Risk Assessment Mitigation Phase
Risk Mitigation Plan

Catastrophic Event Related to Storage Well Integrity
(Chapter SCG-11)

November 30, 2016

Southern California Gas Company
A Sempra Energy utility

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Executive Summary

The Catastrophic Event Related to Storage Well Integrity risk addresses the risk drivers, potential consequences, and baseline and proposed mitigations related to the risk of a catastrophic event related to storage well integrity.

To assess this risk, Southern California Gas Company (SoCalGas) first identified a reasonable worst case scenario for such a catastrophic event related to storage well integrity. This risk is described as an uncontrolled release of gas that occurs over an extended period of time due to a storage well structural integrity issue that requires complex well control operations and results in gas reliability issues or other extensive customer impacts. This scenario was then scored against five residual impact categories (i.e., Health, Safety, Environmental; Operational & Reliability; Regulatory, Legal, Compliance; Financial; and Frequency), as further discussed in Section 3 below. This process resulted in a residual risk score for the identified risk. The residual risk score establishes a baseline and is then used to help assess the effectiveness of existing and proposed mitigations.

Concurrent with this process, SoCalGas examined the risk mitigation activities in place in 2015 and the estimated costs associated with these activities (costs are discussed in Section 4). SoCalGas identified the following categories of risk mitigation activities as of 2015:

1. Existing Maintenance Well Work; and
2. Existing Capital Well Work.

The above activities focus on safety-related impacts (e.g., Health, Safety, and Environment) per guidance provided by the Commission in Decision (D.) 16-08-018, as well as controls and mitigations that may address reliability. These activities establish a baseline that is used to help assess the effectiveness of proposed mitigations.

Based on the foregoing assessment, SoCalGas identified and proposes additional mitigation activities to mitigate the risks associated with the risk of a Catastrophic Event Related to Storage Well Integrity. Here, SoCalGas proposes to continue the two control categories, identified above, and to further mitigate risk through accelerated implementation of its Storage Integrity Management Plan (SIMP). SoCalGas' SIMP was modelled after the federally mandated distribution and integrity management programs, and was designed to provide a proactive, methodical, and structured approach, using state-of-the-art inspection technologies and risk management disciplines to address storage field and well integrity issues. For purposes of risk mitigation analysis, SoCalGas split SIMP activities into two categories:

1. SIMP – Assessments: SIMP includes the expanded use of workover rigs to evaluate downhole casing and tubing conditions. Surface equipment such as valves, wellheads, and well laterals are also evaluated using enhanced integrity management methods.

2. SIMP – New Integrity and Risk Management Regulations: SIMP also involves the development, management and support of the assessment activities, as well as materials and labor associated with new regulatory compliance activities and enhancements.

Using the above proposals, SoCalGas developed a risk spend efficiency. The risk spend efficiency is a new tool that SoCalGas developed to quantify how the proposed mitigations will incrementally reduce risk. The risk spend efficiency was based on subject matter expert input on risk reduction.

SoCalGas then considered potential alternatives to its proposal to continue baseline activities and accelerate SIMP implementation. SoCalGas determined that its proposal was the preferred means by which to enhance safety, reduce risk, and comply with applicable regulations.

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Risk: Catastrophic Event Related to Storage Well Integrity

1 Purpose

The purpose of this chapter is to present the mitigation plan of Southern California Gas Company (SoCalGas) for the risk of a Catastrophic Event Related to Storage Well Integrity. For purposes of this analysis, SoCalGas defines a reasonable worst case scenario for such a catastrophic event to include an uncontrolled release of gas that occurs over an extended period of time due to a storage well structural integrity issue that requires complex well-control operations and results in gas reliability issues or other extensive customer impacts. This risk implicates and this chapter considers risks associated with the following storage field components: (1) process and well servicing operations, well design, corrosion/erosion to casing, tubing, annulus or tree/wellhead; and (2) lateral piping integrity. This risk is applicable to SoCalGas' four active underground storage facilities: Aliso Canyon, Honor Rancho, La Goleta, and Playa del Rey.[1] In 2015, the internal organizations responsible for scoring and managing this risk mainly resided within Storage Operations. As of 2016, Storage Operations and the newly created Storage Risk organization are primarily responsible for managing this risk.

This chapter addresses 2015 baseline risk mitigation activities and costs, and includes analyses of proposed 2017-2019 risk mitigation activities and costs. The risk assessment for Catastrophic Events Related to Storage Well Integrity was completed in September 2015, prior to the October 23, 2015 Aliso Canyon SS-25 well incident.[2] Although the investigation into the cause of the incident is ongoing, the event prompted heightened awareness of underground storage operations risks. As a result, new regulations have been issued by the Division of Oil, Gas, and Geothermal Resources (DOGGR), Pipeline and Hazardous Materials Safety Administration (PHMSA), California Air Resources Board (CARB), and South Coast Air Quality Management District (SCAQMD), and SoCalGas has implemented additional enhancements and improvements of its own.

As mentioned above, this risk is a product of SoCalGas' September 2015 annual risk registry assessment cycle. Any events that occurred after that time were not considered in determining the 2015 risk assessment, in preparation for this Report. Note that while 2015 is used as a base year for mitigation planning, risk management has been occurring, successfully, for many years within the Company. SoCalGas and San Diego Gas & Electric Company (SDG&E) (collectively, the Utilities) take compliance and managing risks seriously, as can be seen by the number and scope of actions taken to mitigate each risk. As this is the first time, however, that the Utilities have presented a Risk Assessment Mitigation Phase (RAMP) Report, it is important to consider the data presented in this plan in that context. The baseline mitigations are determined based on the relative expenditures during 2015;

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[1] The risk does not include the Montebello facility, which was approved for abandonment in Decision 01-06-081.
[2] On October 23, 2015, SoCalGas' Aliso Canyon Well SS-25 failed, causing a sustained and uncontrolled natural gas leak at the Aliso Canyon facility in Los Angeles, California. Ultimately, a relief well was drilled to permanently plug the leaking well on February 18, 2016. The investigation into this incident is ongoing, and the cause of the failure and resulting leak has not yet been determined.

however, because the Utilities do not currently track expenditures in this way, the baseline amounts are the best effort of the utility to benchmark both capital and operations and maintenance (O&M) costs during that year. The level of precision in process and outcomes is expected to evolve through work with the California Public Utilities Commission (Commission or CPUC) and other stakeholders over the next several General Rate Case (GRC) cycles.

The Commission has ordered that RAMP be focused on safety-related risks and mitigating those risks.[3] In many risks, safety and reliability are inherently related and cannot be separated, and the mitigations reflect that fact. Compliance with laws and regulations is also inherently tied to safety and the Utilities take those activities very seriously. In all cases, the 2015 baseline mitigations include activities and amounts necessary to comply with the laws in place at that time. Laws rapidly evolve, however, and the RAMP baseline has not taken into account any new laws that have been passed since September 2015. Some proposed mitigations, however, do take into account those new laws.

