LIFE EXTENSION 2
CONCEPTUAL DESIGN REPORT
VOLUME II
BAYOU CHOCTAW

U.S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
PROJECT MANAGEMENT OFFICE
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BC-MM-775

BC-MM-810

BC-MM-1297

Replace Timber Supports

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Replace Existing Cross Members with New Steel Beams and Cap Existing Timber Piles with Formed, Cast in Place Concrete

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Bayou Choctaw Site Level I Criteria is to be capable of disposing of 110,000 barrels per day of brine and being able to drawdown Sour crude oil at 515,000 Barrels per day. In order to perform either of these missions, raw water, crude oil, and brine are transported within the site and at the brine disposal well area through large diameter, above ground piping on timber supports. These supports are treated timbers typically 12” by 12” by various lengths depending on the number of pipes parallel to one another at a given location.

Functional Requirements

The functional requirement for this project is to provide a dependable, reliable method to support the critical process piping throughout the Bayou Choctaw site. These supports include pilings driven into the ground with a cross beam to support the process piping on it. The Process piping consists of steel piping ranging in quantities of as many as 6 pipes up to 26” diameter or as few as 2 pipes as small as 8” diameter. Each support is spaced and sized for the required load carrying capability. The pipe supports shall be selected and designed for a 25-year life expectancy and shall be suitable for a variety of environmental elements including above grade, below grade, and partially / totally submerged conditions.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA’s and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carrol	DOE, Systems Engineer
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Team Members

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Larry Martinez	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The current approach is to replace the existing timber supports with new timber supports as they are determined to need replacement. This approach has worked well over the years, however as the supports and piles are exposed to the elements it is anticipated that slow, gradual deterioration will continue to occur thus establishing an on-going maintenance requirement.

This approach is the current method employed and results in a “year by year” approach to maintaining adequate pipe supports. This approach is needs-based but is considered to be a “piecemeal” approach.

Viability: No Further Analysis

B. Replace Existing Timber Supports in Kind and Evaluate / Re-Use Existing Timber Piles

This alternative would replace only those timber cross members and timber piles with a life expectancy of 25 years or less with new timber cross members and / or piles in the ground. The majority of the existing piles are generally in dry ground and have not been exposed to fluctuating water levels. A survey of all supports would need to be conducted to determine the quantity and locations of the supports to be replaced.

This alternative supports the project requirements and achieves the mission while the timber support scope would be “needs-based”. An effective timber inspection and criteria for evaluation would be employed and only those supports that would be determined as requiring replacement would be replaced.

Viability: Continue Analysis

C. Replace Existing Timber Supports with New Concrete and Steel Supports

This alternative would be to provide new concrete footings and galvanized structural steel beams to support the process piping thus replacing the timber supports. The number of support beams and spacing would need to be determined during detailed engineering design.

This alternative supports the project requirements and achieves the mission; however, this alternative would provide significantly difficult challenges to excavating, forming, and placing of the necessary concrete footings for the new supports. A concrete footing would need to be designed to support the load of the process piping and the required excavation would need to be performed to form and cast the concrete footing. The scope would include the process pipe supports on the main Bayou Choctaw site as well as those at the Brine Disposal Well area.

Viability: No Further Analysis

D. Replace Existing Cross Members with New Steel Beams and Cap existing timber piles with formed, cast in place concrete.

This alternative would be to provide new concrete caps onto existing piles where sound piles are present. The existing timber beams would be replaced with galvanized structural steel beams to support the process piping. The existing piles would provide the necessary bearing for the supports and piping thus eliminating the labor involved for large, hand excavated spread footings. The galvanized beams would last for many years and would not require future replacement.

This alternative supports the project requirements and achieves the mission. The scope would include the process pipe supports on the main Bayou Choctaw site as well as those at the Brine Disposal Well area.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and C are eliminated from further consideration. The remaining alternatives, B and D are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Existing Timber Supports in Kind and Evaluate / Re-Use Existing Timber Piles

This alternative would replace only those timber cross members and timber piles with a life expectancy of 25 years or less with new timber cross members and / or piles in the ground. The actual quantity and location of piles and/or cross members to be replaced would be determined from a detailed inspection and evaluation against agreed upon criteria. It can be assumed that at least 200, 12” butt x 30’ long piles would be replaced and 100, 12” x 12” x 16’ long timber cross members would require replacement. This is an approximate quantity and length and this number would need to be verified and engineered based upon the location of the support being replaced. The piles and cross members would need to be treated to protect against insects and rot and varying water level conditions.

Assumptions & Constraints

- It is assumed that a wood preservative is available and can be used to treat the new timbers to assure a minimum of 25-year life span while protecting against insect infestation, varying water levels, and rot.
- It is also assumed that the expected method of timber preservative is suitable for use on an SPR Site. Creosote treatment has been used successfully in the past and has shown its effectiveness as a wood preservative.

Benefits & Effectiveness

This alternative would be able to meet the mission and expected life requirements and can be performed in an on-going or piecemeal approach.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replace Existing Timber Supports in Kind and Evaluate / Re-Use Existing Timber Piles

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Desired method of wood preservative is not available to meet design life expectancy.	Alternative methods of coating or installation may be required.	Medium – High	Medium Risk Hazard
Wood preservative meeting specification requirements is not suitable for use on an SPR Site	Seek approval for deviation to allow use of preservative on an SPR site.	Low – High	Low Risk Hazard

B. Replace Existing Cross Members with New Steel Beams and Cap Existing Timber Piles with Formed, Cast in Place Concrete

This alternative would be to provide new concrete caps onto existing piles where sound piles are present. The existing timber beams would be replaced with galvanized structural steel beams to support the process piping. This approach would take advantage of the load bearing capability of the existing pile so as to avoid the larger concrete spread footing. Additionally, it is expected that the concrete would encase the top of the timber pile and that upon completion, all of the pile would be buried and not exposed to the elements. It is estimated that 200 existing piles would need to be capped with at 24” x 24” by 30” H reinforced concrete and that 100 each, galvanized, steel beams would be replaced measuring 12” WF beam x 16’ long. This is an approximate quantity, size and length of pile support caps and beams and this number would need to be verified and engineered based upon the location of the support being replaced.

Assumptions & Constraints

- For this alternative, is assumed that the existing timber piles would only show deterioration at the very top and that removal of the top 18 – 24” of the pile would reveal solid wood.
- It is also assumed that hand excavation around the tops of these piles would be performed after the existing cross timber support was removed.
- In areas that the pilings are in water or very close to water, it is further assumed that a temporary, earthen or other material dike could be easily constructed to facilitate excavation and forming and placement of concrete for a pile cap.

Benefits & Effectiveness

This method of pipe supports would meet mission requirements and should meet or exceed the design life expectancy. Any concern of future deterioration of the cross member supports is mitigated by the use of galvanized steel and the removal of the portion of the timber pile that is exposed to atmospheric conditions will mitigate or prevent any further deterioration of the timber pile.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replace Existing Cross Members with New Steel Beams and Cap Existing Timber Piles with Formed, Cast in Place Concrete

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Extent, method and location of hand excavation to form and place concrete caps.	Necessary safety precautions and work area preparations would need to be performed to assure safe working condition	Medium – Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Existing Timber Supports in Kind and Evaluate / Re-Use Existing Timber Piles

This alternative would replace only those timber cross members and timber piles with a life expectancy of 25 years or less with new timber cross members and / or piles in the ground. The actual quantity and location of piles and/or cross members to be replaced would be determined from a detailed inspection and evaluation against agreed upon criteria. It can be assumed that at least 200, 12" butt x 30' long piles would be replaced and 100, 12" x 12" x 16' long timber cross members would require replacement. This is an approximate quantity and length and this number would need to be verified and engineered based upon the location of the support being replaced. The piles and cross members would need to be treated to protect against insects and rot and varying water level conditions.

B. Replace Existing Cross Members with New Steel Beams and Cap Existing Timber Piles with Formed, Cast in Place Concrete

This alternative would be to provide new concrete caps onto existing piles where sound piles are present. The existing timber beams would be replaced with galvanized structural steel beams to support the process piping**.** This approach would take advantage of the load bearing capability of the existing pile so as to avoid the larger concrete spread footing. Additionally, it is expected that the concrete would encase the top of the timber pile and that upon completion, all of the pile would be buried and not exposed to the elements. It is estimated that 200 existing piles would need to be capped with at 24" x 24" by 30" H reinforced concrete and that 100 each, galvanized, steel beams would be replaced measuring 12" WF beam x 16' long. This is an approximate quantity, size and length of pile support caps and beams and this number would need to be verified and engineered based upon the location of the support being replaced.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Maintenance**	**Safety During Construction**	**Ease of Operations**	**Sustainability**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Adequate*	*Excellent*	*Excellent*	*Adequate*	*Not Rated*
	Excellent	*Adequate*	*Excellent*	*Excellent*	*Adequate*	*Good*
	Good	*Good*	*Good*	*Good*	*Good*	*Good*
Alternative B	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*	*Not Rated*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Good*
	Adequate	*Excellent*	*Marginal*	*Excellent*	*Excellent*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$1,325,226**	**$1,803,074**
Alternative B	**$975,156**	**$975,156**

Recommended Alternative

B. Replace Existing Cross Members with New Steel Beams and Cap Existing Timber Piles with Formed, Cast in Place Concrete

Based on the technical evaluation of the Core Team Members, Alternative B is overall rated higher on the sum total of the evaluation criteria. The initial cost and life cycle cost of Alternative B were both lowest of the alternatives. Therefore, Alternative B is the recommended preferred alternative based on both technical and cost factors studied in the alternative analysis.

BC-MM-1339

Replace BC Perimeter Security Detection Systems

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

FlexZone

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Perimeter Security is provided at SPR sites to prevent undetected intrusion to site facilities. This project is intended to provide a more reliable and maintainable intrusion detection system to replace the current aging system. The existing Bayou Choctaw Perimeter Security Detection System (PSDS) consists of Intelli-Flex, ~14,277 feet of Fiber Optic Intelligence Detection System (FOIDS), Infrared Perimeter Intrusion Detection (IPID), and traditional chain-link fencing.

Functional Requirements

The general requirements of the project are to meet DOE security parameters, ensure functionality of design (used as intrusion deterrent as intended), and provide a more reasonably maintainable system. The following are functional requirements for perimeter security detection on SPR sites:

- Intrusion detection and assessment systems must function effectively in all environmental conditions and under all types of lighting conditions.
- Intrusion Detection Systems (IDS) alarms used for the protection of the SPR must be capable of immediate investigation by the Protection Force (PF), Central Alarm Station (CAS), and/or personnel via Closed Circuit Television (CCTV).
- Exterior IDS must be designed, where economically feasible, with independent redundant data communication paths for protecting DOE SPR interests. The conductors of the redundant data paths must not be installed in the same conduit, cable tray, or duct bank.
- The IDS system must be compatible with the existing Alarm Display and Annunciation System (ADAS) at the site. Close coordination with the ADAS system integrator is required. Upgrades to the ADAS system may be required.
- The IDS must be capable of being operated and maintained to ensure that the number of false and nuisance alarms do not reduce the effectiveness of the system, while meeting the nuisance alarm rates described in DOE Order 473.3 A.; each exterior intrusion detection sensor should not have a false or nuisance alarm rate of more than one alarm per 24 hours of operation.
- The IDS must be capable of detecting, with a probability of 90 percent and confidence level of 95 percent, an individual crossing the detection zone by walking, crawling, jumping, running, rolling, or climbing at any point in the detection zone.
- The system must deter adversaries from circumventing the detection system.
- The IDS must cover the entire perimeter without any gaps in detection, including the sides and tops of structures.
- The system must be located in such a manner that the length of each detection zone is consistent with the characteristics of the sensors used in that zone and the topography.
- The length of each detection zone must be within the optimal performance range of the sensor system and CCTV system.
- The system must be free of wires, piping, poles, and similar objects that could be used to assist an intruder traversing the isolation zone or that could assist in the undetected ingress or egress of an adversary or matter.
- An isolation zone must be at least 20 feet (6 meters) wide and clear of fabricated or natural objects that would interfere with operation of the detection systems or effective assessment.
- The system must incorporate a stabilized apron of ~3 feet on both sides of perimeter fencing to deter rodent burrows and rain erosion underneath the existing fencing.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

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Larry Martinez	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment, resulting in commonality of similar systems for future maintenance and sparing consideration. Maintenance operations will require less attention as new equipment replaces legacy equipment; all new equipment shall come with a service warranty.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction. Safety is of the greatest importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems. The Site Security Specialist shall coordinate with the site leadership and contractor to accommodate for down time to particular assessment systems during construction.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations.

Weight: Less Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Allow the current PSDS system to remain in place and continue to repair as needed. Performance of the FOIDS perimeter detection system is ineffective, difficult to maintain, and it experiences high nuisance alarm rates. FOIDS is secured to perimeter fencing that is consistently under water or highly prone to flooding in multiple detection zones; consequently, the fencing and supports are rusted and sagging which also contributes to nuisance alarms. The existing Infrared Perimeter Intrusion Detection System (IPID) is experiencing very high nuisance alarm rates, requiring constant attention. Continuing to use/rely on the current PSDS will result in continuation of demanding maintenance efforts and obsolescence; all possibly resulting in undetected intrusion.

Viability: No Further Analysis

B. FlexZone w/Chain Link Fencing

Replace with a single sensor system consisting of the latest-generation of fence-mounted microphonic fence disturbance sensor systems and IPID with associated software packages. Stabilize the fence to reduce erosion, deter rodents/animals, control weeds in support the PSDS. Replace fencing and posts where degradation has occurred; replace all barbed wire atop fencing with razor wire on dual outriggers.

Viability: Continue Analysis

C. REDSCAN

REDSCAN is an analog system that can be pole or building mounted to provide an infrared laser wall that is installed inside the perimeter fence. The laser watches the fence area and monitors for any movement. REDSCAN does not meet DOE requirements as a standalone system for climbing, cutting, and bridging, as additional perimeter detection systems must be incorporated to meet functional requirements; REDSCAN vertical detection applications are in test stages. The REDSCAN alternative does not accomplish a single system install solution such as Intelli-Flex or its approved equal.

Viability: No Further Analysis

D. AgilFence

AgilFence uses advanced fiber optic, fence mounted sensors. Sensors are embedded in the optical fiber cable to form an array of sensors for perimeter fence intrusion detection. These extremely responsive sensors are used to detect incidents in various scenarios. A slight disturbance to the physical perimeter will trigger a response in the nearest optical fiber sensor that translates to an intrusion alert. This alternative requires replacing the current traditional chain-link fence in its entirety. Comparatively, one of the reasons for the warranted FOIDS replacement is due to fiber cable rodent damage, specifically to fiber cable in cable trays and along fencing. Used in Southeast Asia and Eastern Europe, AgilFence is not used in the U.S. to date.

