset Type	Threat	Risk	Related Risks
STO015	Valves	Erosion	Erosion of valves may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	N/A
STO012	Meters	Equipment	Compromised measurement may result in uncontrolled flow and release of gas. This may lead to a significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	N/A
STO018	All Segments	Fatigue	Failure of pipeline, equipment, and pipeline controls due to fatigue from internal pressure cycling or vibration may result in loss of containment. This may lead to significant impact on public or employee safety, outages, property damages and/or environmental damage.	N/A
STO037	Pressure Vessels	Internal Corrosion and/or Erosion	Through wall leaks in pressure vessels due to internal corrosion and/or erosion that may result in uncontrolled flow of gas. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or environmental damage.	Calibrated with CP010
STO030	All Segments	1st, 2nd, 3rd Party Damage	Rupture of belowground pipeline or uncontrolled flow from other storage assets due to 1st, 2nd, and 3rd Party damage caused by equipment/vehicles who may not have followed work procedures that may result in uncontrolled flow of gas, outages or replacement of gas supply. This may lead to major impact on public or employee safety, outages or replacement of gas supply, property damage and/or minor environmental damage.	Calibrated with TRA006 and TRA0014 Related to STO030.1
STO003	Reservoir	Construction by 1st & 2nd Party	Loss of reservoir integrity due to 1st and 2nd party drilling through storage field or reworking 1st and 2nd Party well that may result in an improper completion of the well or uncontrolled flow or loss containment with ignition source that can lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	N/A

Risk ID	Asset Type	Threat	Risk	Related Risks
STO019	Pipeline	3rd Party Damage	Rupture of pipeline due to mechanical damage by 3rd party may result in the loss of pipeline isolation and access as well as uncontrolled flow and loss in production. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Calibrated with TRA006
STO021	Pipeline	Construction	Rupture of pipeline due to vintage construction which may result in loss of containment and/or uncontrolled gas flow. This may lead to significant impact on public safety, property damage, prolonged outages or loss of supply, and/or significant environmental damage.	Calibrated with TRA003
STO029	All Segments	3rd Party Damage	Vandalism and/or vehicular damage on above ground pipeline, equipment, wellheads, or valves that may result in damage, over-pressurization, and/or loss of containment. This may lead to impact on public or employee safety, minor outages, property damage and/or minor environmental damage.	Calibrated with CP019 and TRA023
STO023	McDonald Island	Weather and Outside Force	Rupture of pipeline and/or failure of well structure due to subsidence at McDonald Island which may result in uncontrolled flow of gas. This may lead to significant impact on public or employee safety, prolonged outages or replacement of supply, property damage, and/or environmental damage.	Calibrated with STO022 and TRA012
STO013	Valves	Incorrect Operations	Incorrect valve operations which may result in the failure of control valves to open, close, or shut-in. This may lead to minor impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage. (P50)	N/A
STO031	Pipeline	Stress Corrosion Cracking	Rupture of pipeline due to stress corrosion cracking (SCC) may result in loss of containment, and/or uncontrolled gas flow. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage.	Calibrated with TRA009 Related to STO031.1

Risk ID	Asset Type	Threat	Risk	Related Risks
STO011	Wells	Erosion	Damage to the wellhead due to erosion that may result in loss of well isolation and access or uncontrolled flow with ignition source. This may lead to significant impact on public or employee safety, prolonged outages or net replacement of supply, property damage and/or environmental damage.	N/A
STO010	Wells	Incorrect Operations	Failure of well control system during an emergency due to incorrect operations from not following procedures or equipment impairment which may result in uncontrolled gas flow with ignition source. This may lead to significant impact on public or employee safety, and/or prolonged outages or net replacement of supply.	N/A
STO004	Reservoir	Incorrect Operations	Over-pressurization that may result in compromising caprock integrity, gas migration, loss of gas, drinking water contamination, or need to abandon the storage field indefinitely. This may lead to impact on public or employee safety, prolonged outages or net replacement of supply, property damage and/or environmental damage.	N/A
STO022	Los Medanos and Pleasant Creek	Weather and Outside Force	Rupture of pipeline and/or failure of well structure due to subsidence at Los Medanos and Pleasant Creek which may result in uncontrolled flow of gas. This may lead to significant impact on public or employee safety, prolonged outages or replacement of supply, property damage, and/or environmental damage.	Calibrated with STO023 and TRA012
STO025	Storage Field Facilities	Equipment	Interruption of power and failure of backup system at the facilities which may result in loss of operation of equipment and monitoring technologies. This may lead to minor impact on public or employee safety, outages or net replacement of supply or property damage. (P50)	N/A
STO020.1	Pipeline	Manufacturing	Leak in pipeline due to manufacturing may result in loss of containment, and/or uncontrolled gas flow. This may lead to minor impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage. (P50)	Calibrated with TRA005 Related to STO020