The purpose of RAMP is not to request funding. Any funding requests will be made in the GRC. The forecasts for mitigation are not for funding purposes, but are rather to provide a range for the future GRC filing. This range will be refined with supporting testimony in the GRC. Although some risks have overlapping costs, the Utilities have made efforts to identify those costs.

2 Background

Gas storage wells are a necessary and critical component of California's reliable gas delivery infrastructure. SoCalGas operates four underground storage fields with a combined working capacity of approximately 136 Bcf.[4] These fields are: Aliso Canyon (86.2 Bcf), La Goleta (21.5 Bcf), Honor Rancho (26.0 Bcf), and Playa del Rey (2.4 Bcf).

- Aliso Canyon is located in Northern Los Angeles County and is the largest of the four gas storage fields, with a working capacity of approximately 86 Bcf and deliveries to the Los Angeles pipeline loop. As of September 2015, Aliso Canyon had 114 injection/withdrawal/observation wells and was designed for a maximum withdrawal rate of approximately 1.8 Bcf per day at full-field inventory.

- Honor Rancho is also located in Northern Los Angeles County, approximately ten miles north of Aliso Canyon, with a working capacity of approximately 26 Bcf and deliveries to the Los Angeles pipeline loop. Honor Rancho has 40 gas injection/withdrawal wells and is designed for a maximum withdrawal capability of 1.0 Bcf per day.

- La Goleta is located in Santa Barbara County near the Santa Barbara Airport and the University of California–Santa Barbara campus, and provides service to the northern

[3] Commission Decision (D.) 14-12-025 at p. 31.
[4] The volumetric capacity of a natural gas storage field reservoir is measured in units of billion cubic feet (Bcf).

coastal area of the SoCalGas territory. La Goleta has a working capacity of approximately 21 Bcf and has 20 gas injection/withdrawal/observation wells and is designed for a maximum withdrawal capability of 0.4 Bcf per day.

- Playa Del Rey is located in central Los Angeles County, near the Los Angeles International Airport. It is the smallest of the storage fields, yet, due to its location, is a critical asset with a design working capacity of approximately 2.4 Bcf. Playa Del Rey has 54 gas injection/withdrawal/observation wells. Playa Del Rey is designed for a maximum withdrawal rate of 0.4 Bcf per day to meet residential, commercial and industrial loads throughout the western part of Los Angeles, including electric generators and oil refineries.

The four storage facilities help SoCalGas provide safe and reliable gas service to more than 21 million customers and helps provide gas to half the electric generation in its territory. The four storage facilities are an integral part of the energy infrastructure necessary to provide Southern California businesses and residents with safe and reliable energy and gas storage services at a reasonable cost.

3 Risk Information

As stated in the testimony of Jorge M. DaSilva in the Safety Model Assessment Proceeding (S-MAP) Application (A.) 15-05-004, "SoCalGas is moving towards a more structured approach to classifying risks and mitigations through the development of its new risk taxonomy. The purpose of the risk taxonomy is to define a rational, logical and common framework that can be used to understand, analyze and categorize risks."[5] The Enterprise Risk Management (ERM) process and lexicon that SoCalGas has put in place was built on the internationally-accepted IS0 31000 risk management standard. In the application and evolution of this process, the Company is committed to increasing the use of quantification within its evaluation and prioritization of risks.[6] This includes identifying leading indicators of risk. Sections 3 – 9 of this plan describe the key outputs of the ERM process and resultant risk mitigations.

In accordance with the ERM process, this section describes the risk classification, possible drivers and potential consequences of the Catastrophic Events Related to Storage Well Integrity.

3.1 Risk Classification

Consistent with the taxonomy presented by SoCalGas and SDG&E in A.15-05-004, SoCalGas classifies this risk as a gas, operational risk as shown in Table 1.

[5] A.15-05-002, filed May 1, 2015, at p. JMD-7.
[6] Testimony of Diana Day, Risk Management and Policy (SDG&E-02), submitted on November 14, 2014 in A.14-11-003.

Table 1: Risk Classification per Taxonomy

Risk Type	Asset/Function Category	Asset/Function Type
OPERATIONAL	GAS	COMPRESSION
OPERATIONAL	GAS	STORAGE

3.2 Potential Drivers[7]

The 2015 risk assessment for Catastrophic Events Related to Storage Well Integrity identified potential drivers that could lead to this risk occurring. The specific drivers for uncontrolled releases of gas at a storage field are the following:

1. **Aging infrastructure –** this risk driver is based on the age of the wells at SoCalGas' storage fields. Although the four SoCalGas storage fields have been in service for various timeframes, the average age of all wells is approximately 54 years.[8]

2. **Factors including internal/external corrosion –** this risk driver is based on the potential for corrosion on the inside or outside of buried steel casing. Internal corrosion and/or erosion may be caused by the corrosive effect of fluid, sand, and/or reactive constituents such as carbon dioxide in the gas withdrawn from the storage formations and the natural degradation of buried steel casing. External corrosion to buried steel casing may be caused by contact with certain underground soil formation conditions.

3. **Forces of Nature –** this risk driver is based on the known reservoir and geologic conditions and surrounding geological characteristics including such items as fault line and landslide potential. Each storage field has a geologic map that contains the storage field's faulting and landslide potential, which can be used to better understand the outside forces-natural cause risks specific to each well location.

4. **Human Error –** this risk driver is based on the potential for maintenance functions to be performed incorrectly by employees or contractors resulting in an uncontrolled release of gas. The cause of this could be inadequate procedures, failure to follow procedures, inadequate training, or inexperienced personnel.

5. **Incomplete or incorrect records –** this risk driver addresses that an incident could occur if the attributes of a well is unknown or inaccurate. The missing or incorrect information could result from an inadvertent mistake by an employee or contractor.

[7] An indication that a risk could occur. It does not reflect actual or threatened conditions.
[8] *See* Testimony of Phillip Baker, Underground Storage (SCG-06) at p. PED-17, submitted on November 14, 2014 in A.14-11-003.

Table 2 below maps these five specific risk drivers of Catastrophic Events Related to Storage Well Integrity to SoCalGas' taxonomy.