Viability: No Further Analysis

E. IMPASSE II w/FlexZone

Replace the current components of the PSDS system (Intelli-Flex, FOIDS, IPID and fencing) with a combination of FlexZone and Impasse II. Impasse II is a steel palisade fence with an installed internal raceway for detection sensor systems, video cabling and arresting cables. Stabilize the fencing system to reduce erosion, deter rodents/animals, weed control in support the PSDS.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, C, and D are eliminated from further consideration. The remaining alternatives B and E are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. FlexZone with Chain Link Fencing

The Bayou Choctaw perimeter intrusion is experiencing obsolescence and maintenance related issues. Installed ~2002 and ~1997 respectively, the existing fiber optic detection system and infrared perimeter intrusion detection system is not meeting the requirements of DOE 437.3 A. High nuisance alarm rates, weather effects, maintenance difficulties, and overall performance requires immediate attention. FlexZone provides an alternative to address mentioned shortcomings of the Bayou Choctaw PSDS, but also introduces a system very much like others used across the SPR. FlexZone is the manufacturer suggested replacement of the currently used Intelli-Flex; Intelli-Flex is now a legacy system and soon will be phased completely out from the Senstar inventory (correspondence Dated 23 December 2014).

Replacing the existing perimeter detection system (~14,277') with the latest-generation of a fence-mounted microphonic fence disturbance sensor system such as FlexZone or an approved equal with associated software retains the proven performance of the current Intelli-Flex while introducing a similar system. Replacing the existing IPID (~3) with an ECSI International, Inc. product or approved equal shall address the aging and faulty IPID system. New equipment fielding and training, maintenance, and overall performance is similar and therefore provides a substantial advantage when associated with ease of operation/maintenance.

FlexZone is Senstar's latest generation ranging fence-mounted sensor. FlexZone detects and locates any attempt to cut, climb or otherwise break through the fence. It accurately locates intrusions even when there are multiple simultaneous intrusions and in the presence of background environmental noise.

FlexZone can detect and locate perimeter intrusions over a distance of up to 1,968 feet per sensor processor, and within 10 feet of accuracy. One processor can support up to 60 distinct, customizable zones. Both power and data can run over the sensor cables, minimizing infrastructure requirements. Advanced Digital Signal Processing (DSP) enables FlexZone to adapt to a wide variety of fence types including traditional chain-link fence currently in place on the site. Networking capability for remote configurations and alarm reporting is available and the product works reliably in harsh environments. Current FlexZone warranties provide for a minimum of 2 years from installation and the manufacturer ensures replacement parts are available for a minimum of 10 years from purchase. Training of operators and maintenance personnel on calibration and system maintenance is provided.

The Architectural IPID system from ESCI International, Inc. provides a dependable security barrier of pulsed infrared technology to create multiple detection zones, each with a range of up to 1000 feet. Solid state electronics are not affected by environmental conditions such as birds, small animals, puddles, leaves, grass or mechanical vibrations. It works in rain and fog instantly pinpointing the intrusion zone via normally opened or closed dry contacts that can be interfaced with any annunciator or data communication system. IPID does not false alarm. The system will only alarm if an object breaks the 3.54" diameter beam more than 98.5%. Easy to use, extremely low nuisance alarm rates and widely used by Government entities, the product is accompanied by a 10-year warranty.

The fencing and gates on the site consists of traditional chain-link fence that has experienced degradation due to sag and rusting from the salt/humid environment over the past 20+ years. Many sections of the fence have been subjected to flooding subsequently contributing to rust damaged fence posts and fabric. As fencing and gates are replaced, particular attention should be paid to the existing (~23) Balanced Magnetic Sensors (BMS) on gates. Replace the BMS as necessary to address HQ DOE findings 2015 of correcting deficiencies regarding to a lack of end of line sensors.

This alternative shall replace all fencing and posts (~14,277') with new, galvanized before weave (GBW) chain-link fencing fabric and posts. It shall also raise fencing in areas affected by consistent flooding and install ~6' (~3' on either side of outer perimeter fence bottom) of aggregate or concrete under fencing system to reduce erosion, deter rodents/animals, control weeds and obscuration, and support the overall Perimeter Security Detection System (PSDS).

The installation of concrete or aggregate under the fence will alleviate grass cutters from getting near the fence and prevent weed control chemicals from degrading the sensor tie material, resulting in sagging sensor cables as these ties break. Replace all barbed wire with razor wire mounted on dual outriggers atop all perimeter fencing and critical area fencing (~ 14,277').

In an attempt to reduce sagging over time, remove unused gates (~1) on the outer perimeter.

Assumptions & Constraints

Assumptions:

- FlexZone and fencing replacements shall be considered for all security areas deemed necessary.
- Work requires minor adjustments to an already existing DOE approved Task Specification (Intelli-Flex).
- Most, if not all fencing shall be replaced and any additional fencing requirements shall be identified.

Constraints:

- Protection Force (PF) compensatory involvement during construction.
- Chain-link fencing is not considered adequate security to meet today's asymmetric threats.

Benefits & Effectiveness

Replacing the PSDS system will allow for improved security measures on site, which is more cost effective and best meets requirements described in DOE 473.3 A. Repairs to the fencing system and replacements of sensors will allow for expedited response and deterrence of unauthorized entry on site. The items below summarize the benefits/effectiveness and mission need items addressed by replacing the existing PSDS on site with FlexZone.

- Familiar, new equipment and software will provide for improved maintenance and significantly enhanced performance (DOE 473.3 A. Attachment 3, Section A 3-44 [2][a][1]).
- Allows for increased security measures on site, providing optimal security protection (DOE 473.3 A. Attachment 3, Section A 3-45 [3][b][2]).
- FlexZone allows for precision sensitivity leveling/adjustments.
- Removes unserviceable fencing where degradation has occurred (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Communications path redundancy ensures continued perimeter protection in the event of a cable cut.
- Provides better fencing in areas affected by consistent flooding (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Prevent access onto site through removal of un-used gates, further strengthens security measures (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Will allow for better protection against ladder/pole assisted climbing intrusion once all razor ribbon on top of perimeter and critical area fencing is installed (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][1]).
- Concrete or aggregate will allow for better erosion, animal/rodent control, weed control and protect against potential under wire intrusion (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Replacement of the degrading and now legacy PSDS system, upgrading to a current industry standard system (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- FlexZone is noted for low power consumption.
- Optional Ethernet card with Power over Ethernet (PoE) capability.
- Sensors are calibrated with Windows-based point and click utility (over the network or locally by USB).

Risk & Mitigation Factors

Some potential risks associated with replacing the current PSDS with FlexZone include potentially reduced security posture during construction, training employees on a new system, and potential safety issues while updating and installing equipment. The table below summarizes mentioned risks with a correlating mitigation strategy. The table describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for FlexZone with Chain-Link Fencing			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Reduced security posture during construction.	Close coordination between NOLA, site security and contractor work scheduling and sequence.	High - High	High Risk Hazard
Will require training on the new system.	Minimize the length of training by making the training comprehensive, hands on and repetitive.	Medium - Low	Low Risk Hazard
Potential safety hazards involved when updating or installing equipment on site.	The contractors shall prepare a Job Hazard Analysis and the site shall brief employees on site near the system update or installation.	Medium - Low	Low Risk Hazard

B. IMPASSE II with FlexZone

The Bayou Choctaw perimeter intrusion is experiencing obsolescence and maintenance related issues. Installed ~2002, the existing fiber optic detection system and IPID is not meeting the requirements of DOE 437.3 A. High nuisance alarm rates, weather effects, maintenance difficulties, and overall performance requires immediate attention.

This alternative considers a high security fence, combined with installing a new perimeter security detection system such as FlexZone or an approved equal; a single perimeter detection system, arrayed in depth by design with new IPID. A recent Fluor physical security system evaluation (dated March 2016) of the Ameristar Impasse II system yielded familiarity and an overall positive evaluation. The Impasse II is widely used for military sites, government facilities, petroleum and chemical facilities, and airports.

A high security fence, IMPASSE II, is a vertical (~8' in height), palisade steel fencing made of pre-galvanized steel, test-based to ASTM B117 standards, with tamper-proof fastenings and an installed internal raceway for detection systems, video cabling and up to 3 arresting cables. The raceway eliminates the need for any trenching, boring, fastening ties, or degradation from fence sag. The Impasse II security fence panels employ a bracketless design using tamper proof fasteners; are installed with heavier posts (I-beam); includes a 15-year warranty. The panels are constructed of heavy duty steel, eliminating fence sag. The Impasse II does not require the use of razor wire atop its fencing panels – a choice of trident, stronghold or gauntlet style options are available.

Replacing the existing perimeter detection system (~14,277') with the latest-generation of a fence-mounted microphonic fence disturbance sensor system such as FlexZone or an approved equal with associated software retains the proven performance and familiarity of the currently installed Intelli-Flex system.

The Architectural IPID system from ESCI International, Inc. provides a dependable security barrier of pulsed infrared technology to create multiple detection zones, each with a range of up to 1000 feet. Solid state electronics are not affected by environmental conditions such as birds, small animals, puddles, leaves, grass or mechanical vibrations. It works in rain and fog instantly pinpointing the intrusion zone via normally opened or closed dry contacts that can be interfaced with any annunciator or data communication system. IPID does not false alarm. The system will only alarm if an object breaks the 3.54" diameter beam more than 98.5%. Easy to use, extremely low nuisance alarm rates and widely used by Government entities, the product is accompanied by a 10-year warranty.

This alternative shall replace all fencing and posts (~14,277') with the pre-galvanized Ameristar fencing system, Impasse II. It shall also raise areas affected by consistent flooding and install ~6' (~3' on either side of outer perimeter fence bottom) of aggregate or concrete under fencing system to reduce erosion, deter rodents/animals, control weeds and obscuration, and support the overall Perimeter Security Detection System (PSDS). As fencing and gates are replaced, particular attention should be paid to the existing (~23) Balanced Magnetic Sensors (BMS) on gates. Replace the BMS as necessary to address HQ DOE findings 2015 of correcting deficiencies regarding to a lack of end of line sensors.

The installation of concrete or aggregate under the fence will alleviate grass cutters from getting near the fence and prevent weed control chemicals from degrading the sensor tie material, resulting in sagging sensor cables as these ties break.

Assumptions & Constraints

Assumptions:

- Impasse II and FlexZone replacements shall be considered for all security areas deemed necessary.

Constraints:

- Protection Force compensatory activity during installation/construction.

Benefits & Effectiveness

Replacing the fencing and installing FlexZone with IMPASSE II will allow for the optimal security posture on site as described in DOE 473.3 A. This alternative of the PSDS replacement will allow for stricter

deterrence of unauthorized entry and improve degrading systems. The items below summarizes the benefits and effectiveness of adding the IMPASSE II as the PSDS on site.

- Will replace the degrading fence and allow for replacement of the now legacy PSDS system (DOE 473.3 A. Attachment 3, Section A 3-45 [3][b][2]).
- Allows for higher security measures on site, negates the need for razor wire and enables an improved platform for installation of a selected intrusion system (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Capable of being an all-inclusive PSDS system in one installation, allowing for shorter duration installation and disruption to site security posture (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Allows for easier detection probability calculations.
- The Impasse rail system is designed to house all peripherals required to complete a perimeter security system without the expense of trenching and boring typically used in these applications (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- The Impasse rail can accommodate crash barrier components such as arresting cables (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Impasse II is made from 96% recycled steel.
- Permacoat process gives Impasse II distinct advantage over chain link fencing - a corrosion resistant, polyester top coat (test based on ASTM B117 Standard).

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with IMPASSE II on site is reduced security posture during construction, training employees on a new system, and generating potential safety issues while updating and installing equipment. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for IMPASSE II with FlexZone

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security posture during construction.	Close coordination between NOLA, site security and contractor work scheduling and sequence.	Medium - High	Medium Risk Hazard
May require extensive training on a new system.	Minimize the length of training by making the training comprehensive, hands on, and repetitive.	Medium - Medium	Medium Risk Hazard
Potential safety hazards involved when updating or installing equipment on-site.	The contractors shall prepare a Job Hazard Analysis (JHA) and the site shall brief employees near the system update or installation.	Medium - Low	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. FlexZone

Replace with the latest-generation of fence-mounted microphonic fence disturbance sensor systems such as Senstar FlexZone (Senstar suggested product replacement for Intelli-Flex) and IPID or an approved equal with associated software packages. Stabilize under fencing with aggregate or concrete to reduce erosion, deter rodents/animals, and control weeds to support the Perimeter Security Detection System (PSDS). Replace fencing and posts where degradation has occurred. Replace all barbed wire with razor wire mounted on dual outriggers on top of perimeter and critical area fencing. Remove unused gates and any obsolete taut-wire on the site.

B. IMPASSE II with FlexZone

Install the IMPASSE II, is a vertical metal, palisade fencing combined with the latest-generation of fence-mounted microphonic fence disturbance sensor systems such as Senstar FlexZone (Senstar suggested product replacement for Intelli-Flex) and IPID or an approved equal with associated software packages. Stabilize under fencing with aggregate or concrete to reduce erosion, deter rodents/animals, and control weeds to support the Perimeter Security Detection System (PSDS). Remove any unused gates on the site.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Less Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Good*
Alternative B	*Good*	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Good*	*Excellent*	*Excellent*
	Good	*Excellent*	*Good*	*Good*	*Good*	*Good*

Cost Comparison:

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$6,270,241**	**$6,394,853**
Alternative B	**$9,482,355**	**$9,624,995**

Recommended Alternative

A. FlexZone

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria. The initial cost and life cycle cost of Alternative A were both lowest of the alternatives. Therefore, Alternative A is the recommended preferred alternative based on both technical and cost factors studied in the alternative analysis.

BC-MM-1344

Bayou Choctaw Brine Disposal Well Upgrades

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Drill New Brine Disposal Wells

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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Recommended Alternative 6

I. PROJECT CONCEPT

Mission Need

The current 12 brine disposal wells at Bayou Choctaw (BC) are not performing to SPR Level I Criteria requirements. SPR Level I Criteria states that SPR brine disposal wells must be capable of receiving a minimum of 110,000 barrels per day of continuous brine flow at the Bayou Choctaw Site; however, in the short term, rate recovery plans are in place to recover brine disposal rate loss in the event of fill operations.

Functional Requirements

The functional requirement for this task is to provide the Bayou Choctaw site with improved brine disposal system capabilities in order to meet the Level 1 criteria of receiving a minimum of 110,000 barrels per day.

This Project is one component of a series of Projects to upgrade the Brine Disposal System at Bayou Choctaw in accordance with SPR Level I Criteria. Other projects that are part of the completed Brine Disposal System that are affected by this BC-MM-1344 project are: BC-MM-769, 824, BC-MM-770, BC-MM-771, and BC-MM-775. Lighting requirements for the Brine Disposal Facilities are identified in Project BC-MM-308.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Anna Lord	SNL, Principal Investigator
Karen Wynn	FFPO, Sr. Cavern Engineer

III. SELECTION CRITERIA

There were no selection criteria included in the original report from Sandia National Laboratories (SNL) for this task.

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings have been conducted by Sandia National Laboratories (SNL) to determine the viability of each alternative.