Risk ID	Asset Type	Threat	Risk	Related Risks
STO027	Storage Field Facilities	Incorrect Operations	Technology used for monitoring and controlling assets is incorrectly maintained or damaged which may result in loss of well control, manual operations or not being able to operate storage facilities. This may lead to significant impact on outages or net replacement of supply.	N/A
STO016.1	Pipeline	Internal Corrosion and/or Erosion	Leak in pipeline due to internal corrosion and/or erosion may result in loss of containment, and/or uncontrolled gas flow or lost production. This may lead to minor impact on public or employee safety, outages or net replacement of supply, property damage and/or environmental damage. (P50)	Calibrated with TRA015 Related to STO016
STO014	Valves	Equipment	Failure of valves to control due to incorrectly or poorly maintained equipment which may result in a well overflow. This may lead to impact on public or employee safety, prolonged outages or net replacement of supply, property damage.	N/A
STO002	Reservoir	Construction by 3rd Party	Construction by a 3rd Party drilling through storage field or reworking 3rd Party well that may result in an improper completion of the well or uncontrolled flow or loss of containment. This may lead to impact on public or employee safety, outages or replacement of supply, and property damage.	N/A
STO031.1	Pipeline	Stress Corrosion Cracking	Leak in pipeline due to stress corrosion cracking (SCC) may result in loss of containment, and/or uncontrolled gas flow. This may lead to minor impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage. (P50)	Related to STO031
STO030.1	All Segments	1st, 2nd, 3rd Party Damage	Leak of belowground pipeline or mechanical damage to storage assets due to 1st, 2nd, and 3rd Party equipment/vehicles who may not have followed work procedures that may result in uncontrolled flow of gas, outages or replacement of gas supply. This may lead to minor impact on public or employee safety, outages or replacement of gas supply, property damage and/or minor environmental damage. (P50)	Related to STO030

Risk ID	Asset Type	Threat	Risk	Related Risks
STO024	McDonald Island	Weather & Outside Forces	McDonald Island levee break that may result in loss of well, reservoir or facility isolation and access, and uncontrolled flow. This may lead to significant impact on prolonged outages or replacement of supply, property damage, and/or environmental damage.	Calibrated with CP004
STO033	Gill Ranch – Disposal Well	Incorrect Operations, Equipment	Failure to dispose of produced fluids in a Gill Ranch disposal well which may result in the curtailment of gas production.	N/A
STO017.1	Pipeline	External Corrosion	Leak on the pipeline due to external corrosion which may result in the loss of pipeline isolation and access as well as an uncontrolled flow or lost production. This may lead to minor impact on public or employee safety, prolonged outages or net replacement of supply, property damages and/or environmental damage. (P50)	Calibrated with TRA002 Related to STO017
STO034	Gill Ranch – Disposal Well	Internal/External Corrosion	Failure of casing integrity due to corrosion may result in the loss of Gill Ranch disposal well isolation, curtailment of gas production, and/or environmental damage.	N/A
STO005.1	Well Casing	Corrosion	Leak in well casing pipe due to corrosion which may result in the minor loss of well isolation and access, uncontrolled flow of gas and loss of production which may result in minor impact on public or employee safety, outages or net replacement of supply, property damages and/or minor environmental damage. (P50)	Related to STO005
STO001	Reservoir	3rd Party Damage	A 3rd party drilling into a storage field if PG&E does not have the rights/licenses or has lease payment lapse to store gas in all of the acreage which may result in a loss of gas and PG&E trespass. This may lead to replacement of gas supply and property damage.	N/A
STO035	Reservoir	Outside Forces (Geological)	Geological uncertainty which may result in the loss of inventory or gas migration from the storage reservoir or influx of reservoir fluids impounding or trapping storage gas.	N/A

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 26 - Stakeholder Roles and Responsibilities Matrix

Stakeholder Group	Primary Contact	Creation / Enhancement				Utilization	Maintenance	Decommission / Dispose
		Conception	Design	Procure	Construct / Start-up			
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	Sr. 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
Wholesale Marketing & Business Development	Director	X				X		X
General Construction	Sr. Director				X			X
Transmission Integrity Management	Director	X	X	X	X	X	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 27 - 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			
Valve automation	X	X			
Public awareness	X	X			
Inoperable & Hard-to-Turn Valves	X	X	X	X	

Programs of Work	Transmission Pipe	Gas Storage	M&C	C&P	Other
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

The following is a glossary of acronyms and abbreviations used in this asset management plan and related documents.