Table 2: Operational Risk Drivers

Driver Category	Catastrophic Event Related to Storage Well Integrity Driver(s)
Asset Failure	• Aging infrastructure • Factors including internal/external corrosion
Asset-Related Information Technology Failure	Not applicable
Employee Incident	• Human Error • Incomplete or incorrect records
Contractor Incident	• Human Error • Incomplete or incorrect records
Public Incident	Not applicable
Force of Nature	• Forces of Nature (e.g., fault line and landslide)

3.3 Potential Consequences

The following is a list of potential consequences that may result from an uncontrolled release of gas due to storage well blowout or systems failures, in a reasonable worst case scenario:

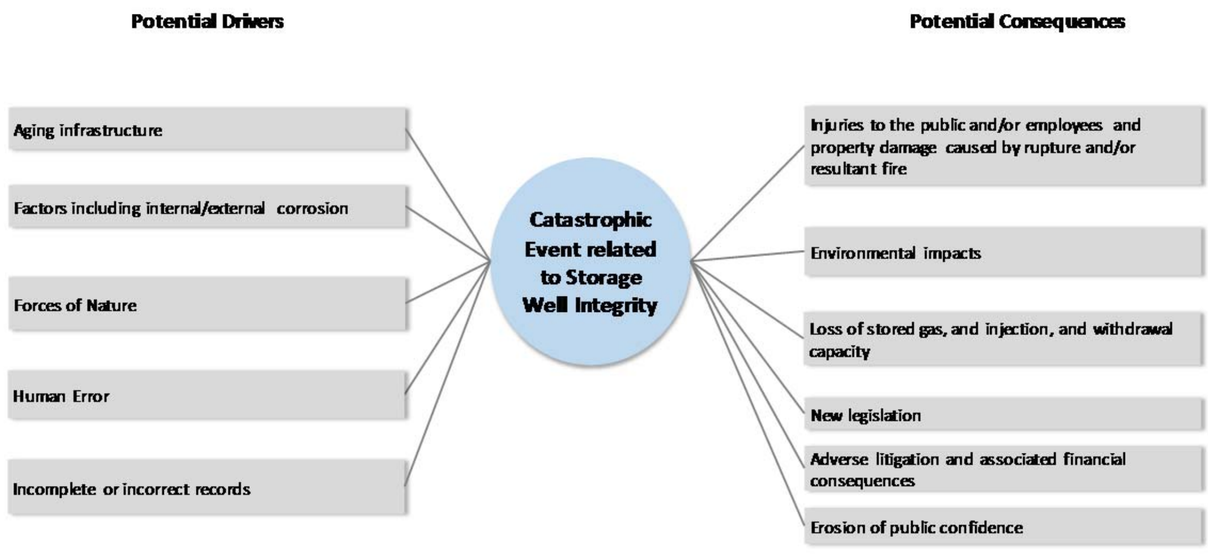
- Injuries to the public and/or employees and property damage caused by rupture and/or resultant fire
- Environmental damage
- Loss of stored gas
- Loss of injection and withdrawal capacity
- New legislation and/or regulations
- Adverse litigation and associated financial consequences
- Erosion of public confidence

These potential consequences were used in the scoring of Catastrophic Event Related to Storage Well Integrity risk that occurred during SoCalGas' 2015 risk registry process. See Section 4 for more detail.

3.4 Risk Bow Tie

The risk "bow tie," shown below, is a commonly-used tool for risk analysis. The left side of the bow tie illustrates potential drivers that lead to a risk event and the right side shows the potential consequences of a risk event. SoCalGas applied this framework to identify and summarize the information provided above.

Figure 1: Risk Bow Tie



4 Risk Score

The SoCalGas and SDG&E ERM organization facilitated the 2015 risk registry process, which resulted in the inclusion of Catastrophic Event Related to Storage Well Integrity as one of the enterprise risks. During the development of the 2015 risk register, subject matter experts assigned a score to this risk, based on empirical data to the extent it is available and/or using their expertise, following the process outlined in this section.

4.1 Risk Scenario – Reasonable Worst Case

There are multiple possible ways in which an event related to storage well integrity can occur. For purposes of scoring this risk, subject matter experts used a reasonable worst case scenario to assess the impact and frequency. The scenario represented a situation that could happen, within a reasonable timeframe, and lead to a relatively significant adverse outcome. These types of scenarios are sometimes referred to as low frequency, high consequence events. The subject matter experts selected a reasonable worst case scenario to develop a risk score for Catastrophic Event Related to Storage Well Integrity:

- An uncontrolled release of gas that occurs over an extended period of time due to a storage well structural integrity issue that requires complex well control operations and results in numerous reports of public impacts, supply issues and extensive customer impacts. The release of gas into the atmosphere results in an environmental impact and increased regulatory oversight in the form of new regulations and requirements.

Note that the following narrative and scores are based on this scenario; they do not address all consequences that can happen if the risk occurs.

4.2 2015 Risk Assessment

Using this scenario, subject matter experts then evaluated the frequency of occurrence and potential impact of the risk using SoCalGas and SDG&E's 7X7 Risk Evaluation Framework (REF). The framework (also called a matrix) includes criteria to assess levels of impact ranging from Insignificant to Catastrophic and levels of frequency ranging from Remote to Common. The 7X7 framework includes one or more criteria to distinguish one level from another. The Commission adopted the REF as a valid method to assess risks for purposes of this RAMP.[9] Using the levels defined in the REF, the subject matter experts applied empirical data to the extent it is available and/or their expertise to determine a score for each of four residual impact areas and the frequency of occurrence of the risk.

Table 3 provides a summary of the Catastrophic Event Related to Storage Well Integrity risk score in 2015. This risk has a score of 4 or above in the Health, Safety, and Environmental impact area and, therefore, was included in the RAMP. These are residual scores because they reflect the risk remaining after existing controls are in place. For additional information regarding the REF, please refer to the RAMP Risk Management Framework chapter within this Report.

Table 3: Risk Score

Residual Impact				Residual Frequency	Residual Risk Score
Health, Safety, Environmental (40%)	Operational & Reliability (20%)	Regulatory, Legal, Compliance (20%)	Financial (20%)		
5	5	5	5	2	1,826

4.3 Explanation of Health, Safety, and Environmental Score

Although natural gas is non-toxic, a well failure in populated areas may result in a rupture and/or fire, which could lead to injuries to the public and employees, property damage, and/or impacts to the environment. Should the wells be located near the public as compared to a more remote location (such as the middle of the storage field), the impacts to real property caused by the rupture and/or fire may be increased. Therefore, SoCalGas scored this risk a 5 (extensive) in the Health, Safety, and Environmental impact area due to the potential for injuries, property damage, and environmental impacts.

4.4 Explanation of Other Impact Scores

Based on the selected reasonable worst case risk scenario, SoCalGas gave the other residual impact areas each a score for the following reasons:

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[9] D.16-08-018 at Ordering Paragraph 9.

A loss of stored gas may cause reduced withdrawal and injection capacity from the storage fields. This could also lead to operational impacts if the loss of stored gas was significant. Accordingly, SoCalGas scored this risk a 5 (extensive) in the Operational and Reliability impact area since there is potential to affect service to more than 50,000 customers, multiple critical locations and result in substantial disruption of service for greater than 10 days.

An uncontrolled release of gas due to storage well structural integrity issues would likely result in litigation, regulatory investigations, and/or financial-related penalties. A catastrophic event related to storage well integrity would likely also result in increased regulatory oversight and erosion of public confidence. SoCalGas, therefore, scored the Regulatory, Legal, Compliance impact a 5 (extensive). SoCalGas estimates that the financial impacts of an event similar to the risk scenario identified above could have an impact in the range of $100 million to $1 billion. As such, SoCalGas scored the Financial risk impact a 5 (extensive).