A. Status Quo

This alternative would be to continue to maintain the existing brine disposal wells. Current practices at BC take untreated brine and filter the fluid to 10 microns. The filtered brine is injected into the brine disposal wells that are available to accept the fluid, out of the 12 total wells located on the site. The current status of each well is as follows:

- Well 1 – Sand 2 – Locked out and waiting for workover
- Well 2 – Sand 2 – Screen Clear
- Well 3 – Sand 2 – Screen Clear
- Well 4 – Sand 2 – Screen Clear
- Well 5 – Sand 2 – Screen Clear
- Well 6 – Sand 1 – Only portion of the perforated interval is clear and a packer and 7" tubing is suspended above which may limit recompletion options.
- Well 7 – Sand 2 – Locked out and waiting for workover
- Well 8 – Sand 2 – Plugged
- Well 9 – Sand 1 – Plugged
- Well 10 – Sand 1 – Locked out and waiting for workover
- Well 11 – Sand 1 – Probably Clear
- Well 12 – Sand 5 – Plugged

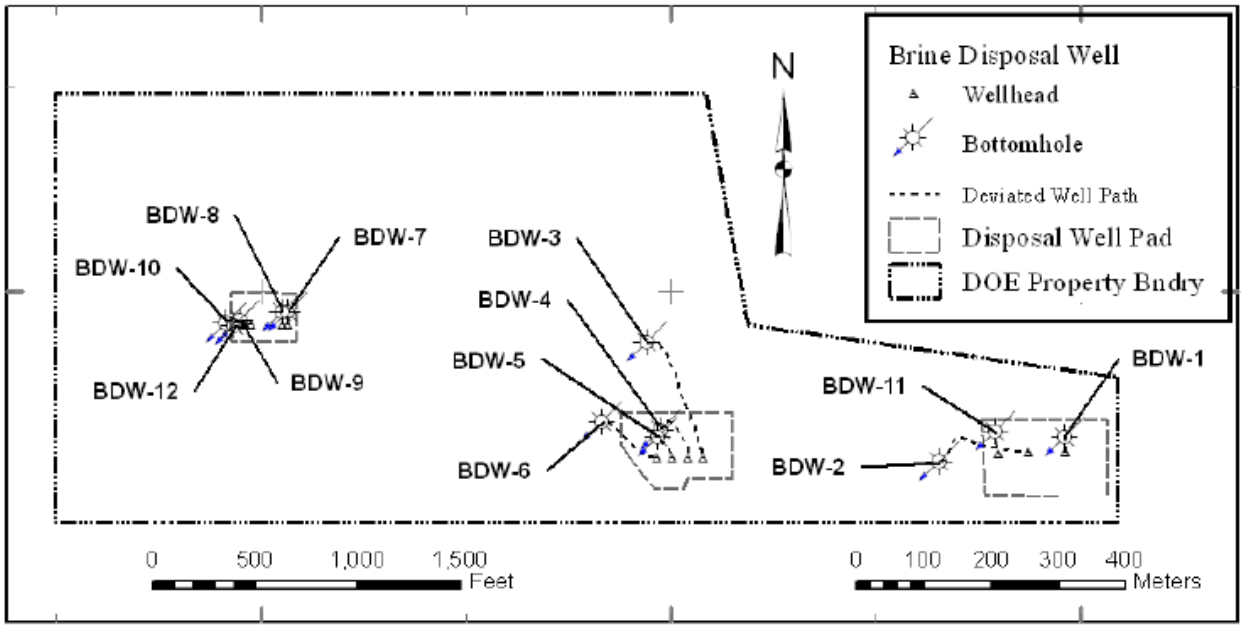

Figure 1 – Map showing detailed locations of the SPR brine disposal wells and the three well pads from which they were drilled (Figure 3 from Rautman and Looff, 2011).

Due to the infrequent, non-continuous requirements for brine disposal operations, Bayou Choctaw has experienced problematic brine disposal capability that will continue to consume scarce resources. This alternative does not meet the mission need and functional requirements.

Viability: <u>No Further Analysis</u>

B. Drill New Brine Disposal Wells

This alternative would drill new brine disposal wells located at the current well pads and would require the well pads to be extended in order to accommodate these new wells. There are sufficient sub-surface sands available between 7000 ft. and 8000 ft. for brine disposal within the DOE property and sufficient untouched acreage within the SPR property, especially in the western region for the development of new brine disposal wells. Several sand structure-contour maps were constructed from previously mapped seismic horizons. These maps are intended to be used as an aid in determining brine disposal well locations and can be

found in a report prepared by Rautman and Looff (2011). The maps help identify the structural highs, lows, and dip directions of each layer, which assists in determining the best positon options for new brine disposal wells that mitigate interference and pressure buildup. Wells will most likely need to be deviated from the pads in order to not interfere with the current system and ensure maximum injection capability. Direction drilling is an option and the success of BDW-3 indicates that significant horizontal deviations are possible.

Viability: Continue Analysis

C. Re-Entry and Re-Completion of Current Wells

This alternative would re-enter and re-complete existing brine disposal wells. The 2011 geologic study (Rautman and Looff, 2011) infers that ample sand exists at depth below the current BC brine disposal wells for additional brine disposal. However, it is advised not to re-enter wells and extend to the depth. This guidance is based on the fact that the current well configuration and age of the existing wells is not conducive to re-entry. The existing wells were designed with a gravel pack and screen system and to re-enter the well and extend to a lower disposal zone would require removal of the screen and gravel pack, which would probably result in the unraveling of the screen wire in an uncased zone that is predicted to get stuck in the hole.

Re-entry into the old wells is possible if the goal is to re-complete into a shallower disposal zone. However, the risk associate with a shallower completion is that wells will be closer together and thus there is a greater chance of communication between wells and subsequent pressure build-up.

Viability: No Further Analysis

D. Stimulate Current Wells and Change Operating Procedures

This alternative would seek to stimulate the current brine disposal wells and institute better ways to operate the wells in order to extend the lifetime of the wells. In 2010, Sabine Storage performed a study that both evaluated the current status of the Bayou Choctaw brine disposal wells as well as recommended how to stimulate the wells and institute better ways to operate the wells in order to extend the lifetime of the wells. It is believed that at the current screened intervals, the sand formation experienced process-induced damage when the wells were acidized to combat biofouling (bacteria buildup) and the spent acid was pumped into the formation rather than being circulated out of the well. This resulted in the spent acid, which is substantially more viscous, creating an artificial pressure barrier further out in the formation that cannot be removed. The barrels per day target specified by the SPR Level I Criteria will not be achieved due to increased back pressure generated in the formation at high injection rates and a resulting permanent reduction in the wells' injection rates.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, C, and D are eliminated from further consideration. The remaining alternative, B is examined below as alternative A.

The below analyses provide the research and technical information gathered by Sandia. These analyses are not evaluative or comparative.

A. Drill New Brine Disposal Wells

This alternative would drill new brine disposal wells located at the current well pads and would require the well pads to be extended in order to accommodate these new wells. There are sufficient sands available between 7000 ft. and 8000 ft. for brine disposal within the DOE property and sufficient untouched acreage within the SPR property, especially in the western region for the development of new brine disposal wells. Several sand structure-contour maps were constructed from the mapped seismic horizons. These maps are intended to be used as an aid in determining brine disposal well locations and can be found in a report prepared by Rautman and Looff (2011). The maps help identify the structural highs, lows, and dip directions of each layer, which assists in determining the best positon options for new brine disposal wells that mitigate interference and pressure buildup. Wells will most likely need to be deviated from the pads in order to not interfere with the current system and ensure maximum injection capability. Direction drilling is an option and the success of BDW-3 indicates that significant horizontal deviations are possible. With the proposed addition of three new wells to Disposal Pad No. 3 and one new well to Disposal Pad No. 2, the valveing and piping that carries brine to this well pad and brine disposal well (Projects BC-MM-770 and BC-MM-775) would need to be evaluated for adequate sizing and design. Additionally, the additional power requirements and lighting would need to be evaluated and addressed in Projects BC-MM-771 and BC-MM-308.

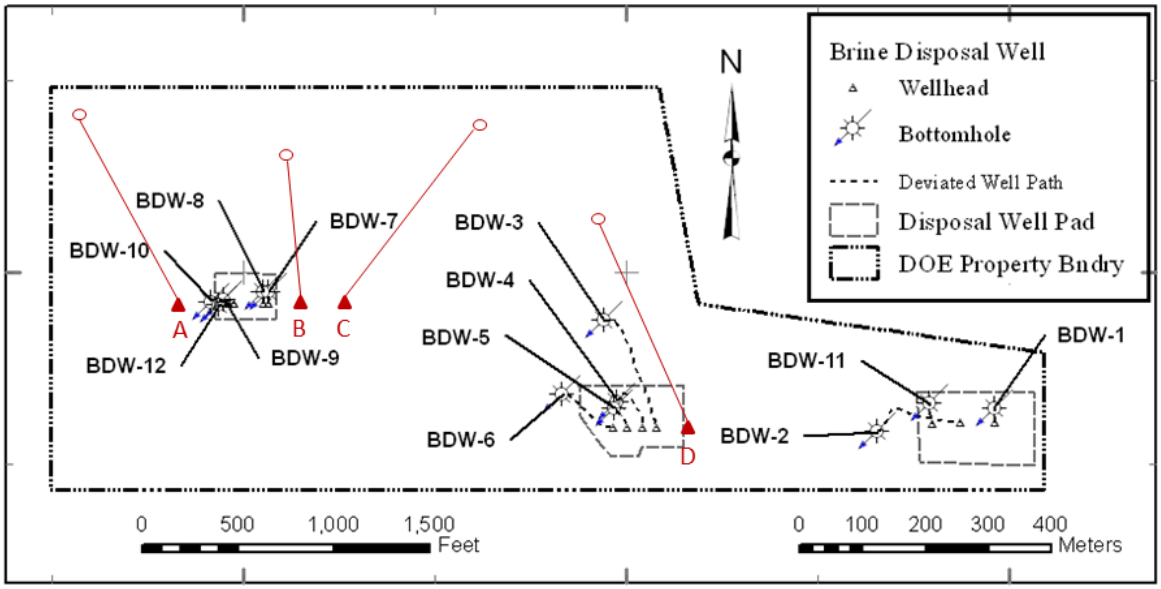

Figure 1 – Proposed locations for four (4) new brine disposal wells.

Assumptions & Constraints

Assumptions:

- Keep wells and injection points within the current DOE property boundary.
- New wells will be located within the containment area of expanded, existing well pads.
- Wells will be drilled to a final depth of ~8500 ft.
- New wells would be added to Well Pads 2 & 3 only.

Constraints:

- Well Pad 1 is not an option as it is too close to the edge of DOE property.
- The lower limit of brine disposal horizons is the top of the Anahuac Shale at ~9500 ft.

Benefits & Effectiveness

The benefits from the additional wells is that the Mission Requirements will be met and there would be 3 or 4 additional wells to apply brine to. The added availability of wells and injection capability would improve the continuous brine disposal capability. The extended well pads and additional facilities would allow for adequate / improved access and capability for performing well workover activities. The addition of the new wells would be configured in a manner similar to what is proposed in Project BC-MM-775 and the new electrical requirements would need to be addressed in Project BC-MM-771 and additional lighting in Project BC-MM-308.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Drill New Brine Disposal Wells

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Wetland issues due to pad expansions	An Environmental Assessment study would need to be conducted to determine impacts or mitigation requirements.	High – Medium	Medium Risk Hazard
Delays or inability to obtain necessary permits for the drilling and operation of new disposal wells.	Meet with State Regulators to determine well requirements for design and operation.	Low – High	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Drill New Brine Disposal Wells

This alternative would drill new brine disposal wells located at the current well pads and would require the well pads to be extended in order to accommodate these new wells. There are sufficient sands available between 7000 ft. and 8000 ft. for brine disposal within the DOE property and sufficient untouched acreage within the SPR property, especially in the western region for the development of new brine disposal wells.

Comparison of Alternatives

There were no selection criteria evaluation ratings included in the original report from Sandia National Laboratories (SNL) for this task

Cost

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
BC-MM-1344	**$151,498,817**	**$151,890,883**

Recommended Alternative

Based on the report from Sandia, Alternative A is the recommended preferred alternative.

BC-MM-1351

Bayou Choctaw Degas

VCI Project Engineer: Lorna Madison

Recommended Alternative:

In-Storage Degassing

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Data modeling and prediction of vapor pressure regain for the BC sweet and sour crude oil streams suggest that some form of vapor pressure mitigation will be required by 2021. If no action is taken by this time, the risk of exposing terminal personnel to high levels of hydrogen sulfide and benzene increases. The size and working condition of the current Degas II plant generally preclude relocation of the plant to the BC site to address the increase in oil vapor pressure. The Degas II plant is too large to relocate to BC on the existing developed property without reconfiguration. The projected cost of refurbishment of the existing plant equipment and piping systems upon completion of processing at West Hackberry (WH) will make the Degas plant move to BC uneconomic.

Functional Requirements

- A Drawdown rate of 515,000 bpd (515 MBD) was used for sour crudes from caverns BC15, BC17, BC19, and BC101.
- A Drawdown rate of 300,000 bpd (300 MBD) was used for sweet crudes from caverns BC18 and BC102.
- In-Storage treatment rates between 50,000-70,000 bpd (50-70 MBD) were used for all crudes.
- Sweet crudes come from caverns at a temperature 114 ^{o}F.
- Sour crudes come from caverns at a temperature 108 ^{o}F.
- Minimum propane recovery is 95%.
- Maximum shrinkage is 0.3%
- Maximum bubble point pressure (BPP) of the crude is 14.7 psia at 93 ^{o}F on delivery.

II. PROCESS

The Final Conceptual Design Report for Bayou Choctaw Degas, BC-MM-1351, was previously issued to and accepted by DOE.

Alternatives Analysis Plan

The Analysis of Alternatives (AoA) Process Plan is not applicable to projects with final conceptual design reports previously issued to and accepted by DOE.

III. SELECTION CRITERIA

Formal selection criteria are not applicable to projects with final conceptual design reports previously issued to DOE.

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Cooling Options

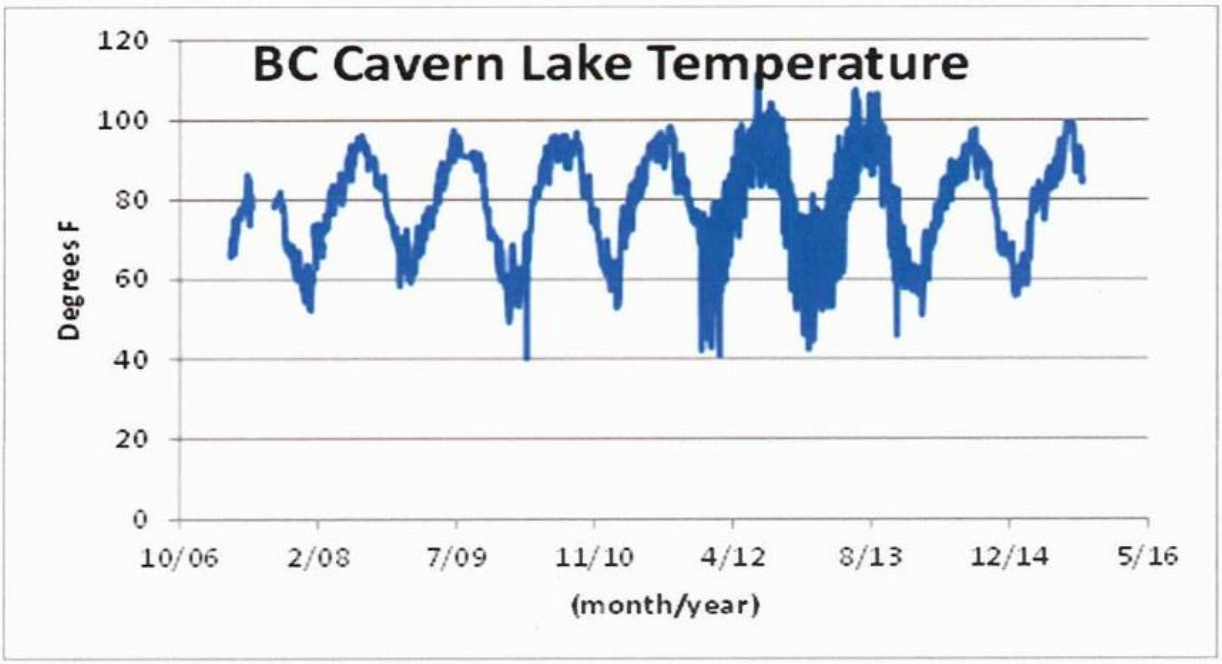
The Cooling cavern inventory below the BPP of 14.7 psia is a viable option so long as the temperature of the inventory in the cavern can be maintained. Due to the depth of the salt plug, heat from the cavern walls

increases inventory temperature over time and makes it necessary to continually cool inventory. This is accomplished by recirculating cavern inventory through coolers which use a cooling medium. The following options were explored using this basic concept.