Table 28 - Acronyms and Abbreviations

Acronym	Meaning
AC	Atmospheric Corrosion
AF	Asset Family
AFO	Asset Family Owner
AHS	Asset Health Scorecard
AMBBS	Asset Management Backbone & Stations
AMP	Asset Management Plan
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
Bcf	Billion cubic feet
BHP	Brake Horsepower
C&P	Compression & Processing
CAP	Corrective Action Program
CIS	Close Interval Survey
CNG	Compressed Natural Gas
CP	Cathodic Protection
CPUC	California Public Utilities Commission
DHSV	Downhole Safety Valve
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

Acronym	Meaning
ESD	Emergency Shut Down
FIMP	Facility Integrity Management Program
GC	Gas Chromatograph
GIS	Geographic Information System
GPOM	Gas Pipeline Operations & Maintenance
GRC	General Rate Case
GRN	Gamma Ray Neutron
GSDB	Gas Storage Database
GT	Gas Transmission
GTI	Gas Technology Institute
GT&S	Gas Transmission and Storage
HAZOP	Hazard and Operability
HCA	High Consequence Area
HP	Horsepower
I/W	Injection/Withdrawal
IC	Internal Corrosion
ICDA	Internal Corrosion Direct Assessment
ILI	In-Line Inspection
IM	Integrity Management
IMLAP	Internal Metal Loss Action Plan
I&R	Instrument & Regulation
LM	Los Medanos
LNG	Liquefied Natural Gas
LOB	Line of Business
M&C	Measurement and Control

Acronym	Meaning
MAOP	Maximum Allowable Operating Pressure
MAT	Major Activity Type
Mcf	Thousand cubic feet
MFL	Magnetic Flux Leakage
MMcf	Million cubic feet
MI	McDonald Island
MIC	Microbiologically Induced Corrosion
MIT	Mechanical Integrity Test
ML	Microlog
MMCF	Millions of Cubic Feet
MOP	Maximum Operating Pressure
NDE	Non-Destructive Examination
NOV	Notice of Violation
OBS	Observation
OPP	Over-Pressure Protection
OSHA	Occupational Safety and Health Administration
PC	Pleasant Creek
PCC	Provider Cost Center
PG&E	Pacific Gas and Electric
PHA	Process Hazard Analysis
PHMSA	Pipeline and Hazardous Materials Safety Administration
PLC	Programmable Logic Controller
PLM	Pipeline Maintenance
PM	Preventive Maintenance

Acronym	Meaning
PRCI	Pipeline Research Council International
PSIG	Pounds per Square Inch Gauge
PSRS	Project Status Reporting System
PSSR	Pre-Startup Safety Review
RIM	Records Integrity Management
SAP	Systems, Applications, Products
SCADA	Supervisory Control and Data Acquisition
SCC	Stress Corrosion Cracking
SCCDA	Stress Corrosion Cracking Direct Assessment
SME	Subject Matter Expert
SWD	Salt Water Disposal
TCS	Turner Cut Station
TIMP	Transmission Integrity Management Program
TSA	Transportation Security Administration
UHSV	Uphole Safety Valve
USA	Underground Service Alert
UVIR	Ultra Violet InfraRed
VIED	Vehicular Improvised Explosive Device
WD	Withdrawal
WELL	Well Integrity Management Program
WSS	Whiskey Slough Station

G. Change Log

The following table summarizes revisions since the previous publication of GP-1108: Gas Storage Asset Management Plan, Revision 2, 8/12/2015.

Table 29 - Asset Management Plan Change Log

Section	Change	Reason for Change	Implication of Change
2	Added sand inspection and leak survey results	Provide more condition data.	
4	Added details about desired state.	Provide clarity.	Maturing of asset management.
Appendix J	Added DOGGR Emergency Regulations	Provide PG&E status	
Entire Asset Management Plan	Updated charts and table	Updated with current data.	