4.5 Explanation of Residual Frequency Score

In connection with the risk registry completed in September 2015 and used in the analysis, SoCalGas considered significant incidents at storage facilities across the United State, which were isolated and infrequent. Prior to September 2015, the last significant storage well incident in SoCalGas service territory had occurred in 1975.[10] Recent incidents of note that occurred elsewhere in the country were the leaks that occurred at Market Hub Partners' Moss Bluff Storage in Liberty County, Texas and the wellbore failure at Kansas Gas Service's Yaggy storage field in Hutchinson, Kansas.

- Market Hub Partners' Moss Bluff Storage: On August 19, 2004, the Market Hub Partners' Moss Bluff storage facility located in Liberty County, Texas, had a well control incident and natural gas fire at Cavern #1. Over a period of six and one-half days, approximately 6 billion cubic feet of natural gas in the cavern was released and burned.

- Kansas Gas Service's Yaggy Storage Field: On January 17 and 18, 2001, an accident occurred at the Yaggy underground natural gas storage field operated by Kansas Gas Service, where a wellbore failure led to a series of gas explosions in Hutchinson, Kansas. The storage field injected natural gas at a depth of 600 to 900 feet underground into salt caverns. Gas leaked from the storage field well production casing, migrated approximately nine miles underground, and then traveled to the surface through old brine, or salt wells, in the Hutchinson, Kansas area. An explosion in downtown Hutchinson destroyed two businesses, damaged 26 other businesses, and killed two persons in a mobile home park.

[10] In 1975, at SoCalGas' Aliso Canyon storage facility, sand eroded aboveground piping adjacent to the wellhead which lead to a leak and fire.

Based on SoCalGas' history and incidents that occurred elsewhere, SoCalGas assessed the frequency of an event occurring related to storage well integrity as a 2 (rare), defined as once every 30-100 years.

5 Baseline Risk Mitigation Plan[11]

In 2015, the risk baseline mitigations included:

- Existing Maintenance Well Work
- Existing Capital Well Work

These controls focus on safety-related impacts[12] (i.e., Health, Safety, and Environment) per guidance provided by the Commission in D.16-08-018[13] as well as controls and mitigations that may address reliability, which is inherently related to safety. Accordingly, the controls and mitigations described in Sections 5 and 6 address safety-related impacts primarily. Note that the controls and mitigations in the baseline and proposed plans are intended to address various events related to storage well integrity, not just the scenario used for purposes of risk scoring.

5.1 Existing Maintenance Well Work

Storage Operations is responsible for the operation, maintenance, integrity, and engineering functions associated with the use of the wells within the perimeter of the fields. This responsibility also extends beyond the plant perimeter in some limited areas, where gas storage wells exist outside of the storage field processing and compression facilities. In general, the activities are performed to comply with increasing regulatory requirements that drive historical and future O&M costs. These activities include salaries and expenses associated with routinely operating storage reservoirs including, but not limited to: turning wells on and off, well testing and pressure surveys, and wellhead and down-hole activities for contractors that perform subsurface leak surveys on injection/withdrawal facilities. Other activities include patrolling field lines, lubricating valves, cleaning lines, disposing of pipeline drips, injecting corrosion inhibitors, pressure monitors, and maintaining alarms and gauges. Existing maintenance well work mitigates risks associated with asset failure, forces of nature, human error, and other factors including internal/external corrosion.

Also in 2015, as part of maintenance well work, SoCalGas continued its effort to develop the Storage Integrity Management Plan (SIMP) proposed in the Test Year 2016 General Rate Case (GRC).[14] These

[11] As of 2015, which is the base year for purposes of this Report.
[12] The Baseline and Proposed Risk Mitigation Plans may include mandated, compliance-driven mitigations.
[13] D.16-08-018 at 146 states "Overall, the utility should show how it will use its expertise and budget to improve its safety record" and the goal is to "make California safer by identifying the mitigations that can optimize safety."
[14] The SIMP was approved by the CPUC in D.16-06-054. As explained in greater detail below, SoCalGas' SIMP was modelled after the federally mandated distribution and integrity management programs and designed to provide a proactive, methodical, and structured approach, using state-of-the-art inspection technologies and risk management disciplines to address storage field and well integrity issues.

efforts continued the efforts began by the Company in 2014[15] and included running well inspection logs during well workovers and preparing electronic well history files for the Risk and Threat Analysis to be performed as part of SIMP.

5.2 Existing Capital Well Work

The activities associated with capital well work include: replacing failed components on existing wells, and the design, abandoning existing wells, drilling and completion of replacement wells for the injection and withdrawal of natural gas and reservoir observation purposes. This includes well workover contractors (major well work), drilling contractors, and component materials such as tubing, casing, valves, pumps, and other down-hole equipment. By replacing and upgrading storage assets, the existing capital well work mitigates the risks associated with asset failure, forces of nature, human error, and other factors including internal/external corrosion.

6 Proposed Risk Mitigation Plan

The 2015 baseline mitigations outlined in Section 5 – Routine Maintenance Well Work and Capital Well Work – will continue to be performed in the proposed plan. In addition, SoCalGas proposes to accelerate and expand SIMP activities – including the acceleration SIMP baseline assessments and additional risk and integrity management activities. These incremental changes, along with updates about other controls are described in below.

6.1 Maintenance Well Work

The proposed maintenance well work is consistent with the baseline maintenance well work addressed in Section 5.

6.2 Capital Well Work

The proposed capital well work is consistent with the baseline capital well work addressed in detail in Section 5.

6.3 SIMP

In 2016, in D.16-06-054, the Commission approved SoCalGas' SIMP. SIMP was proposed as a proactive, methodical, and structured integrity management approach to storage facilities that uses state-of-the-art inspection technologies and risk management disciplines to address storage field and well integrity issues. The SIMP is designed to:

[15] The SIMP pilot was conducted primarily in 2014. As part of the pilot, SoCalGas began using well inspection tools during scheduled rig work. This included various inspection tools, including: Magnetic Flux Leakage (MFL), Multifinger Imaging Caliper, UltraSonic Imager Tool (USIT), Ultrasonic Casing Imager Tool (UCIT), and Ultrasonic Radial Scanner (URS). These efforts succeeded in developing an initial understanding of SIMP costs for purposes of the 2016 GRC forecast and the assessment of the currently available inspection tools.

- Identify threats and perform risk assessment for all wells
- Develop an assessment plan for all wells
- Remediate conditions identified in the risk assessments
- Develop preventative and mitigation measures for the storage field
- Maintain associated SIMP assessment data and develop more detailed metrics to identify threats and guide integrity management actions

6.3.1 SIMP Assessments

SIMP includes the expanded use of workover rigs to evaluate downhole casing and tubing conditions. Surface equipment such as valves, wellheads, and well laterals are also evaluated using enhanced integrity management methods. Once an issue is identified, repair work is initiated to enhance safety. Lesser-risk integrity work will be prioritized to plan and efficiently execute mitigation or preventative actions. SoCalGas will establish detailed baseline assessments on its underground assets.[16] This risk management approach will enhance the proactive assessment, management, planning, repair, and replacement of below-ground facilities to eliminate situations that could potentially expose the public or employees to uncontrolled well-related situations.