1. Cavern Lake Water Cooling

Cavern Lake is located at the boundary of the BC site and could be considered for use as the cooling medium for an in-storage circulation system. Water would be pumped from the lake by new water circulation pumps which use the existing water distribution system to reach each of the cavern locations. At each cavern location a new crude circulation pump and cooler would be installed to maintain segregated inventories. The water from the existing inlet header passes through the cooler and returns to the lake in a new return header. Oil from the cavern is drawn through the existing tubing string by the crude circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern would be equipped with a new well so that they would remain drawdown ready during the cooling cycle.

Cooling of the crude in the cavern can reduce the BPP by reducing the temperature low enough to reach the required value of 14.7 psia. The water in Cavern Lake varies seasonally in temperature (Graph 1). During the months of April through September, lake water temperatures are too high to support cooling of the cavern crude. Initial cooling must be undertaken during the October through March period when lake water temperatures are sufficiently low. The cavern crude then regains heat and increases in temperature during the months when no cooling is possible. Sufficient cooling water must be available in Cavern Lake to provide the initial cavern cooling plus the maintenance cooling on a seasonal basis. It is estimated that Cavern Lake can provide 7.1 million barrels of water before thermal contamination occurs due to recycling of the water back to the lake. This is considerably less than the 27 million barrels of water required for the initial cool down of the inventory of a single cavern. The shortage of cool water inventory makes this option infeasible. In addition to providing an insufficient amount of water, this option does not eliminate the need to use scavenger should drawdown occur in the warmer months. See Tables 1 – 3 for Projected Seasonal Vapor Pressure Impacts.



Graph 1 – Bayou Choctaw Cavern Lake Water Temperature

Projected Seasonal Vapor Pressure Impacts
Oct-15
CURRENT

treams	Oct 15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

treams	Oct 16	N v-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr- 7	May- 7	Jun-17	Jul- 7	Aug- 7	Sep- 7
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

	Historical Data
OK	BP <= 14.7 psi
OK-GOR	BP > 14.7 psi GOR <= 0.6 scf/bbl, H_2S Scavenger Required
Note 1	GOR > 0.6 scf/bbl

* Original data basis from the 4th Quarter Vapor Pressure Model, August 2015

Table 1 – Projected Seasonal Vapor Pressure Impacts – Current

Projected Seasonal Vapor Pressure Impacts
Oct-15
BC Cooling

Streams	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK

Streams	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK

Streams	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21
BC SW	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK

Streams	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22
BC SW	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK

	Historical Data
OK	BP <= 14.7 psi
OK-GOR	BP > 14.7 psi GOR <= 0.6 scf/bbl, H_2S Scavenger Required
Note 1	GOR > 0.6 scf/bbl

* Original data basis from the 4th Quarter Vapor Pressure Model, August 2015

Table 2 – Projected Seasonal Vapor Pressure Impacts – Cooling

Projected Seasonal Vapor Pressure Impacts
Oct-15
BC Cooling with 2σ Regain

Streams	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK-GOR	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
BC SW	OK-GOR	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21
BC SW	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

Streams	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22
BC SW	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR
BC SO	OK	OK	OK	OK	OK	OK	OK	OK	OK-GOR	OK-GOR	OK-GOR	OK-GOR

	Historical Data
OK	BP <= 14.7 psi
OK-GOR	BP > 14.7 psi GOR <= 0.6 scf/bbl, H_2S Scavenger Required
Note 1	GOR > 0.6 scf/bbl

* Original data basis from the 4th Quarter Vapor Pressure Model, August 2015

Table 3 – Projected Seasonal Vapor Pressure Impacts – Cooling with 2σ Regain

To support the drawdown ready requirement during the cooling cycle an additional well for each cavern would be needed so the existing wells can be used for circulation of the crude. There is also an environmental issue associated with returning process water to the lake, as required by this option. To provide suitable mitigation and a position for an environmental assessment, a holding pond and waste water treatment plant must be provided. Operating costs will also add significantly to this option, as the temperature of the crude oil must be maintained by cooling over the life of the project.

Viability: Continue Analysis

2. Aquifer Water Cooling

The Plaquemine Aquifer lies beneath the BC site at a depth of between 60 ft. and 500 to 600 ft. and is a potential source of cooling water. Temperatures in the aquifer are cold enough to provide sufficient cooling for the cavern inventory. To develop this water source, producing wells would need to be drilled within the boundaries of the property and spaced in a way to optimize the supply of water. To dispose of the water returning from the intermediate water coolers, a set of injection wells would be drilled to return the water to the aquifer. The location selected would provide the maximum amount of water before thermal contamination from the injection wells reaches the producing wells. Each producing water well is equipped with a downhole pump to supply water so heat can be exchanged with a secondary closed loop cooling system. This secondary system isolates the cavern coolers from the aquifer water. This closed loop circuit circulates warmer water through intermediate water coolers for cooling as it exchanges heat with the cooler water from the aquifer. The cooled water then circulates through the cavern coolers to cool the crude oil from the caverns. Water which leaves the cooler returns to the inlet of the intermediate water coolers to complete the closed loop circuit. The existing water distribution system to the wells is utilized as part of the intermediate water supply system. A new aquifer water supply and return header system would be required to provide cooling water to each one of the cavern locations. As in the Cavern Lake option, each cavern is equipped with a crude oil circulation pump and crude oil cooler. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string.

To support the drawdown ready requirement during the cooling cycle an additional well for each cavern would be needed so the existing wells can be used for circulation of the crude. There is also an environmental issue associated with returning process water to the aquifer. To provide suitable mitigation and a position for an environmental assessment, an intermediate water circulation system is provided. Thermal contamination of the aquifer may still be an issue, however, and forms a constraint on the amount of water that can be taken from the aquifer. Once thermal breakthrough occurs from the injection wells to the producing wells, the aquifer can no longer supply sufficiently cool water and cooling stops. The amount of water available before this occurs is 76.2 million barrels. This can provide enough cooling to initially cool down five of the six caverns. There is insufficient volume to initially cool down all six caverns or to maintain their temperature. In addition to providing an insufficient amount of water this option also does not eliminate the need to use scavenger should drawdown occur in the warmer months. Because cavern crude inventory will regain heat from the cavern walls, cooling will be required throughout the life of the project. However, it has insufficient water to support initial cool down of all six caverns and subsequent temperature maintenance.

Viability: Continue Analysis

3. Cooling Tower Cooling

Another option for providing a supply of cooling water to the individual caverns is by cooling the water in a cooling tower and then supplying it to the various caverns in a closed loop system. A closed loop system would provide water from the cooling tower basin and pump the supply to each of the caverns. It then passes through the tube side of the cavern cooler and returns to the cooling tower by way of the return header system. The cooling tower utilizes the air brought in by fans to cool the water by evaporation. Water must be added to the system to replace the water lost by evaporation. Water must also be withdrawn from the system to prevent solids build-up within the equipment. The water added must also provide for this amount of blowdown in addition to the water lost by evaporation. Oil from each cavern is circulated through the existing tubing string by the oil circulation pumps. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

Cooling of the crude in the cavern is dependent upon the temperature of the inlet water from the cooling tower. This water temperature varies seasonally as the wet bulb temperature varies. See Table 4 for seasonal variations in wet bulb temperatures. Cooling towers can be designed to approach this wet bulb temperature within 10 ^{o}F. In cool weather the crude temperature can be maintained below that which yields a BPP of 14.7 psia. Once cooling water temperatures rise above this level, cooling stops. The cooled crude in the cavern then regains heat from the cavern walls and the temperature increases. When the seasonal wet bulb temperature is low enough for cooling water to begin cooling again, the cavern crude can start circulating through the coolers. The caverns can be initially cooled down from October through March of each season when the wet bulb temperature is sufficiently low. Each following year the cavern must be re-cooled to eliminate the heat regained from the cavern walls. The initial cool down will allow the cavern inventory to maintain a maximum temperature of 90 ^{o}F during reheat before the maintenance cooling cycle begins. The cooling water temperature during the cooling cycle is sufficiently low to maintain this temperature but not to decrease it. This maintenance temperature is high enough to require the addition of scavenger. Seasonal changes in cooling water temperature will require the use of scavenger should drawdown occur during the seven warmest months of the year. Because heat is regained by the crude oil from the cavern walls, cooling will be required throughout the life of the project.

Viability: Continue Analysis

4. Chilled Water Cooling

A chilled water system utilizes refrigeration to reduce cooling water temperatures below those that can be achieved with a conventional cooling tower. Several types of refrigerant are available that can achieve the desired temperatures. One type commonly used for this application is ammonia. All refrigerant systems will require a compressor with a condenser to produce a liquid refrigerant. The refrigerant is then passed through an expansion valve which drops the temperature in the chiller coil to the desired level. Heat from the circulating chilled water is removed in the chiller by vaporization of the refrigerant. From the chiller the vaporized refrigerant returns to the suction of the compressor where the pressure is increased sufficiently to repeat the cycle. A condenser utilizes water from a conventional cooling tower to cool and condense the

refrigerant from the compressor discharge. This cooling water is circulated through the cooling tower by pump in a closed loop system. The water that is chilled in the refrigerant chiller is circulated by pump through the crude oil cooler. The return water is circulated back to the chiller where the temperature is reduced by the refrigerant in a closed loop.

DRY BULB AND WET BULB TEMPERATURES					
Bayou Choctaw Cavern Location					
	Month		Dry Bulb ^0C		Wet Bulb ^0C
	January		25.2		20.2
	February		26.3		19.9
	March		28.5		20.4
	April		30.4		21.6
	May		33.3		24.2
	June		34.9		25.1
	July		35.5		25.7
	August		35.8		25.4
	September		34.6		24.6
	October		31.8		23.4
	November		28.2		21.8
	December		26.1		21.4

Table 4 – Bayou Choctaw Dry and Wet Bulb Temperatures

5. Chilled Water Cooling

A chilled water system utilizes refrigeration to reduce cooling water temperatures below those that can be achieved with a conventional cooling tower. Several types of refrigerant are available that can achieve the desired temperatures. One type commonly used for this application is ammonia. All refrigerant systems will require a compressor with a condenser to produce a liquid refrigerant. The refrigerant is then passed through an expansion valve which drops the temperature in the chiller coil to the desired level. Heat from the circulating chilled water is removed in the chiller by vaporization of the refrigerant. From the chiller the vaporized refrigerant returns to the suction of the compressor where the pressure is increased sufficiently to repeat the cycle. A condenser utilizes water from a conventional cooling tower to cool and condense the refrigerant from the compressor discharge. This cooling water is circulated through the cooling tower by pump in a closed loop system. The water that is chilled in the refrigerant chiller is circulated by pump through the crude oil cooler. The return water is circulated back to the chiller where the temperature is reduced by the refrigerant in a closed loop.

Each cavern is equipped with its own refrigeration package, circulation pump, and cooler for temperature maintenance. The chilled water is circulated through the existing water distribution system to the oil cooler. The water from the inlet header passes through the cooler and returns to the chiller. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

For initial cool down of cavern inventory two refrigeration packages with circulation pumps and cooler are required. One package is semi-portable and is relocated at each cavern location requiring cool down. After all six caverns have been cooled, the semi-portable unit serves as a spare unit for the other six refrigeration packages which are permanently installed at each well site.

It will also require one new well for each cavern to maintain drawdown readiness. Refrigeration of the cooling water allows cooler cavern temperatures to be maintained throughout the year. The cooler temperatures, however, make it more likely that waxing will occur in the equipment which can lead to less reliable operations. Although it is possible to maintain cavern temperatures at a suitable level to maintain a BPP of 14.7 psia, there is a possibility that long term storage at the terminal location will cause the crude temperature to rise and the BPP, as well. As a result, scavenger will still be needed should drawdown occur

in the three warmest months of the year. Like other cooling options, heat regain from cavern walls will make it necessary to maintain cooling throughout the life of the project.

Viability: Continue Analysis

B. Degassing Options

Increased crude oil BPP at BC is primarily the result of crude oil heating in storage and accumulation of light ends in the stored crude oil. Simply cooling the crude oil to reduce its BPP would seem to be a practical approach to reducing the crude oil BPP of the oil. However, cooling alone will not produce the desired results for all caverns. Removal of the methane and ethane and some of the propane and butanes accumulated in the stored oil can be implemented to reduce the BPP of the stored oil to ensure that scavenger addition is not required. Crude oil degassing removes these volatile components from the crude oil by separation of the vapor from the liquid in a vessel under reduced pressure. The vapor generated will contain the majority of components that contribute to the high BPP. Vapor from the separator is collected in a vapor compression system to allow for disposal. Vapors collected in this fashion can be cooled to increase propane recovery. The cooled gas can then be treated to eliminate the hydrogen sulfide. With the lower crude oil BPP it is possible to add back the hydrogen sulfide without the danger of it vaporizing. This treatment strategy can provide a means of eliminating the need to add a hydrogen sulfide scavenger to the crude. This is the current practice at BC during drawdown. Although the cost of adding hydrogen sulfide scavenger can be reduced with sophisticated sulfur analyzers and injection rate control, the focus of this study is to eliminate the need to inject liquid scavenger by properly treating the crude oil. Several technologies are available to accomplish this and are compared in more detail in Section V.

1. In-Storage Degassing

The current method of controlling crude oil BPP is provided by the In-Storage Degas II design. This design utilizes a cavern circulation system that removes crude from the top of the cavern and returns it to the bottom of the cavern. The crude oil from the cavern is pumped through an exchanger which cools the crude before transferring it to a liquid/vapor separator where the crude oil is flashed to atmospheric or slightly lower pressure. Crude oil from this separator is pumped back to the cavern. Vapor released by flashing is gathered in a compression system where it is compressed and then cooled to condense heavier components for addition back in the crude oil. The remaining vapor fraction is treated in an amine unit for removal of the hydrogen sulfide which is also added back to the crude oil. The remaining off-gas from the amine unit is further cooled by refrigeration to reduce the size of the stream and to recover additional propane. The small amount of off-gas that remains following refrigeration is combusted in a flare gas system.