H. Asset Health Scorecard

The Asset Health Scorecards (AHS) for gas storage wells and their associated components is a method that quantifies the overall health of aggregated wells within a gas storage field by utilizing a set of metrics to score major components within a gas well and using these component scores to grade the well condition. The individual well scores roll-up to an overall pad/platform score and the pad/platform condition scores roll-up to an overall field condition score. The AHS will provide the asset family owner with asset reporting, improved analytics, and insight into asset performance and condition by:

- Using actual asset attribute data uploaded into a database system.
- Generating reports which assess asset health using diagnostic testing data.
- Presenting data metrics which identifies assets in poor condition.

The basic elements evaluated when performing a condition assessment of Gas Storage Facilities are the individual components (pieces of equipment) within the well. The condition assessment of these components makes use of specific properties to determine the relative ranking of health of the component. The individual property scores are combined using a weighted summation to compute an overall score for the evaluated component. The individual component scores are combined to calculate the overall health score of their associated well. The individual component weighing factors are summarized in Tables 30 and 31. The well scores that comprise the wells associated with a specific pad/platform contribute to the health score of that pad/platform. Table 32 shows an example of well weighing factors for a specific pad/platform. The pad/platform scores in each field cascade to the overall health score of the field. Weighing factors for calculating the overall health score of a field are shown in Table 33. The Asset Hierarchy for Gas Storage is summarized in Figure 12.

Table 30 - Example of Property Weightings at Component Level

Health Property	Health Property Weighting Factor	Component Grade
Wellhead Leak	15%	∑ of Health Property Scores
Hydraulic Port Leak	15%	
Casing Wing Valve1 External Leak	10%	
Casing Wing Valve 2 External Leak	10%	
Master Gate Valve (Tubing) External Leak	10%	
Casing Wing Valve 1 Internal Leak	10%	
Casing Wing Valve 2 Internal Leak	10%	
Master Gate Valve (Tubing) Internal Leak	10%	
Physical Condition	10%	

Table 31 - Example of Component Weightings at Well Level

Component	Component Weighting Factor	Well Grade
Wellhead Including Flanges	5%	∑ of Component Scores
Well Location	5%	
Surface Casing	15%	
Up Hole Safety Valve - Tubing	12.5%	
Up Hole Safety Valve - Casing	12.5%	
Gravel Pack/ Liner	15%	
Down Hole Safety Valve	15%	
Production Casing	20%	
Tubing	0%	

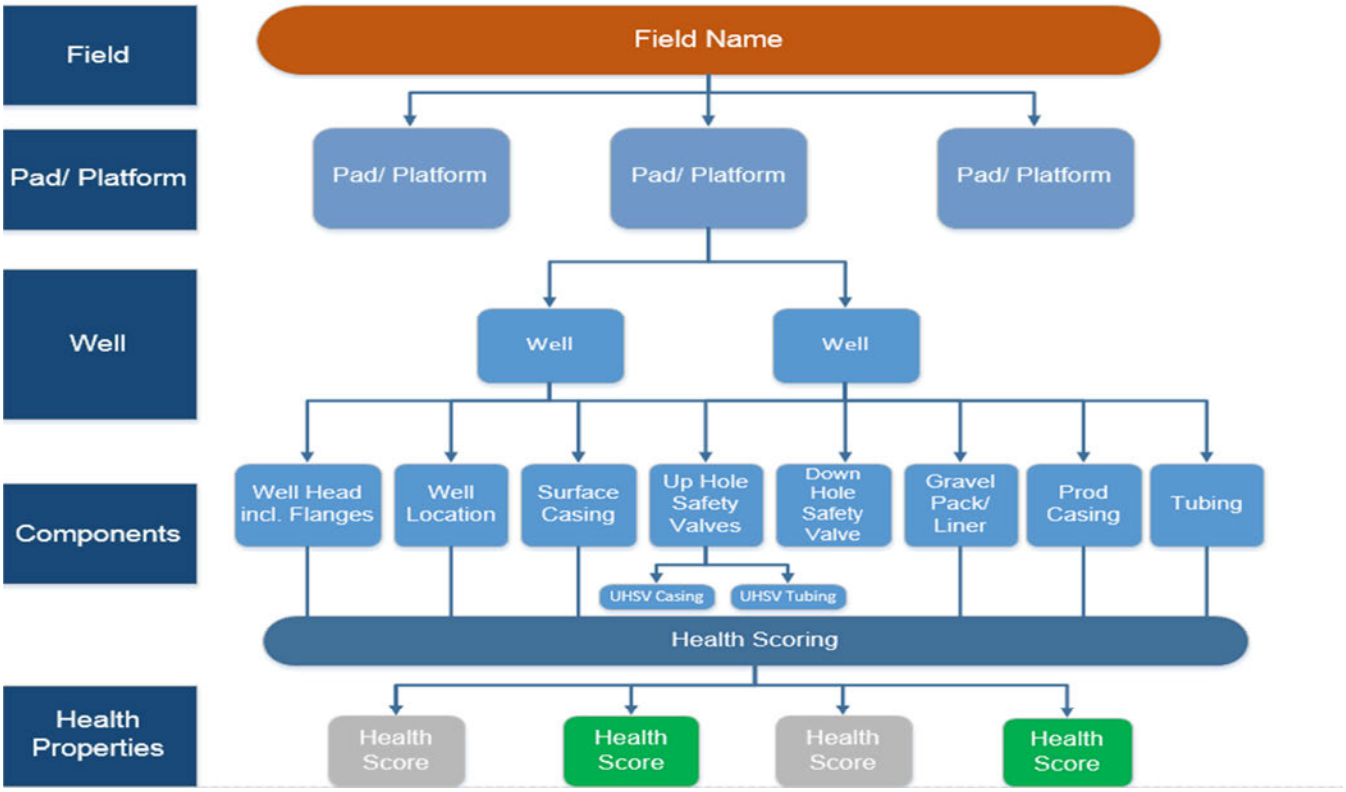
Table 32 - Example of Well Weightings at Pad/Platform Level