In order to prioritize well inspections, SoCalGas developed a new threat-assessment matrix using existing well data that includes consideration of the following:

- Age of well
- Proximity to sensitive areas or populations
- Workover history
- Inspection data
- Historical withdrawal rates (energy release potential)
- Known reservoir and geologic conditions
- Surrounding geologic conditions (fault lines, landslide potential, etc.)

As proposed in the 2016 GRC, the SIMP baseline assessment was to last 6 years. However, SoCalGas is now planning to complete the SIMP baseline assessment in 4 years or less. The accelerated pace will enhance safety, validate well integrity, and reduce the risk profile of SoCalGas' storage facilities. In addition to enhancing safety and validating well integrity more expeditiously, accelerating the SIMP baseline physical integrity assessments is consistent with recent regulations mandating comprehensive well assessments (e.g., 14 California Code of Regulations (CCR) Section 1724.9, DOGGR Emergency Order 1109, Senate Bill 380, and Senate Bill 887), PHMSA guidance,[17] and federal recommendations on

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[16] The goals and objectives of SIMP are similar to those of the Distribution and Transmission Integrity Management Programs. SIMP would be focused on vertical casing pipe and components (wells) and associated above-ground facilities.

[17] PHMSA's Advisory Bulletin ADB-2016-02 ("In this Advisory Bulletin, PHMSA recommends that all operators of underground storage facilities used for the storage of natural gas, as defined in 49 CFR parts 192, have processes, procedures, mitigation measures, periodic assessments and reassessments, and emergency plans to

well integrity.[18] SoCalGas' accelerated SIMP will expeditiously validate well integrity and increase the margin of safety of the storage fields.

After the baseline assessment (which includes threat identification, risk assessment, inspection and preventative and mitigation measures) period of the SIMP, it is expected that expanded well assessments (and reassessments) will be performed on a regular basis as part of ongoing SIMP efforts. Through these periodic assessments, SoCalGas will gather more well data, allow for additional inspections, seek to manage and predict possible risk, and better assess the potential of leaks occurring. If any significant conditions are encountered during the evaluation, the well will be idled and a detailed work prognosis will be prepared, which may include, but is not limited to, running inner liners, new tubing, cement squeezing of holes, or well-abandonment.

6.3.2 SIMP – New Integrity and Risk Management Regulations

In addition to the assessments conducted for the SIMP, SIMP also drives other integrity enhancements and compliance with new integrity and risk management regulations. These new regulations not only require the SIMP inspections that were described above, but also additional ongoing maintenance and integrity management activities. Some examples of the new activities include:

- Fence line Monitoring System will detect methane crossing the fence line between the storage field and the surrounding area. SoCalGas is currently investigating a high resolution, commercially available and field-deployable sensor to be installed along the fence line and transmit alarms and regular methane level reads over the facility radio and Advanced Meter (AM) Networks, to be monitored by SoCalGas personnel. In some instances, SoCalGas may install similar area monitoring systems.

- As part of new thermal imaging leak detection requirements, SoCalGas will implement daily well inspections pursuant to DOGGR Emergency Regulations, Title 14 of the California Code of Regulations, Section 1724.9(e), at all underground storage facilities owned and operated by SoCalGas. The daily well inspections are already being performed at Aliso Canyon pursuant to the SCAQMD Order for Abatement Case No. 137-76.

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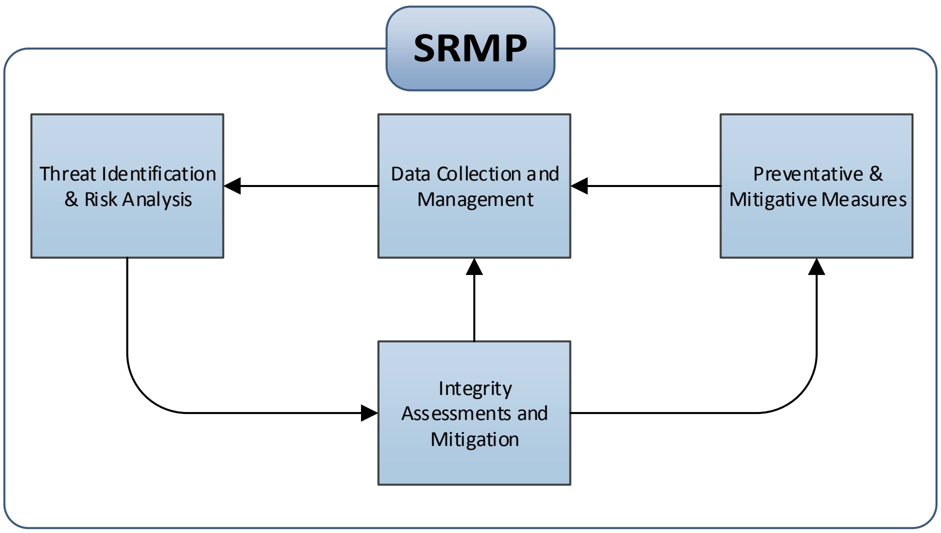
maintain the safety and integrity of all wells and associated storage facilities whether operating, idled, or plugged.")

[18] Interagency Task Force Well Integrity Observations and Recommendations, *Ensuring Safe and Reliable Underground Gas Storage: Final Report of the Interagency Task Force on Natural Gas Storage Safety*, at 55-56 (October 2016) ("All operators should undertake a rigorous evaluation of the current state of their well inventories… Evaluations should include: (1) a compilation and standardization of all available well records relevant to mechanical integrity; (2) an integrity testing program that includes usage of leakage surveys and cement bond and corrosion logs to establish that all wells are currently performing as expected; (3) documentation of a risk management plan to guide future monitoring, maintenance, and upgrades; (4) establishment of design standards for new well casing and tubing; and (5) establishment of safe operating pressures for existing casing and tubing.").

Finally, to focus SIMP activities and analytics and promote robust and dynamic data gathering and analysis, SoCalGas has also created a Storage Risk Management Program (SRMP). The SRMP is applicable to the Underground Storage Facility assets noted above and was created consistent with14 CCR 1724.9(g). The SRMP organization will provide a centralized organization that will mitigate risk by providing added focus on monitoring new compliance activities, emerging technology to mitigate risks, and developing data and analysis to focus funding and mitigation activities. The diagram below displays an overview of the elements in SRMP.



At this time, SoCalGas anticipates that these new regulations and requirements will begin in the 2016-2017 timeframe.