The Degas II design capacity is 125 MBD with the processing unit configured to transport from site to site. For Bayou Choctaw (BC), this plant is nearly twice the size required to mitigate the increased BPP at BC. The Degas II plant footprint is too large for the smaller area available at the BC site. Landowner, lease, and security issues severely hinder acquisition of more land over the fence at BC to allow the installation of this larger degassing unit. Hence, re-engineering of Degas II is required to fit it onto the BC site. The existing Degas II unit will be over 15 years old and has been moved twice in that time. A considerable investment will be required to refurbish the equipment (including the connecting piping, electrical wiring, and controls) plus the additional costs associated with breaking down the unit and shipping it to BC will be incurred. Initial estimates of moving Degas II to BC with the required refurbishment and reconfiguration start at 100 % of the estimated Total installed cost (TIC) for a new and smaller degassing unit. For In-Storage processing of crude oil at BC, re-engineering Degas II as a new, smaller degassing unit for BC appears an attractive alternative to refurbishing and relocating Degas II. This option can be readily designed to satisfy the processing requirements, siting constraints, and operating constraints to operate at BC. However, consideration can also be given to re-using some equipment from Degas II that is in good operating condition and is reasonably sized for the new conditions.

The processing equipment required for In-Storage Degassing is of such a size that it can be suitable for modularization. This type of construction allows a more mobile type of design so modules can be readily relocated at other sites once processing is completed at BC. In addition, there is a significant cost savings associated with modular construction. It is estimated that 40% of the field constructed portion of the TIC for degassing is labor. Shop fabrication is able to reduce labor costs through increased productivity.

The In-Storage Degassing option will require more complex processing as a result of its smaller size. The six caverns at BC can be processed in about 3 years and the modules can be made ready for degassing at other locations. Once processing is completed on a cavern, the cavern contents are left in drawdown ready condition which reduces the amount of duplicate equipment. Well work-overs will be required to cut tubing strings for circulation in the. Additional operating and maintenance personnel will be required for the additional rotating equipment during the duration of degassing.

Viability: Continue Analysis

2. Drawdown Degassing at Site

The Drawdown Degassing option will require many of the same processing units as the In-Storage Degassing. Capacity requirements will be greater to accommodate the higher drawdown rate of 515 MBD. This necessarily results in larger sized equipment with a correspondingly higher cost. Some existing equipment is utilized, however. Crude oil from the caverns is cooled in the existing coolers on site. It is then degassed in a new vapor/liquid separator at reduced pressure. From this point, the process is very similar in processing steps to the In-Storage Degassing Option.

For Drawdown at BC, a significantly larger area is needed for the larger 515 MBD capacity equipment than for the In-Storage process. The larger equipment can be engineered to fit the available plot space by splitting the process up into its unique pieces and should be considered a feasible option for location at the BC site. The logistics unique to this type of batch mode operation include equipment lay-up between batches and permanent staffing to address Drawdown critical operations. In addition, the process design for Drawdown must achieve a higher threshold of equipment availability to maintain the overall complex reliability at greater than 95 %.

Viability: Continue Analysis

3. Drawdown Degassing at Terminal

In principle, it is possible to implement vapor pressure control on Drawdown at the terminal end of the pipeline. This potentially provides access to more land at the terminal for layout of the processing equipment and facilitates the disposal of the material responsible for the increased vapor pressure in the BC crudes. However, the logistics for pursuing this approach are complicated by the fact that BC crude can be transferred to multiple locations. Where crude oil is typically routed south by pipeline to the St. James Terminal, another delivery point is also located to the north at the ExxonMobil Refinery in Baton Rouge. On Drawdown, oil movement across these two delivery points is made all the more likely by the need to empty the caverns as quickly as possible in response to the nominations (bidding) process for crude oil off-take. Implementing BPP control by degassing at two locations would double life cycle costs for this option. Transfer of control of the degassing systems to third party operations at these locations would significantly reduce overall system reliability. Although there may be some synergies available at the terminal location which could reduce operating costs, life cycle costs at the individual locations are expected to be comparable to the Degassing Option at BC.

Although not a typical degassing process, vapors generated at the storage terminal storage tanks can be collected and eliminated by combustion during drawdown. The St. James Terminal is equipped with six conventional external floating roof storage tanks. These tanks can be equipped with aluminum geodesic domes that allow vapors that escape past the tank roof seals to be captured. A new type of aluminum floating roof would be installed to eliminate the possibility of the roof sinking as a result of high vapor load under the roof. In addition, a vapor collection and destruction system is required. This system would require 8” and 10” collection lines from each of the storage tanks and a vapor blower for each Vapor Destruction Unit (VDU) to provide sufficient flow to capture the vapor generated between the floating roof and geodesic dome when the tanks are filling.

For the maximum drawdown rate of 515,000 barrels per day anticipated during a drawdown order, a total of three VDUs would be required. A single VDU could be sized to handle the total flow, but the unit would be much larger than the three units which are 11 ft. diameter by 60 ft. in elevation. In addition, a second unit would be required to provide the redundancy required for drawdown. The three units, on the other hand, can be sized slightly larger to provide extra capacity should one unit be taken out of service.

The VDUs thermally oxidize all vapor components with a destruction efficiency of over 99%. Operating costs for this type of system will be required during drawdown only and are relatively low. However, the individual blowers and VDU's must be maintained and operated on a frequent basis to ensure reliability.

Viability: No Further Analysis

C. Configuration Alternatives for Degassing Options

Alternatives exist for optimizing individual process blocks within the In-Storage and Drawdown degassing options selected for further study in Section V. The process alternatives that were evaluated are summarized in this section. Some of these alternatives are applicable to both in-storage and drawdown degassing options; some are not.

1. Mitigation of Hydrogen Sulfide Emissions

Hydrogen sulfide (H_2S) poses an emissions problem when combustion is used to convert it to the less toxic sulfur dioxide. When left unconverted it poses a serious exposure hazard as well as a hazardous air pollutant (HAPS) issue which can result in hazardous emissions when vaporization of the crude oil occurs at the terminal storage site. The BC site is located in an area classified as a non-attainment area from an air quality standpoint. It is not likely that sulfur dioxide resulting from the combustion of the hydrogen sulfide will be allowed under existing permits without amendment of the permit. Further permitting work is needed if incineration is to be considered as an alternative. For the purposes of this phase it was assumed that the permitting effort would yield negative results and other options were explored to mitigate the H_2S emissions. These alternatives are evaluated in the following sections.

a. Injection of Liquid Scavenger

H_2S can be rendered non-volatile in solution by complexation and/or reaction with a liquid scavenger. The use of liquid scavengers injected directly in the crude during Drawdown has been approved by the Louisiana state regulators as an interim measure to cope with the exposure hazard of H_2S in the shipping and handling of high BPP crude. The cost of liquid scavenger injection is quite high from an operating standpoint unless sophisticated sulfur analyzers and injection rate control are implemented to avoid overfeed and scavenger waste. Although specifically allowed for Drawdown, this method of mitigation is also applicable to In-Storage processing. One of the objectives of this study is to eliminate the use of liquid scavenger.

Viability: Continue Analysis

b. Amine Treating with Acid Gas Reinjection into Crude

H_2S can be selectively removed from the off-gas for disposal by means of absorption into a physical or chemical solvent. Most commonly, this is done with contact with a regenerable amine solution. The H_2S rich off-gas is contacted with a circulating amine solution across an absorption column wherein the H_2S is selectively absorbed into the amine, liberating an off-gas depleted of H_2S for further process. The H_2S loaded amine is then circulated across a regenerator column where the H_2S and other soluble gases are stripped out as a separate H_2S rich gas stream for reinjection into the crude oil. The stripped amine solution, lean in H_2S, is recycled back to the absorption column to reuse. The capital investment associated with amine contacting systems is relatively low due to the small size required. With selection of a thermally and chemically stable amine tailored to the process, the process is very robust. With proper operator training and H_2S monitoring, the hazards associated with handling an H_2S stream are addressed. From an environmental standpoint, routing the H_2S back to the crude for delivery to downstream refineries which are better equipped to environmentally process H_2S into sulfur is appealing. This option is currently used in the Degas II plant design.

Viability: Continue Analysis

c. Solid Bed Scavenger

H_2S can be selectively removed from the off-gas by adsorption onto a solid bed scavenger with subsequent reaction to chemically "fix" the H_2S into the solid for offsite reprocessing or disposal. Solid material scavengers have been available for a number of years. The oldest of these is iron sponge, a hydrated iron oxide. This type of material is difficult to handle and can react exothermically with air when dumped with the potential to catch fire. It is not suitable for use in the current environment. Other iron based scavengers

have been developed that utilize a ceramic base which increases the scavenger cost but decreases the disposal handling problems. These types of scavengers are best suited to small scale requirements such as that produced by the In-Storage processing option.

Viability: Continue Analysis

d. Liquid Bed Scavenger

H_2S can also be selectively removed from the off-gas by absorption and reaction with a liquid scavenger for offsite reprocessing or disposal. Liquid bed scavengers work in similar fashion to solid bed materials in that they have a fixed volume and can recover a fixed amount of H_2S before change out. The equipment required is similar in capital cost to the solid bed scavenger system. The ease of emptying a liquid based scavenger is partially off-set by the differences in disposal options. Solid based scavengers are typically land filled whereas spent liquid scavengers are either regenerated off-site and recycled or disposed of by incineration or deep well injection. Liquid bed scavenger is better suited to the In-Storage Option where lower rates would reduce the rate of change out frequency of scavenger. However, in the best case scenario, this alternative effectively equates to a batch amine contacting operation which offers no economic advantage over continuous amine contacting and regeneration system operation on site. Hence, this alternative can be eliminated from further consideration.

Viability: No Further Analysis

e. H_2S Incineration

Disposal of gas containing any amount of H_2S can be achieved by combustion or incineration. Direct incineration of H_2S rich off-gas or off-gas of reduced H_2S concentration with greater than 99.9 % H_2S destruction efficiency remains a viable option subject to the emissions permitting issues mentioned previously. This alternative must be reviewed for the impact of permitting a source that would emit almost 300 tons of sulfur dioxide per year.

Viability: Continue Analysis

2. Removal and Disposal of Gas On-Site

H_2S concentration has only a very small impact on crude bubble point pressure (BPP). Larger contributions are made by the lighter crude components such as methane, ethane, propane, and butanes. To meet the vapor pressure requirements of the design basis it is necessary to remove a portion of these materials from the crude as an off-gas stream by degassing and dispose of them. Ideally, this off-gas steam is treated to remove H_2S to satisfy environmental constraints and product sales specifications. This section addresses the various methods for disposal of the methane, ethane, propane, and butane rich off-gas by the alternatives listed below.

a. Off-Gas Incineration

Incineration can be considered as an effective means for disposing of sweetened (H_2S lean) off-gas. Thermal oxidation is a proven process which will combust hydrocarbon material with high thermal destruction efficiency while meeting stringent NO_x emissions requirements. Even so, permit requirement reviews are needed to determine the impact for both the rather low emissions produced by the In-Storage Option and the higher volumes produced by the Drawdown Option. If permit limits are exceeded, the evaluation of this alternative should consider the purchase of NO_x credits as an additional operating cost.

Viability: Continue Analysis

b. Sell as Fuel Gas

Sweetened off-gas produced from a single stage of flash is high in propane and butane content. The addition of propane refrigeration to chill the off-gas can reduce the amount of materials present in the stream. However, the stream will still have a methane content between 18%-28%, while the ethane and propane content will range between 35%-47% depending upon the cavern crude composition. This methane content is too low and the ethane and propane content too high for normal fuel gas such that it is considered unlikely that a buyer could be found for this material. The In-Storage Option produces too low a volumetric stream to be commercially attractive. The Drawdown option does not guarantee a continuous

supply in a given time frame to attract potential buyers. This alternative does not appear feasible for these reasons.

Viability: No Further Analysis

c. Sell as Y-Grade

The sweetened off-gas stream must be condensed to be sold as a liquid Y-grade material. The vapor pressure must be less than 600 psig at 100 ^{o}F when in the liquid state to meet a standard y-grade specification. The methane content of the off-gas is too high to bring the vapor pressure below 1500 psig at 100 ^{o}F. To meet the Y-grade specification additional compression and cooling would be necessary. The resulting Y-grade stream produced at specification during Drawdown is of such a low rate as not to be of commercial interest.

Viability: No Further Analysis

d. Generate Power

The sweetened gas supply available is of a low rate, but can be used in smaller turbine generator sets for the generation of electrical power. Unfortunately, the fuel quality is not sufficiently high in methane content to serve as a suitable fuel. Outside fuel gas would have to be imported to the site to blend down the off-gas with high methane content fuel gas. The cost of infrastructure required to bring fuel gas to the site would have to be considered. This fuel source may be required anyway if the H_2S is recovered by circulation amine. If would serve as a source of heat for regeneration of the amine, in this case. The costs associated with increasing microturbine reliability through design and sparing would also have to be considered. Internal combustion engines may office an alternative to microturbines for the generation of electrical power, subject to similar “lean burn” and reliability considerations. The issues associated with operating this equipment must be considered as well. For example, given the shorter duration of Drawdown, start-up and operation of power generation equipment may prove too problematic to pursue.

If refrigeration is added to the process to increase the propane recovery without exceeding the BPP, the off-gas rate can be substantially reduced. As the propane has the much higher value as liquid product, higher propane recovery is a more attractive alternative. The remaining off-gas stream is, then, too small to be considered for power generation and is eliminated by disposal in a flare system.

Viability: Continue Analysis

3. Crude Oil Cooling

Increasing the crude oil temperature in storage increases the crude oil BPP. The longer the crude remains in cavern storage the higher the crude storage temperature becomes as a result of geothermal heating. A reduction in this temperature could be considered as an option for meeting the required bubble point specification for In-Storage or Drawdown. For this condition alone to satisfy the criterion the temperature to which the crude is cooled must ensure that the criteria is not exceeded when placed in atmospheric storage at reasonable summertime ambient conditions. The criterion of a bubble point pressure of 14.7 psia at 93 ^{o}F was selected for this purpose. As can be seen from Table 5, only cavern BC17 would satisfy the criteria with cooling alone. The other cavern crudes do not meet the criterion and additional processing is required. The simplest and most effective method of meeting the criterion is to provide a single stage of flash to remove the lighter components that contribute the most to the vapor pressure. The following alternatives have been considered as a means to implementing this concept.

a. No Cooling

Table 5 illustrates that a bubble point pressure can be achieved that will meet the design basis without the benefit of cooling the crude taken from storage, as all BPP values are below the required 14.7 psia at 93 ^{o}F. However, this same table shows that crude from cavern BC102 will not recover the required 95% of the propane if cooling is not implemented. Less than 90% of the propane would be recovered in this case. Single stage flash without the benefit of some pre-cooling will not achieve the target specification and, so, is not feasible unless additional means of cooling the off-gas to recover additional liquids is implemented.