Well	Well Weighting Factor	Pad A Grade
LM-1A	~ 33%	∑ of Well Scores
LM-2A	~ 33%	
LM-3A	~ 33%	

Table 33 - Example of Field Pad/Platform Weightings at Field Level

Pad/Platform	Pad/Platform Weighting Factor	Field Grade
Whiskey Slough	~ 39%	∑ of Pad/Platform Scores
Turner Cut	~ 39%	
Peripheral / Non-Platform Wells	~ 15%	
Observation Wells	~ 7%	

Figure 12 - Storage Asset Health Scorecard Hierarchy



The data evaluated includes properties that measure the condition of the component. The data measured by these properties is evaluated and quantified as a numerical score, using a point scale with a range of 1 to 10, where lower scores indicate better component condition. Then a weighted summation of the individual health property scores for a component are subsequently rolled up to a well, pad/platform, and field level which are also on a 1 through 10 score.

A red, amber, green (RAG) status for scores and dashboard of preliminary results of the well assets for the Asset Health Scorecard (AHS) is as follows:

Table 34 - Storage AHS Red, Amber, Green Status

RAG Status:
$1 \leq x \leq 3.3$
$3.3 < x \leq 6.6$
$6.6 < x \leq 10$

Figure 13 - Storage Asset Health Dashboard - Preliminary Results

Storage Asset Health Dashboard

Average Scores			
	Pad	Well	Component
Los Medanos	3.14	3.19	2.60
McDonald Island	2.66	2.84	2.39
Pleasant Creek	2.14	2.14	1.98

Component RAG Counter			
	Green	Amber	Component
Los Medanos	127	26	21
McDonald Island	420	97	70
Pleasant Creek	28	0	7

Highest Asset Health Score						
	Los Medanos		McDonald Island		Pleasant Creek	
		Score		Score		Score
Pad/Platform	PAD A	3.54	Turner Cut	3.12	Pleasant Creek	2.14
Well	LM-17D	3.75	TC-12N	4.27	PC 4-1	2.28

At the time of this Asset Management Plan's publication, the Storage asset family was performing quality assurance on the calculated condition health scores. Another phase of the development of this scorecard will be to analyze the weighting of scores. Future progress of the Asset Health Scorecard will be to adopt the scoring methodology developed by the Transmission Pipe, Compression & Processing, and Measurement & Control asset families and incorporate them into the health of the Storage facilities.

I. Research Projects

The following table shows an overview of research projects in progress, completed projects, and the related risks being addressed.