7 Summary of Mitigations

Table 4 summarizes SoCalGas' 2015 baseline risk mitigation plan, the risk driver(s) a control addresses, and the 2015 baseline costs for Catastrophic Event Related to Storage Well Integrity. While control or mitigation activities may address both risk drivers and consequences, risk drivers link directly to the likelihood that a risk event will occur. Thus, risk drivers are specifically highlighted in the summary tables.

SoCalGas does not account for and track costs by activity, but rather, by cost center and capital budget code. So, the costs shown in Table 4 were estimated using assumptions provided by SMEs and available accounting data. These baseline costs include both capital and O&M activities.[19]

[19] Additionally, in 2014 and 2015, SoCalGas conducted inspections as part of a Storage Integrity Management Plan pilot and engaged in initial SIMP developmental activities. These early efforts helped support SoCalGas' 2016 General Rate Case SIMP proposal. The SIMP pilot occurred primarily in 2014 and the SIMP initial

Table 4: Baseline Risk Mitigation Plan[20]
(Direct 2015 $000)[21]

ID	Control	Risk Drivers Addressed	Capital[22]	O&M	Control Total[23]	GRC Total[24]
1	Maintenance work performed on gas storage wells and SIMP Pilot and programmatic costs *	• Asset Failure • Forces of Nature • Factors including internal/ external corrosion • Human Error • Incomplete or Incorrect Records	n/a	$3,480	$3,480	$3,480
2	Abandonment, replacement materials and labor associated with each activity *	• Asset Failure • Forces of Nature • Factors including internal/ external corrosion • Human Error • Incomplete or	43,580	n/a	43,580	43,580

development and implementation work occurred primarily in 2015. Costs in Table 4 below only include 2015 SIMP activities. SIMP is discussed in greater detail in Section 6.

[20] Recorded costs were rounded to the nearest $10,000.

[21] The figures provided in Tables 4 and 5 are direct charges and do not include Company overhead loaders, with the exception of vacation and sick. The costs are also in 2015 dollars and have not been escalated to 2016 amounts.

[22] Pursuant to D.14-12-025 and D.16-08-018, the Company is providing the "baseline" costs associated with the current controls, which include the 2015 capital amounts. The 2015 mitigation capital amounts are for illustrative purposes only. Because projects generally span several years, considering only one year of capital may not represent the entire mitigation.

[23] The Control Total column includes GRC items as well as any applicable non-GRC jurisdictional items. Non-GRC items may include those addressed in separate regulatory filings or under the jurisdiction of the Federal Energy Regulatory Commission (FERC).

[24] The GRC Total column shows costs typically presented in a GRC.

ID	Control	Risk Drivers Addressed	Capital[22]	O&M	Control Total[23]	GRC Total[24]
		Incorrect Records				
	TOTAL COST		$43,580	$3,480	$47,060	$47,060

***** Includes one or more mandated activities

7.1 Existing Maintenance Well Work

The O&M activities include salaries and expenses associated with routinely operating storage reservoirs such as: turning wells on and off, well testing and pressure surveys, and wellhead and down-hole activities for contractors that perform subsurface leakage surveys on injection/withdrawal facilities. Other O&M expenses include the costs associated with patrolling field lines, lubricating valves, cleaning lines, disposing of pipeline drips, injecting corrosion inhibitors, pressure monitors, and maintaining alarms and gauges.

7.2 Existing Capital Well Work

The capital activities include: abandonments, wellhead valve replacements, well tubing replacements, wellhead leak repairs, well inner-string replacements, and drilling new wells.

Table 5 summarizes SoCalGas' proposed mitigation plan, associated projected ranges of estimated O&M expenses for 2019, and projected ranges of estimated capital costs for the years 2017-2019. It is important to note that SoCalGas is identifying potential ranges of costs in this plan, and is not requesting funding approval. SoCalGas will request approval of funding, in its next GRC. There are non-CPUC jurisdictional mitigation activities addressed in RAMP; the costs associated with these will not be carried over to the GRC. As set forth in Table 5, the Utilities are using a 2019 forecast provided in ranges based on 2015 dollars.

Table 5: Proposed Risk Mitigation Plan[25]
(Direct 2015 $000)

ID	Mitigation	Risk Drivers Addressed	2017-2019 Capital[26]	2019 O&M	Mitigation Total[27]	GRC Total[28]
1	Maintenance work performed on gas storage wells *	• Aging Infrastructure • Forces of Nature • Factors including internal/ external corrosion • Human Error • Incomplete or Incorrect Records	n/a	$3,310 - 3,650	$3,310 - 3,650	$3,310 - 3,650
2	Well abandonments, replacement materials and labor associated with each activity *	• Aging Infrastructure • Forces of Nature • Factors including internal/ external corrosion • Human Error • Incomplete or Incorrect Records	117,140 - 129,470	n/a	117,140 - 129,470	117,140 - 129,470
3	SIMP – Well Assessments *	• Aging Infrastructure • Forces of Nature	159,300 - 230,100	8,100 - 11,700	167,300 - 241,800	167,300 - 241,800

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[25] Ranges of costs were rounded to the nearest $10,000.
[26] The capital presented is the sum of the years 2017, 2018, and 2019 or a three-year total. Years 2017, 2018 and 2019 are the forecast years for SoCalGas' Test Year 2019 GRC Application.
[27] The Mitigation Total column includes GRC items as well as any applicable non-GRC items.
[28] The GRC Total column shows costs typically represented in a GRC.

		• Factors including internal/ external corrosion • Human Error • Incomplete or Incorrect Records				
	SIMP – New Integrity and Risk Management Regulations *	• Aging Infrastructure • Forces of Nature • Factors including internal/ external corrosion • Human Error • Incomplete or Incorrect Records	7,650 - 11,050	13,500 - 19,500	21,150 - 30,550	21,150 - 30,550
	TOTAL COST		$284,090 - 370,620	$24,910 - 34,850	$308,900 - 405,470	$308,900 - 405,470

☐ (white)	Status quo is maintained
☐ (shaded)	Expanded or new activity
*	Includes one or more mandated activities

7.3 Maintenance Well Work

Because the proposed maintenance well work is consistent with SoCalGas' 2015 mitigation activities, the forecast was established using a five-year trend. However, because there is some variability and uncertainty related to the cost of maintenance well work from one year to another,[29] SoCalGas utilized a range in Table 5 for forecasted costs of maintenance well work.

[29] Examples of uncertainty associated with storage facilities are large complex interconnected industrial equipment that continues to age; the increasing volume, frequency and complexity of above-ground and below-ground maintenance work; and the declining availability of replacement components for older assets exposed to demanding field conditions.

7.4 Capital Well Work

Similar to the maintenance well work, due to the variability in costs in a given year, a five-year trend was selected with a range to account for potential fluctuations and uncertainty in the future.

7.5 SIMP

The SIMP costs forecasted in Table 5 were developed using a zero-based forecast which are based SoCalGas' experience engaging in similar work (e.g., past workover experience) as a reference. A range was developed to account for potential uncertainty with the timing of incurring and the potential scope for these costs.