Viability: No Further Analysis

COOLING WITH SINGLE STAGE FLASH								
Operating Condtion		Parameter	BC15	BC17	BC18	BC19	BC101	BC102
Cool to BPP of 14.7 psia	(1)	Temperature at Flash Drum-°F	87	98	90	78	72	68
Cool to 93 °F at 14.7 psia	(2)	C3 Recovery off Flash Drum-%	99.7	100.0	99.8	99.3	99.1	97.5
No Cooling	(3)	C3 Recovery off Flash Drum-%	98.3	98.9	95.9	97.6	97.6	89.8
No Cooling	(4)	Degassed Crude BPP at 93 °F-psi	12.7	12.6	11.52	12.7	12.8	13.2
No Cooling	(5)	Volume Loss_%	0.04	0.02	0.10	0.06	0.06	0.13
Cool to Recover 95% C3	(6)	Temperature at Flash Drum-°F	n.a.	n.a.	n.a.	n.a.	n.a.	103
Maximum Drawdown with No Cooling	(7)	Drawdown Rate-bpd	515,000	515,000	300,000	515,000	515,000	300,000
Maximum Drawdown with No Cooling	(8)	Offgas Rate-acfm	299	184	428	402	431	579

Notes:
(1) Flash drum is operating at a pressure of 14.7 psia and cold enough to eliminate off-gas.
(2) Flash drum is operating at a pressure of 14.7 psia and at 93 °F. Propane recovery is greater than 95% for all caverns.
(3) Crude cooler is bypassed. Propane recovery is greater than 95% for all caverns but BC102.
(4) Crude cooler is bypassed. BPP is less than 14.7 psia for all caverns.
(5) Crude cooler is bypassed. Volume %loss is less than 0.3% for all caverns.
(6) Crude from BC102 must be cooled to 103 °F to recover 95% propane. Other caverns require no cooling.
(7) Rate used for the analysis.
(8) Off-gas produced from the flash drum at the crude rate used in the analysis with no cooling.

Table 5 – Cooling Options with Single Stage Flash

b. Use Existing Exchangers

The existing Drawdown coolers are capable of cooling 515 MBD of crude oil from a temperature of 121 °F to 97 °F using 85 °F cooling water based on the DynMcDermott report of 30 October, 2010. When cooling water at a temperature of 85 °F is used, the Drawdown cooler outlet will reach a temperature of 97 °F with Drawdown from cavern BC102 at a rate of 300 MBD. This outlet temperature is much lower than the 103 °F required to recover 95% of the propane from cavern BC102, so the existing exchangers have sufficient surface area to cool the crude prior to the single stage of flash used to degas the crude. Although compression and cooling may be required for the off-gas recovery, they are not required to meet the propane recovery criteria. Liquid recovered as a result of cooling the compressed gas only increases the propane recovery when the liquid is combined back with the crude. The bubble point pressure of the blended crude can be maintained below the required 14.7 psia at 93 °F.

Viability: Continue Analysis

c. Air Cooling

Normal design outlet temperature for the process side of an air cooled heat exchanger is set at 120 °F. This temperature is higher than either the sour or sweet crude coming from cavern storage. Air cooling, then, is not an alternative for Drawdown as proper cooling must be available year around to achieve the required propane recovery.

Viability: No Further Analysis

d. Wet Surface Air Cooling

Cooling water temperature required for the single stage flash is 85 °F. The maximum wet bulb temperature for the BC location is 78 °F based on data taken from the 2005 ASHRAE handbook. Wet Surface Air Cooling can accommodate a 7 °F approach to design and is a reasonable choice for cooling the crude for the In-Storage Option. A cost analysis between a conventional cooling tower and a WSAC would be required for this same decision to be applied to the Drawdown Option.

Viability: Continue Analysis

e. Lake Water Cooling

Cavern Lake can provide water at temperatures suitable for cooling to the required 103 °F at the inlet of the degassing drum as indicated in DynMcDermott's 30 October, 2010 report. However, returning the water to the lake at a higher temperature will have negative environmental consequences. The potential for

contamination of the water should the exchangers begin leaking also could have a negative impact on the lake water quality if returned to the lake. In accord with current practices to avoid these environmental issues, the lake water cannot be circulated back to the lake. Either the lake water must be restricted to a cooling tower water basin to recirculate the water through a cooling tower or routed once-through the exchangers into the caverns to displace the crude. The first solution works for both the In-Storage and Drawdown scenarios although it requires additional investment. The second solution only works for the Drawdown option which requires injecting the water into the cavern to displace the crude oil as demonstrated in current operations.

Viability: Continue Analysis

f. Tempered Water Cooling

Tempered water cooling requires the use of refrigeration to reduce the cooling water temperature below 85 ^{o}F. As temperatures below this value are not necessary, a tempered water cooling process is not required.

Viability: No Further Analysis

g. Chilled Water Cooling

Chilled water cooling would normally deliver a cooling water supply at a temperature of 45 ^{o}F. If this temperature were required, it would introduce potential fouling or “waxing” of exchanger tube bundles for crudes with high paraffin content. However, neither chilled water nor tempered water systems are required for meeting the cooling requirements of the inlet crude stream.

Viability: No Further Analysis

h. Heating and Cooling

With a single stage flash process additional off-gas can be recovered by raising the inlet temperature and then compressing and cooling the off-gas to recover the required amount of propane. However, the incoming crude is at a sufficiently high temperature to flash and meet the bubble point pressure criteria. In fact, cavern BC102 must be cooled before the degassing drum to recover 95% of the propane. Heating of the crude prior to degassing is not necessary.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives B3, C1d, C2b, C2c, C3a, C3c, C3f, C3g, and C3h are eliminated from further consideration. The remaining alternatives, A1, A2, A3, A4, B1, and B2 are examined below as Part 1 alternatives A, B, C, D, E, and F, respectively. The remaining alternatives C1a, C1b, C1c, C1e, C2a, C2d, C3b, C3d, and C3e are examined below at Part 2 alternatives A1, A2, A3, A4, B1, B2, C1, C2, and C3, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

PART 1 – Vapor Pressure Management Options

A. Cavern Lake Water Cooling

Process Description

Cavern Lake is located at the boundary of the Bayou Choctaw site and is considered for use as the cooling media for an in-storage circulation system. Water would be pumped from the lake by new water circulation pumps which use the existing water distribution system to reach each of the cavern locations. At each cavern location a new crude circulation pump and cooler would be installed to maintain segregated inventories. The water from the existing inlet header passes through the cooler and returns to the lake in a new return header. Oil from the cavern is drawn through the existing tubing string by the crude circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern would be equipped with a new well so that they would remain drawdown ready during the cooling cycle.

Basis

The following basis was used to evaluate this option:

- Minimum recorded cavern lake temperatures for the period from June 2013 to May 2014 from BC logs.
- Cavern Lake volume of 300 MM gal. as determined from an estimated area of 500,000 sq. ft. and a depth of 80 ft.
- Oil circulation is hydraulically limited by tubing string velocity to a rate of 120,000 bpd by the tubing outside diameter of 10.75”.
- BC101 was selected to represent typical cavern conditions for all 6 caverns.
- Cavern circulation was selected as top out-bottom in.
- Geothermal temperature regain for all caverns is based on BC101 temperature response for the period from April 1996 to August 1998.
- Cooling water rates are based on the minimum required to provide acceptable exchanger performance.
- The initial cooling cycle was started in October.
- Cooling was operated seasonally and was terminated when lake water temperatures approached cavern top temperatures.
- Opex is based on 4% of TIC for equipment (does not include cavern wells and workovers)
- Electrical cost is based on an average winter cost of $0.01864/Kw-hr.
- Holding pond is sized for 24 hours of cooling water.
- Treatment plant is sized for 33 days of processing holding pond inventory.

Assumptions & Constraints

Assumptions:

- Simplest process configuration consisting of only new lake water pumps, lake water return header, and one oil circulation pump and exchanger at each cavern.
- Development of 6 wells at $14 MM each will be required.

Constraints:

- Inadequate water volume to support cooling. Only enough lake water available to support partial cool down of one cavern.
- Lake water volume insufficient to maintain a single cavern at required temperature.
- Lacks drawdown ready capability due to circulation through existing tubing string.

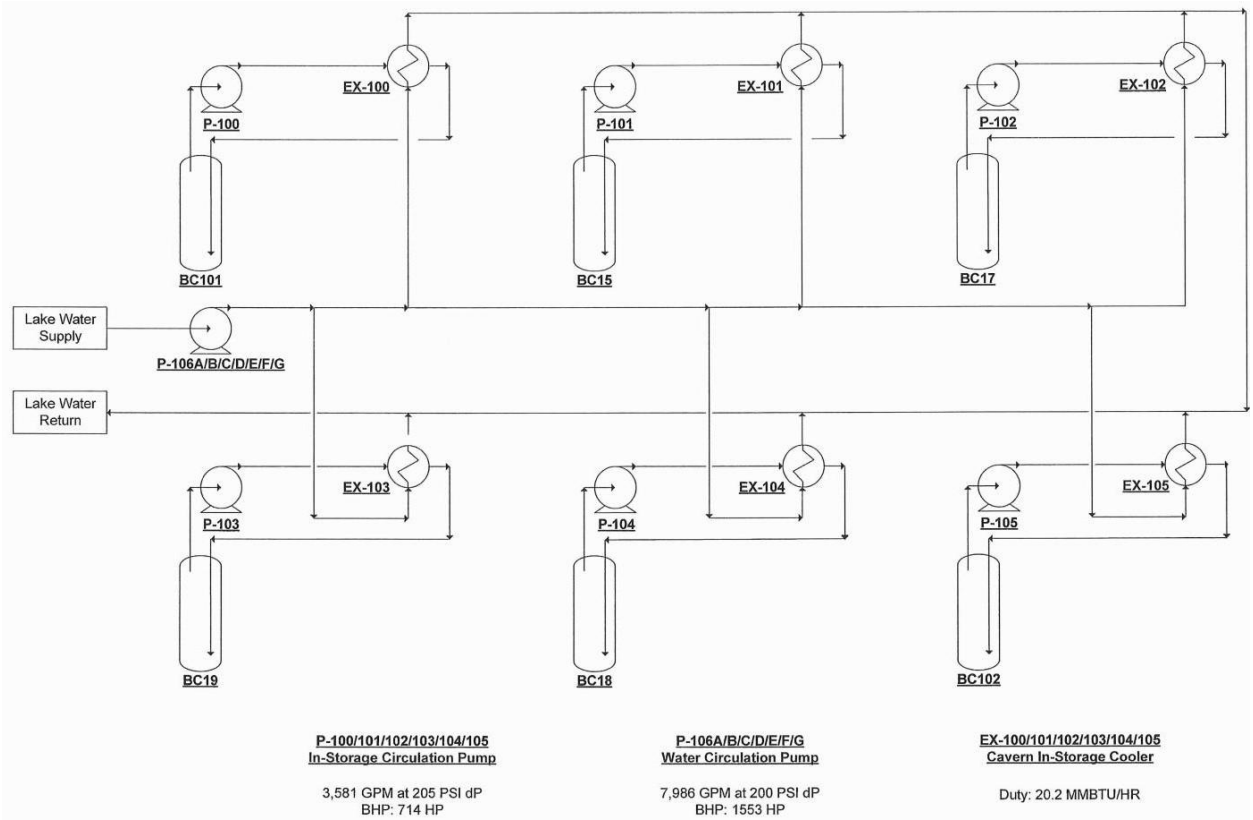


Figure 1 – Cavern Lake Water Schematic

Risk & Mitigation Factors

The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Cavern Lake Water Cooling			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Significant NEPA issues and obtaining a discharge permit is a concern as the water could be classified as process water.	An EA would be required to be done to verify any NEPA issues as well as the basis for obtaining permits	High – High	High Risk Hazard
Potential thermal and oil contamination	Install holding pond, treatment plant, analytical testing and monitoring equipment. Pond and plant will require significant plot area.	Medium – High	Medium Risk Hazard
Delivery point storage conditions can potentially re-heat material in storage tanks during summer months.	Scavenger would be required.	Medium – High	Medium Risk Hazard

B. Aquifer Water Cooling

Process Description

The Plaquemine Aquifer lies beneath the Bayou Choctaw site at a depth of between 60 ft. and 500 to 600 ft. and is a potential source of cooling water. Temperatures in the aquifer are cold enough to provide sufficient cooling for the cavern inventory. To develop this water source producing wells would be drilled within the boundaries of the property and spaced in a way to optimize the supply of water. To dispose of the water returning from the intermediate water coolers a set of injection wells would be drilled. The location selected would provide the maximum amount of water before thermal contamination from the injection wells reaches the producing wells. Each producing water well is equipped with a downhole pump to supply water to exchange heat with a secondary closed loop cooling system, thereby isolating the cavern coolers from the aquifer water. This closed loop circuit passes water through the intermediate water coolers for cooling as it exchanges heat with the cooler water from the aquifer. The cooled water then circulates through the cavern coolers to cool the crude oil from the caverns. Water which leaves the cooler returns to the inlet of the intermediate water coolers to complete the closed loop circuit. The existing water distribution system to the wells is utilized as part of the intermediate water supply system. A new aquifer water supply and return header system would be required to provide cooling water to each one of the cavern locations. As in the Cavern Lake option, each cavern is equipped with a crude oil circulation pump and crude oil cooler. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during cooling.

Basis

The following basis was used to evaluate this option:

- An aquifer temperature of 55 ^{o}F.
- Six producing wells and four injection wells placed so as to maximize available water within the boundary of the site.
- Aquifer water volume of 3,200 MM gal as determined from the maximum volume that can be injected before thermal breakthrough occurs in the producing wells.
- Oil circulation is set to cool down the cavern inventory over 12 months.
- BC101 was selected to represent typical cavern conditions for all 6 caverns.
- Cavern circulation was selected as top out-bottom in.
- Geothermal temperature regain for all caverns is based on BC101 temperature response for the period from April 1996 to August 1998.
- Cooling water rates are based on the minimum required to provide acceptable exchanger performance.
- Cooling was terminated altogether when thermal breakthrough occurs from the injection to producing wells.
- Opex is based on 4% of TIC for equipment (does not include cavern wells and workovers)
- Electrical cost is based on an average yearly cost of $0.03235/Kw-hr.

Assumptions & Constraints

Assumptions:

- The aquifer contains over ten times more water than Cavern Lake.
- Development of 6 wells at $14 MM each will be required.

Constraints:

- Inadequate water volume to be a sustainable solution. Not enough water available to cool down and maintain multiple caverns.

- Lacks drawdown ready capability due to circulation through existing tubing string.