Table 35 - Research Projects 2013 – 2017

Ref.	Risks	Description	Vendor	Status	Planned Completion
1	STO018, STO020, STO020.1	Explorer Hardness Tester	NYSEARCH	Active	2016
2	STO031, STO031.1	Robotics (Explorer) Crack Sensor	NYSEARCH	Completed	2015
3	STO005, STO005.1	Factors Affecting Downhole MFL Accuracy (US-3B)	PRCI-2013	Completed	2013
4		Improving Casing Assessments: Downhole Stress Effects on MFL and Confirmation of RSTRENG accuracy (US-3B)	PRCI-2014	Active	2015
5		ILI Technology Comparative Testing (US-3J)	PRCI-2015	Active	2016
6		Defect Characterization of Well Casing Pipe Using NDT to Confirm Field ILI Tool Accuracy (US-3H)	PRCI-2015	Active	2016
7		Cement Degradation Mechanisms (US-3A)	PRCI-2012	Completed	2013
13		Assess the Accuracy of MFL Inspection Tools, US-3K	PRCI-2016	Active	2016
20		Field Evaluation of Cement Bond Log Tool, US-4-1	PRCI-2016	Active	2016
8	STO022, STO023, STO024, STO026	Unmanned Aerial System (UAS) Regulatory and Assessment	NYSEARCH	Active	2016
14		Application of Miniature Methane/Ethane Sensors on Small-UAV ROW-3H	PRCI-2016	Active	2017
15		Fast, Accurate, Automated System to Find and Quantify Natural Gas Leaks (ROW-3H)	PRCI-2014	Active	2016
16		UC Merced Applicability of Unmanned Aerial Systems for Leak	UC Merced	Completed	2015
9	Methane	Methane Emissions Quantification Project	LBNL	Active	2016

Ref.	Risks	Description	Vendor	Status	Planned Completion
12	Reduction	Review Methane Emission Qualification Techniques, US-4-2	PRCI-2016	Active	2016
10	STO017, STO017.1	Field Applied Coatings Performance	OTD-GTI	Completed	2014
11	STO029	Demonstration of a cyber security device	SecLab	Completed	2014
17	STO005, STO005.1	NYSEARCH - Robot to visually inspect pipe casing	NYSEARCH	Active	2016
18	STO016, STO016.1, STO017, STO017.1	Develop an Alternate Method for Potential Measurement to Satisfy the Cathodic Protection Criteria	PRCI-2013	Completed	2014
19		Internal Corrosion Sample Collection Guidelines	PRCI-2014	Completed	2014
21		Real-Time Active Pipeline Integrity Detection System	CEC	Completed	2015
22	STO022, STO023, STO024, STO026	Girth weld integrity underground movement	JIP CRESS	Completed	2016

J. DOGGR Emergency Regulations

On October 23, 2015, a leak was detected at Southern California Gas Company's (SoCal Gas) Aliso Canyon underground storage facility and was permanently plugged on February 18, 2016. During the leak on January 6, 2016, the California Governor issued a state of emergency through a proclamation with 14 directives. The Division of Oil, Gas, and Geothermal Resources (DOGGR) then issued Emergency Regulations (Requirements for Underground Gas Storage Projects, California Code of Regulations Title 14, Division 2, Chapter 4, Subchapter 1, Article 3, Section 1724.9) based on the Governor's Emergency Proclamation Directive #13 with an effective date of February 5, 2016. As of the writing of this Asset Management Plan, PG&E has completed five of the seven items included in the DOGGR Emergency Regulations with the pending two items on target for completion by August 2016. The following table lists the status of PG&E's efforts related to the DOGGR Emergency Regulations as of June 2016.

Table 36 - PG&E's Status of DOGGR Emergency Regulations

Directive #	Description	Status
13a	Providing required data.	• On-going. • PG&E has submitted responses in timely manner.
13b	Establish minimum and maximum pressure limits for each gas storage facility in the state.	• In progress. • Developing supporting documentation due Aug 18, 2016.
13c	Verification of the mechanical integrity of all gas storage wells.	• Complete and on-going.
13d	Regular testing of all safety valves used in wells.	• Complete. • PG&E submitted letter to DOGGR on May 25, 2016, regarding 5 wells' valves to be replaced during 2016 rework program.
13e	Daily inspections of gas storage well heads, using gas leak detection technology.	• Complete. • Daily inspections and leak survey implemented Jan 23, 2016. • Submitted protocol Feb 26, 2016. • Received DOGGR feedback April 5, 2016. • Submitted revised protocol May 16, 2016. • DOGGR and ARB reviewing week of June 6, 2016.
13f	Regular testing of master valves and isolation valves.	• Complete. • DOGGR witnessed testing. • All valves had successful functional test.
13g	Establish a comprehensive risk management plan that evaluates and prepares for risks at each facility, including corrosion potential of pipe and equipment.	• In progress and on track to meet Aug 5, 2016 deadline.

K. Roadmap

The following figure shows an overview of milestones for data improvement and mitigation programs utilized in the Storage asset family to assess condition and risk.

Figure 14 - Gas Storage Asset Family Roadmap for 2014 – 2020