8 Risk Spend Efficiency

Pursuant to D.16-08-018, the utilities are required in this Report to "explicitly include a calculation of risk reduction and a ranking of mitigations based on risk reduction per dollar spent."[30] For the purposes of this Section, Risk Spend Efficiency (RSE) is a ratio developed to quantify and compare the effectiveness of a mitigation at reducing risk to other mitigations for the same risk. It is synonymous with "risk reduction per dollar spent" required in D.16-08-018.[31]

As discussed in greater detail in the RAMP Approach chapter within this Report, to calculate the RSE the Company first quantified the amount of Risk Reduction attributable to a mitigation, then applied the Risk Reduction to the Mitigation Costs (discussed in Section 7). The Company applied this calculation to each of the mitigations or mitigation groupings, then ranked the proposed mitigations in accordance with the RSE result.

8.1 General Overview of Risk Spend Efficiency Methodology

This subsection describes, in general terms, the methods used to quantify the *Risk Reduction*. The quantification process was intended to accommodate the variety of mitigations and accessibility to applicable data pertinent to calculating risk reductions. Importantly, it should be noted that the analysis described in this chapter uses ranges of estimates of costs, risk scores and RSE. Given the newness of RAMP and its associated requirements, the level of precision in the numbers and figures cannot and should not be assumed.

8.1.1 Calculating Risk Reduction

The Company's SMEs followed these steps to calculate the Risk Reduction for each mitigation:

1. **Group mitigations for analysis:** The Company "grouped" the proposed mitigations in one of three ways in order to determine the risk reduction: (1) Use the same groupings as shown in the Proposed Risk Mitigation Plan; (2) Group the mitigations by current controls or future mitigations, and similarities in potential drivers, potential consequences, assets, or dependencies

[30] D.16-08-018 at Ordering Paragraph 8.
[31] D.14-12-025 also refers to this as "estimated mitigation costs in relation to risk mitigation benefits."

(e.g., purchase of software and training on the software); or (3) Analyze the proposed mitigations as one group (i.e., to cover a range of activities associated with the risk).

2. **Identify mitigation groupings as either current controls or incremental mitigations:** The Company identified the groupings by either current controls, which refer to controls that are already in place, or incremental mitigations, which refer to significantly new or expanded mitigations.
3. **Identify a methodology to quantify the impact of each mitigation grouping:** The Company identified the most pertinent methodology to quantify the potential risk reduction resulting from a mitigation grouping's impact by considering a spectrum of data, including empirical data to the extent available, supplemented with the knowledge and experience of subject matter experts. Sources of data included existing Company data and studies, outputs from data modeling, industry studies, and other third-party data and research.
4. **Calculate the risk reduction (change in the risk score).** Using the methodology in Step 3, the Company determined the change in the risk score by using one of the following two approaches to calculate a Potential Risk Score: (1) for current controls, a Potential Risk Score was calculated that represents the increased risk score if the current control was not in place; (2) for incremental mitigations, a Potential Risk Score was calculated that represents the new risk score if the incremental mitigation is put into place. Next, the Company calculated the risk reduction by taking the residual risk score (See Table 3 in this chapter.) and subtracting the Potential Risk Score. For current controls, the analysis assesses how much the risk might increase (i.e., what the potential risk score would be) if that control was removed.[32] For incremental mitigations, the analysis assesses the anticipated reduction of the risk if the new mitigations are implemented. The change in risk score is the risk reduction attributable to each mitigation.

8.1.2 Calculating Risk Spend Efficiency

The Company SMEs then incorporated the mitigation costs from Section 7. They multiplied the risk reduction developed in subsection 8.1.1 by the number of years of risk reduction expected to be realized by the expenditure, and divided it by the total expenditure on the mitigation (capital and O&M). The result is a ratio of risk reduction per dollar, or RSE. This number can be used to measure the relative efficiency of each mitigation to another. Figure 2 shows the RSE calculation.

Figure 2: Formula for Calculating RSE

$$Risk\ Spend\ Efficiency = \frac{Risk\ Reduction * Number\ of\ Years\ of\ Expected\ Risk\ Reduction}{Total\ Mitigation\ Cost\ (in\ thousands)}$$

[32] For purposes of this analysis, the risk event used is the reasonable worst case scenario, described in the Risk Information section of this chapter.

The RSE is presented in this Report as a range, bounded by the low and high cost estimates shown in Table 5 of this chapter. The resulting RSE scores, in units of risk reduction per dollar, can be used to compare mitigations within a risk, as is shown for each risk in this Report.

8.2 Risk Spend Efficiency Applied to This Risk

SoCalGas analysts used the general approach discussed in Section 8.1, above, in order to assess the RSE for the Storage risk. The RAMP Approach chapter in this Report provides a more detailed example of the calculation used by the Company.

For purposes of calculating Risk Reduction, the mitigations for this risk were group as follows:

1. Maintenance Work (current controls)
2. Abandonments and New Wells Drilled (current controls)
3. SIMP-Inspections, Abandonments, New Wells (incremental mitigations)
4. SIMP-New Integrity and Risk Management Regulations (incremental mitigations)

- **Maintenance Work (current controls)**

An assessment was performed for routine well maintenance activity. Well maintenance activity consists of ongoing maintenance work and labor performed on existing and newly constructed gas storage wells as had been done in 2015.

SoCalGas currently has 228 wells in place. Of these, 26 are slated to be abandoned and nine new wells are to be drilled. The resulting number of wells that will require maintenance work are 211. SoCalGas subject matter experts estimated that if maintenance work on these 211 wells were discontinued, the likelihood of an incident will move from a score of 2 (one every 30-100 years) to a 3 (one every 10-30 years) on the 7-point frequency scale. Thus, based on the forecasted cost of the activity and the risk increase if the activity were discontinued, SoCalGas calculated a Risk Spend Efficiency of 1.05.

- **Capital Well Work – Abandonments and New Wells Drilled (current controls)**

As part of the baseline risk mitigation projects, SoCalGas plans to abandon 26 wells and drill 9 new wells. SoCalGas subject matter experts determined that if the abandonment projects did not occur, the likelihood of an incident would increase to a score of 3 from a baseline likelihood score of 2, for the 26 wells. To represent the small risk of operating newly drilled wells, the risk for 9 new wells would increase slightly, from a 0 to a 1 (once every 100+ years). Thus, based on the forecasted cost of the projects and the risk increase if the projects did not occur, SoCalGas calculated a Risk Spend Efficiency of 0.26.

The abandonments will reduce the likelihood of an incident, and thus reduce the risk. The new wells, however, are required to maintain the capacity requirements for gas storage, but will increase the risk. These projects were thus combined into a single mitigation, the net effect of which is an overall risk reduction.

- **SIMP – Inspections, Abandonments, and New Wells (incremental mitigations)**

SIMP activities consist of well inspections and resultant repairs, abandonments, and construction of additional wells. SoCalGas subject matter experts estimated that approximately 160 wells will be inspected under the SIMP program, approximately 46 wells will be abandoned, and approximately 18 new wells will be drilled.