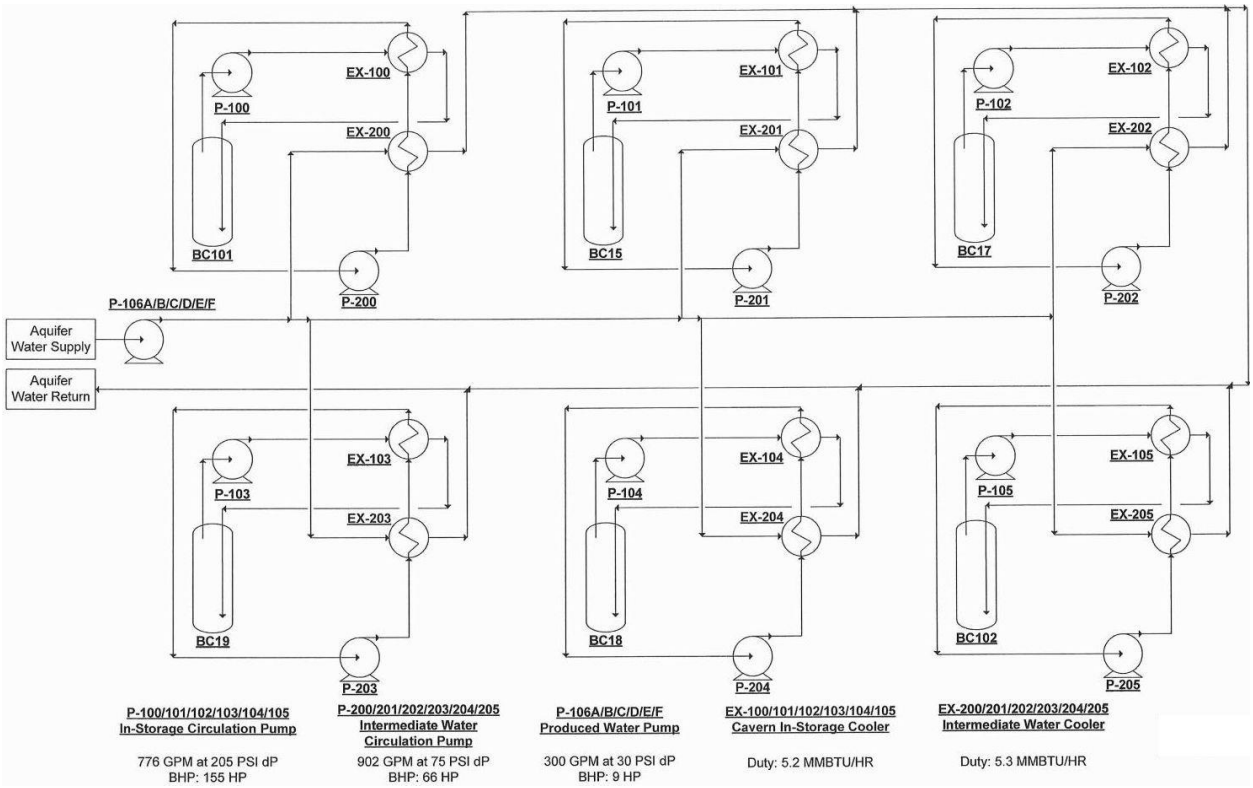


Figure 2 – Aquifer Water Schematic

Risk & Mitigation Factors

The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Aquifer Water Cooling			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Significant NEPA issues and obtaining a discharge permit is a concern as the water could be classified as process water.	An EA would be required to be done to verify any NEPA issues as well as the basis for obtaining permits	High – High	High Risk Hazard
Potential thermal and oil contamination	Install holding pond, treatment plant, analytical testing and monitoring equipment. Pond and plant will require significant plot area.	Medium – High	Medium Risk Hazard
Potential contamination of drinking water (aquifer is a source of drinking water).	Demonstrate the return water is not process water	Medium – High	Medium Risk Hazard
Delivery point storage conditions can potentially re-heat material in storage tanks during summer months.	Scavenger would be required.	Medium – High	Medium Risk Hazard

C. Cooling Tower Cooling

Process Description

Another option for providing a supply of cooling water to the individual caverns is by cooling the water in a cooling tower and then supplying it to the various caverns in a closed loop system. A closed loop system would provide water from the cooling tower basin and pump the supply to each of the caverns. It would pass through the tube side of the cavern cooler and return to the cooling tower by way of the return header system. The cooling tower, then, utilizes the air brought in by fans to cool the water by evaporation. Water must be added to the system to replace the water lost by evaporation. Water must also be withdrawn from the system to prevent solid build-up within the equipment. The water added must also provide for this amount of blowdown in addition to the water lost by evaporation. Oil from each cavern is circulated through the existing tubing string by the oil circulation pumps. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

Basis

The following basis was used to evaluate this option:

- Seasonal Wet bulb temperatures from the 2005 ASHRAE Handbook for the Bayou Choctaw region.
- Approach to wet bulb temperature is 10 ^{o}F as determined by a reasonable cooling tower design.
- Cavern cooling is initiated when cooling water supply temperatures drop below cavern top temperatures and terminated when supply temperatures approach cavern top temperatures.
- Oil circulation is hydraulically limited by tubing string velocity to a rate of 120,000 bpd by the tubing outside diameter of 10.75”.
- BC101 was selected to represent typical cavern conditions for all 6 caverns.
- Cavern circulation was selected as top out-bottom in.
- Geothermal temperature regain for all caverns is based on BC101 temperature response for the period from April 1996 to August 1998.
- Cooling water rates are based on the minimum required to provide acceptable exchanger performance.
- Opex is based on 4% of TIC for equipment (does not include cavern wells and workovers).
- Cooling tower make-up water treatment costs are included in the overall Opex costs.
- Electrical cost is based on an average winter cost of $0.01864/Kw-hr.
- Surface disposal of cooling tower blowdown is acceptable with a discharge permit amendment (permit cost not included).

Assumptions & Constraints

Assumptions:

- A closed loop cooling water system is sustainable for cavern cool down as well as maintenance through all years.
- Multiple caverns can be cooled down and maintained.
- Development of 6 wells at $14 MM each will be required.

Constraints:

- Cooling can only occur during six months out of the year during moths of cooler wet bulb temperatures.
- Seasonal wet bulb temperatures are not sufficiently low to maintain cavern temperatures below 90 ^{o}F before the arrival of the next cooling season.
- Lacks drawdown ready capability due to circulation through existing tubing string.

- Requires chemical handling and storage (hazardous chemicals) to minimize bacterial/algal contamination and scaling.

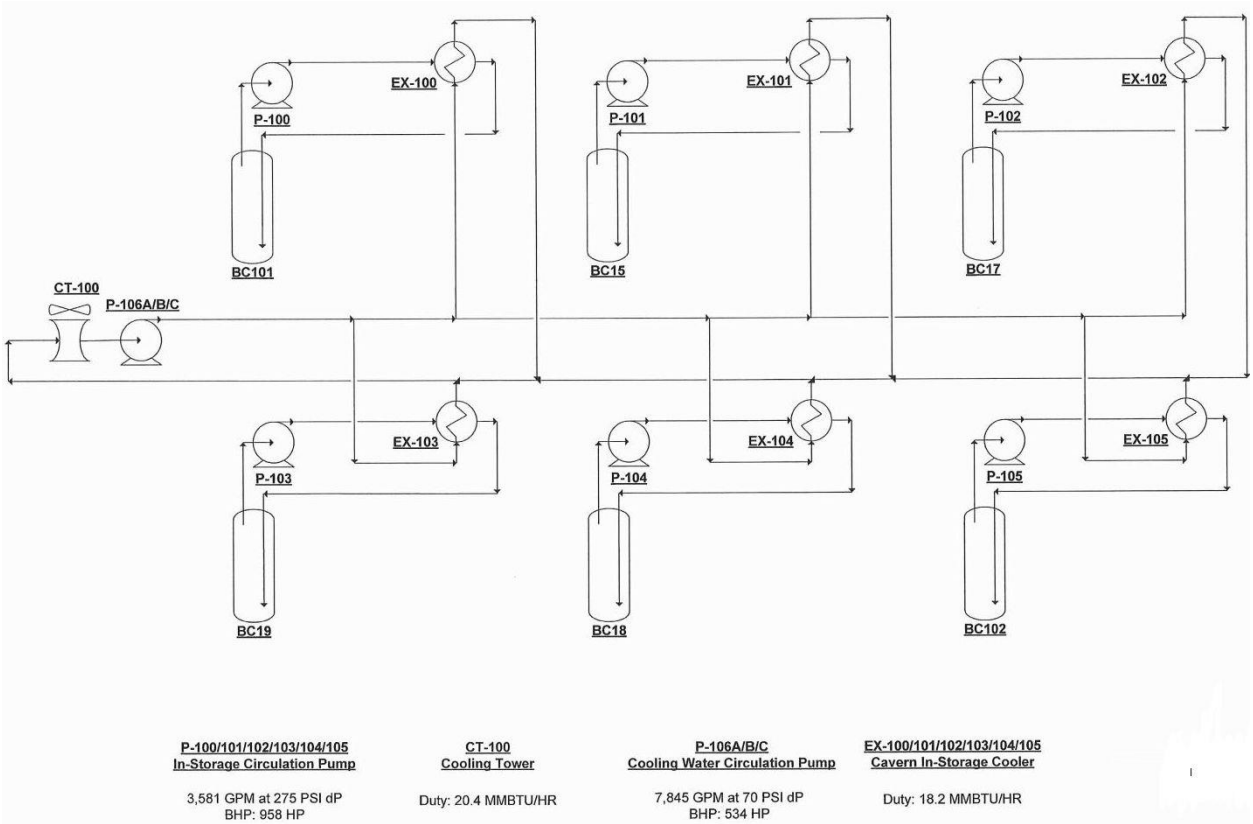


Figure 3 – Cooling Tower Schematic

Risk & Mitigation Factors

The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Cooling Tower Cooling			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Delivery point storage conditions can potentially re-heat material in storage tanks during summer months.	Scavenger would be required.	Medium – High	Medium Risk Hazard

D. Chilled Water Cooling

Process Description

A chilled water system utilizes refrigeration to reduce cooling water temperatures below those that can be achieved with a conventional cooling tower. Several types of refrigerant are available that can achieve the desired temperatures. One common one in use is ammonia. All refrigerant systems will require a compressor with a condenser to produce a liquid refrigerant. The refrigerant is then passed through an expansion valve which drops the temperature in the chiller coil to the desired level. Heat from the circulating chilled water is removed in the chiller by vaporization of the refrigerant. From the chiller the vaporized refrigerant returns to the suction of the compressor where the pressure is increased sufficiently to repeat the cycle. A condenser utilizes water from a conventional cooling tower to cool and condense the refrigerant from the compressor discharge. This cooling water is circulated through the cooling tower by pump in a closed loop system. The water that is chilled in the refrigerant chiller is circulated by pump through the crude oil cooler. The return water is circulated back to the chiller where the temperature is reduced by the refrigerant in a closed loop.

Each cavern is equipped with its own refrigeration package, circulation pump, and cooler for temperature maintenance. The chilled water is circulated through the existing water distribution system to the oil cooler. The water from the inlet header passes through the cooler and returns to the chiller. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

For initial cool down of cavern inventory two refrigeration packages with circulation pumps and cooler are required. One package is semi-portable and is relocated at each cavern location requiring cool down. After all six caverns have been cooled, the semi-portable unit serves as a spare unit for the other six refrigeration packages.

Basis

The following basis was used to evaluate this option:

- Ammonia was selected as the refrigerant.
- The water circulated to the oil cooler was chilled to 44 ^{o}F.
- Oil circulation is hydraulically limited by tubing string velocity to a rate of 120,000 bpd by the tubing outside diameter of 10.75”.
- BC101 was selected to represent typical cavern conditions for all 6 caverns.
- Cavern circulation was selected as top out-bottom in.
- Geothermal temperature regain for all caverns is based on BC101 temperature response for the period from April 1996 to August 1998.
- Chilled water rates are based on the minimum required to provide acceptable exchanger performance.
- Cooling tower water was assumed to be 85 ^{o}F to provide a 10 ^{o}F approach to maximum wet bulb temperatures in the BC region.
- Opex is based on 4% of TIC for equipment (does not include cavern wells and workovers)
- Electrical cost is based on an average yearly cost of $0.03235/Kw-hr.

Assumptions & Constraints

Assumptions:

- All caverns can be cooled down and maintained to meet drawdown requirements.
- Development of 6 wells at $14 MM each will be required.

Constraints:

- Process is one of the most complex of all options.
- Colder chilled water inlet temperatures make paraffin wax out in the crude coolers more likely.
- Lacks drawdown ready capability due to circulation through existing tubing string.

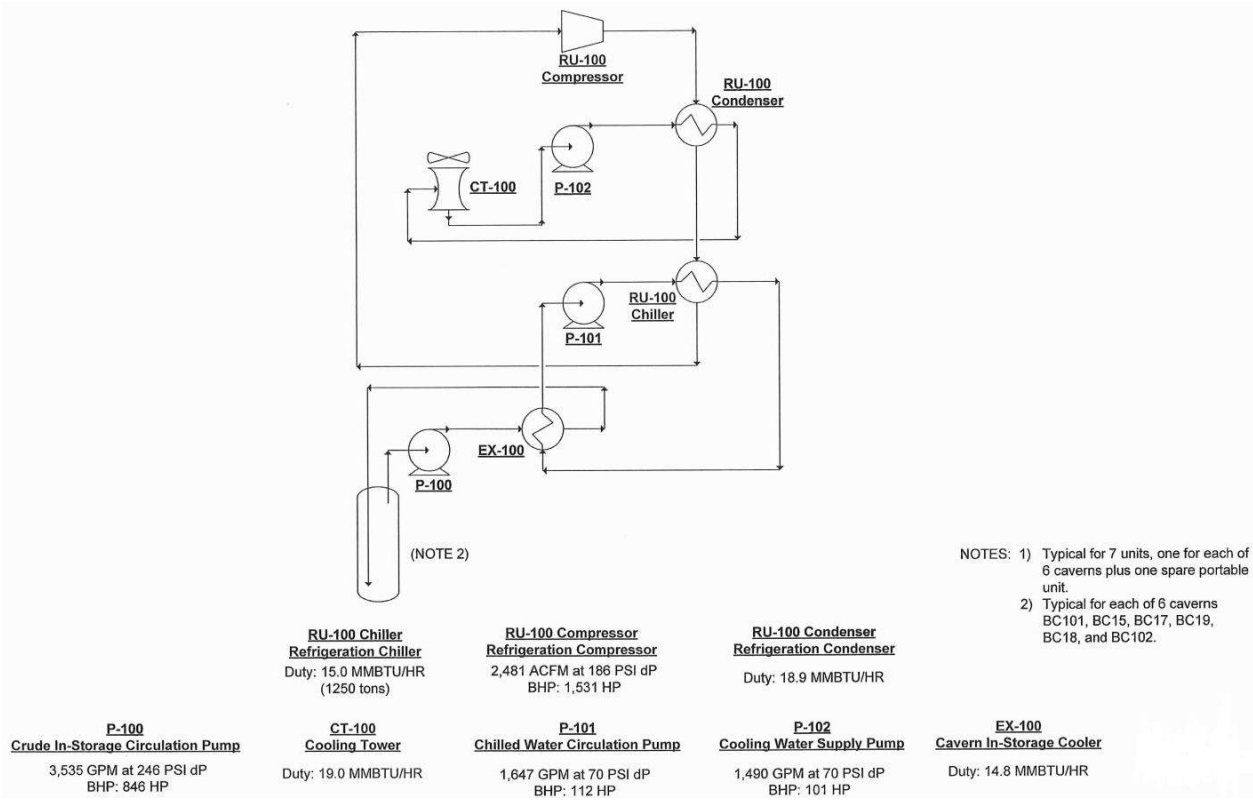


Figure 4 – Chilled Water Cooling Schematic

Risk & Mitigation Factors

The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Chilled Water Cooling			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Delivery point storage conditions can potentially re-heat material in storage tanks during summer months.	Scavenger would be required.	Medium – High	Medium Risk Hazard

E. In-Storage Degassing

Process Description

A single process package would be utilized for degassing the six caverns at BC. The equipment is packaged to make it portable for use at other SPR sites. With this process crude oil from cavern storage would be circulated through a cooler to reduce the temperature prior to separation of the volatile vapor in a two-phase separator at near atmospheric pressure. The off-gas from this degassing separator is compressed and cooled to recover the heavier components from the off-gas stream and thereby reduce the shrinkage of the crude processed. An air cooled exchanger is used as the source of cooling. The outlet of the air cooled exchanger is collected in a vapor/liquid separator and the off-gas is sent to an amine unit for recovery of hydrogen sulfide. The liquid from the separator is combined with the liquid from the degassing separator and is transferred by pump back to the cavern. The hydrogen sulfide from the amine unit is combined with the off-gas product for disposal. The amine package consists of a contactor and regenerator so regenerated amine can be circulated by pump in a closed loop system. The off-gas from the amine contactor is further condensed by propane refrigerant to remove additional heavy components for injection back into the crude. The small amount of off-gas and hydrogen sulfide that remains after recovery of the heavier components is sent to a high efficiency flare for final disposal by combustion. The flare is elevated and is sized to handle the larger relief loads from the equipment during a fire scenario.