SoCalGas subject matter experts estimate that if the well inspection programs are done, the likelihood score for the 160 wells will move from a 2 to a 1. If the 46 wells are abandoned, the likelihood score for the 46 wells will move to a 0. For the 18 new wells, the likelihood score will increase from 0 to a 1. Thus, based on the forecasted cost of the projects and their risk reduction benefits, SoCalGas calculated a Risk Spend Efficiency of 0.09.

- **SIMP – New Integrity and Risk Management Regulations (incremental mitigations)**

This mitigation consists of the development, management and support of the SIMP, as well as materials and labor associated with new regulatory compliance activities and enhancements. This mitigation affects the risks associated with all wells in the system. SoCalGas SMEs determined that if these programs and activities were done the likelihood score would move from its baseline level of a 2 to a 1. Thus, based on the forecasted cost of the projects and activities, and their risk reduction benefits, SoCalGas calculated a Risk Spend Efficiency of 0.07.

8.3 Risk Spend Efficiency Results

Based on the foregoing analysis, SoCalGas calculated the RSE ratio for each of the proposed mitigation groupings. Following is the ranking of the mitigation groupings from the highest to the lowest efficiency, as indicated by the RSE number:

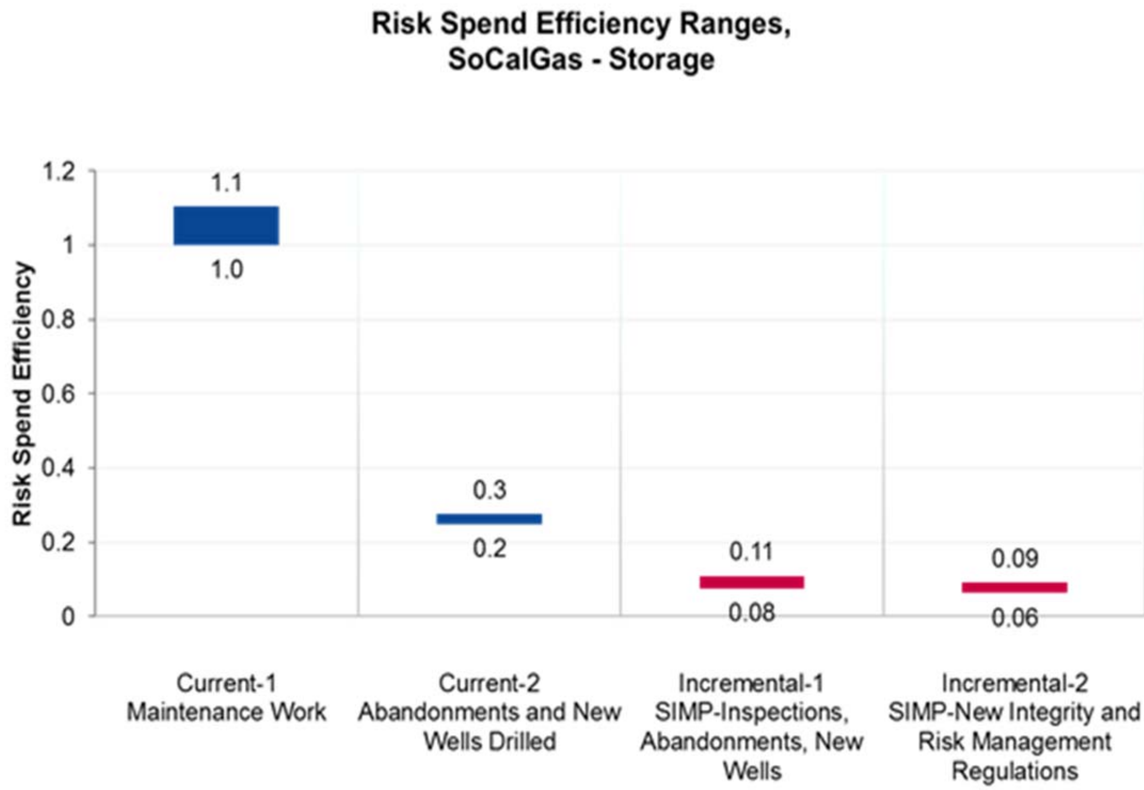
1. Maintenance Work (current controls)
2. Abandonments and New Wells Drilled (current controls)
3. SIMP-Inspections, Abandonments, New Wells (incremental mitigations)
4. SIMP-New Integrity and Risk Management Regulations (incremental mitigations)

Figure 3 displays the range[33] of RSEs for each of the SoCalGas Storage risk mitigation groupings, arrayed in descending order.[34] That is, the more efficient mitigations, in terms of risk reduction per spend, are on the left side of the chart.

[33] Based on the low and high cost ranges provided in Table 5 of this chapter.

[34] It is important to note that the risk mitigation prioritization shown in this Report, is not comparable across other risks in this Report.

Figure 3: Risk Spend Efficiency



9 Alternatives Analysis

The alternatives considered by SoCalGas Storage Operations took into account risk reduction, cost, new and existing requirements and compliance obligations, and the 2016 GRC decision approving the SIMP.

9.1 Alternative 1 – 6-Year SIMP Baseline

The first alternative considered was to complete the SIMP baseline assessments in six years. This alternative would align with the original SIMP 6-year assessment completion timeframe. Although a 6-year timeframe results in costs being spread out over a longer timeframe compared to SoCalGas' proposed plan to accelerate this work, this alternative was not chosen for multiple reasons. First, new DOGGR regulations and state law includes inspection requirements that can more readily be met on a 4-year SIMP timeframe.[35] Second, federal and state guidance has been issued indicating the importance of integrity assessments to validate well integrity. Third, although the proposed 4-year SIMP timeframe result in accelerated costs, it will improve the risk profile of the SoCalGas storage facilities. As such, the 6-year alternative was rejected in favor of the 4-year proposal in order to better comply with new

[35] See e.g., 14 CCR 1724.9.

laws and regulations, respond to federal and state well integrity guidance, and more expeditiously validate well integrity, enhance safety, and improve the risk profile of SoCalGas' storage fields.

9.2 Alternative 2 – Abandon Additional Wells

The second alternative considered was to abandon additional wells and drill new wells over a 6-year time period. This alternative proposal would result in SoCalGas abandoning 90 wells among all four storage fields and drilling 45 new replacement wells to maintain deliverability at a 2:1 ratio. This alternative was not chosen for two reasons. First, it was determined to be more cost effective to first inspect the wells and make any necessary repairs to maintain safety and deliverability to the customers. Second, the 4-year option is expected to cost less and enhance safety more effectively than drilling 45 new wells in 6 years. As such, the alternative to abandon additional wells and drill new wells over a 6-year period was rejected in favor of the 4-year SIMP proposal in order to expeditiously validate well integrity and improve the risk profile of SoCalGas' storage fields.