Oil from the cavern is drawn through the existing tubing string by the oil circulation pump and returned to the cavern through the existing water injection tubing string. A new oil return header will bring the degassed crude back to the suction side of the crude circulation pump. A closed loop cooling water system with a cooling tower is used to cool down the crude in a new exchanger before degassing. Each cavern would be equipped with a new well so that they remain drawdown ready during the cooling cycle.

Basis

The following basis was used to evaluate this option:

- Ambient air is 95 ^{o}F.
- Cooling water approaches wet bulb temperatures within 10 ^{o}F.
- Oil circulation is set at 72,000 bpd.
- BC19 was selected to establish equipment sizes for cost estimating.
- Cavern circulation was selected as top out-bottom in.
- Geothermal temperature regain for all caverns is based on BC101 temperature response for the period from April 1996 to August 1998.
- Cooling water rates are based on the minimum required to provide acceptable exchanger performance.
- The amine unit is the smallest packaged unit commercially available with a rated circulation rate of 10 gpm.
- The refrigeration package is rated at approximately 1 ton.
- Recovery of propane is greater than 95% and is limited by the BPP of 14.7 psia at 93 ^{o}F.
- Opex is based on 4% of TIC for equipment.
- Electrical cost is based on an average yearly cost of $0.03235/Kw-hr.
- Work-over cost to position tubing string for degassing is $600,000/cavern.

Assumptions & Constraints

Assumptions:

- All caverns can be degassed to meet drawdown requirements.
- Once a cavern is degassed it is drawdown ready for an extended period of time and the degassing equipment can be used on another cavern so that duplicate equipment is not required.

- The equipment purchased for Bayou Choctaw can be re-used at other sites/locations as needed.
- Time caverns are taken out of drawdown configuration is minimized.
- Operational experience obtained from other SPR installations can be utilized.
- Technical know-how is available for building small portable units.
- Process has proven reliability.
- Degassing process can be completed in 4 years of operation for all caverns.
- Permitting issues have been addressed in previous applications. Simpler process to amend existing permits.
- Provides a flexible solution for buying new oil with higher vapor pressures.
- Most complex process of options but with fewer required equipment items than chilled water cooling option as there is no requirement to maintain cavern conditions once degassing has occurred.

Constraints:

- Additional operating/maintenance personnel are required for the additional rotating equipment and are required on a full time basis.
- Requires well workover to cut the tubing string for circulation in all six caverns.
- Requires new return header to connect the degas process to all wells in the crude oil circulation system.

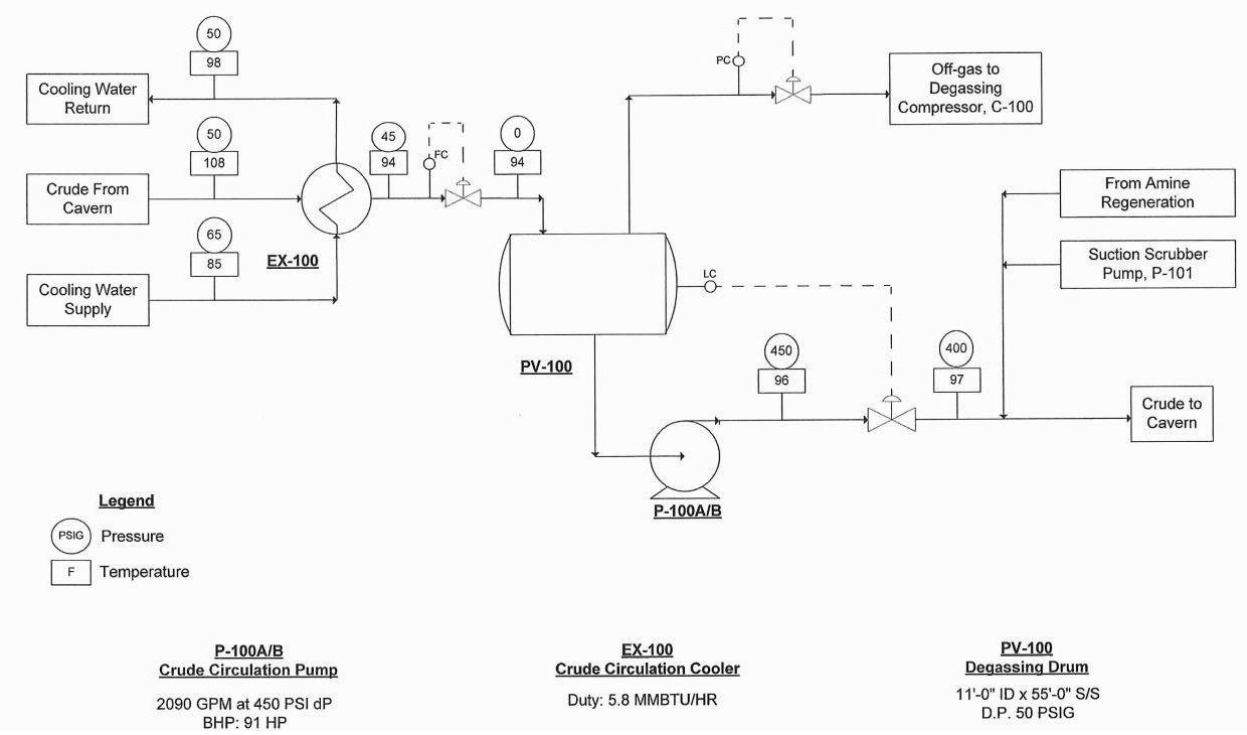


Figure 5 – In-Storage Degassing Schematic

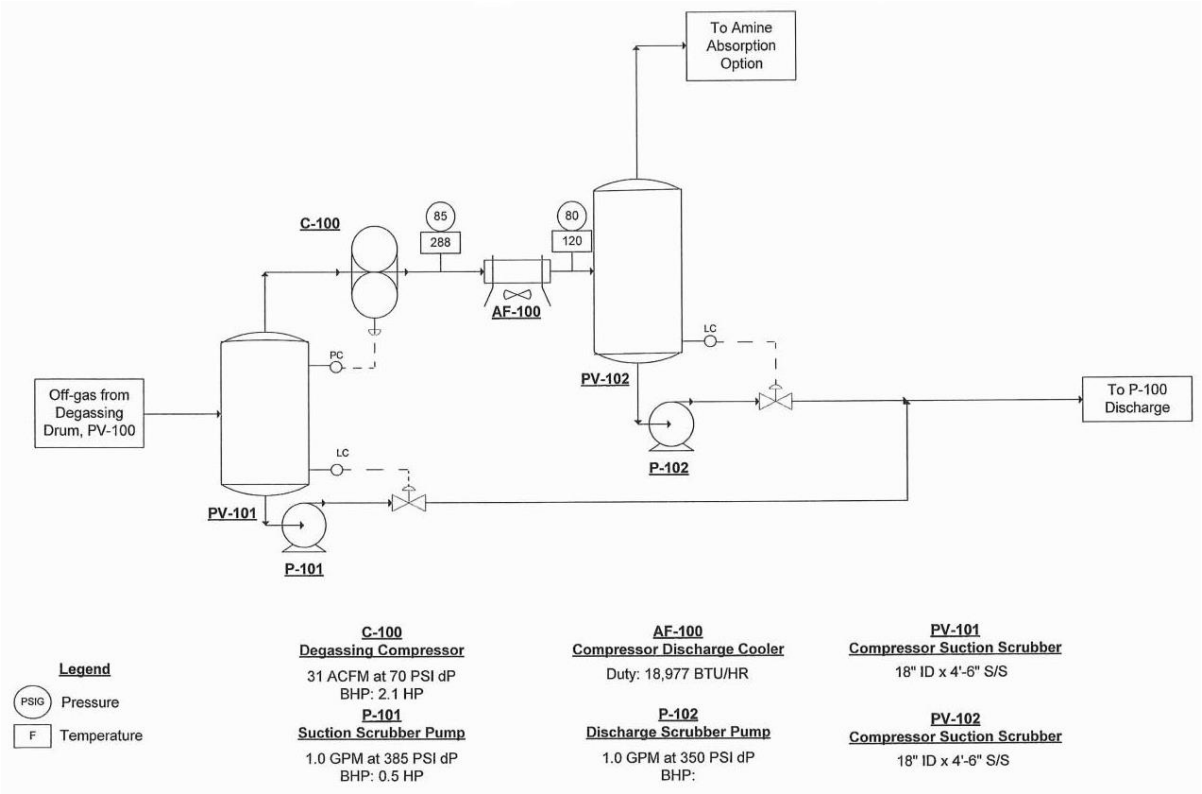


Figure 6 – Compression In-Storage Degassing Schematic

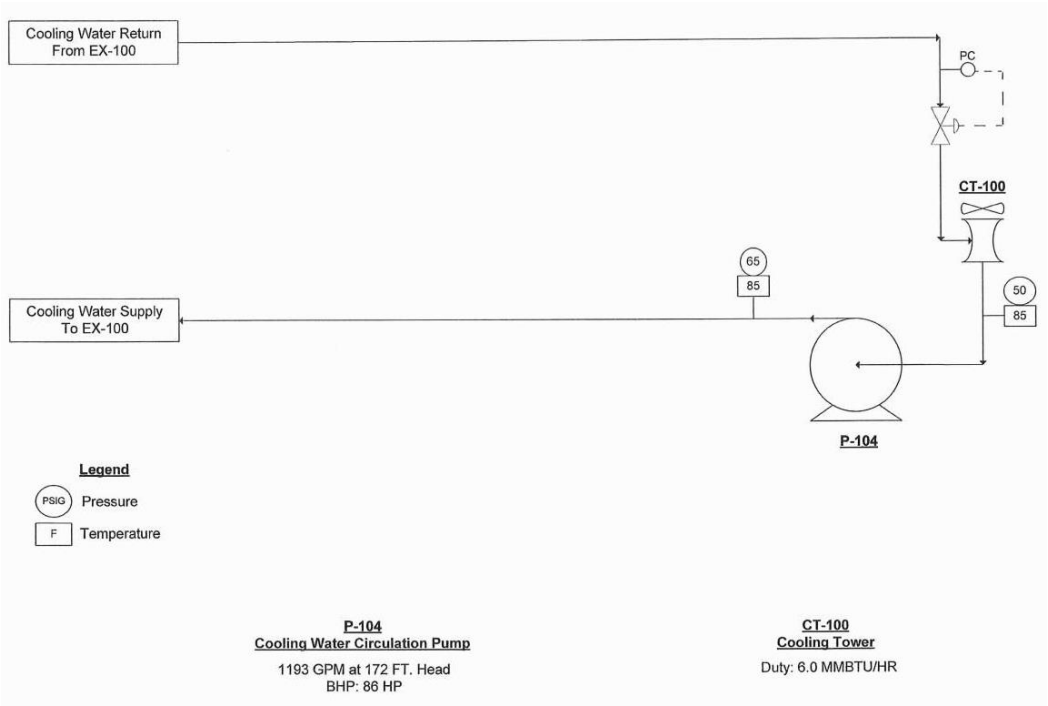


Figure 7 – Cooling Water System In-Storage Degassing Schematic

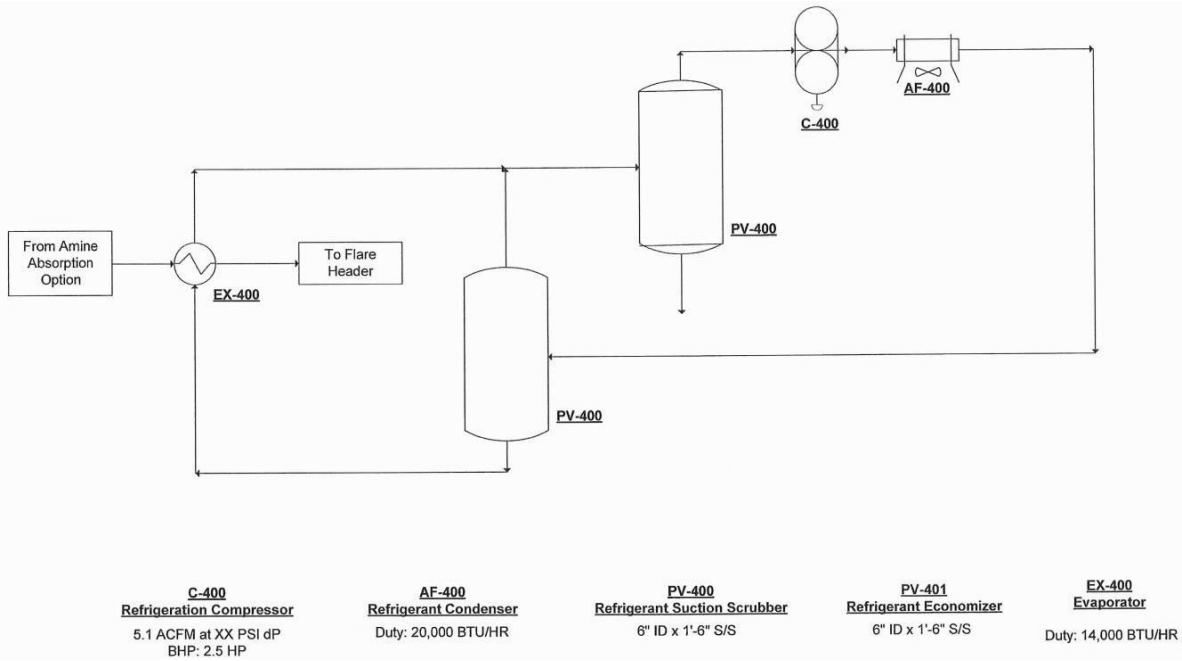


Figure 8 – Refrigeration In-Storage Degassing Schematic

F. Drawdown Degassing

Process Description

Due to the larger size of the degassing equipment required for drawdown, the equipment would be located for dedicated use at BC. With this process crude oil from cavern storage would be drawn down through the existing crude cooler to reduce the temperature prior to separation of the volatile vapor in a two phase separator at near atmospheric pressure. The off-gas from this degassing separator is compressed and cooled to recover the heavier components from the off-gas stream and thereby reduce the shrinkage of the crude processed. An air cooled exchanger is used as the source of cooling for condensation of the off-gas. Two stages of compression and cooling are required for sufficient reduction of the off-gas rate. The outlet of the second stage air cooled exchanger is collected in a vapor/liquid separator and the off-gas is sent to an amine unit for recovery of hydrogen sulfide. The liquids from each of the compressor discharge separators are combined with the liquid from the degassing separator which is transferred by pump to the pipeline supplying crude to the terminal. The hydrogen sulfide that is recovered from the amine unit is injected back into the crude from the degassing separator. The amine package consists of a contactor and regenerator with amine circulated by pump in a closed loop system. The off-gas from the amine contactor is further condensed by propane refrigerant to remove additional heavy components for injection back into the crude. The small amount of off-gas that remains after recovery of the heavier components is sent to a high efficiency flare for final disposal by combustion. The flare is elevated and is large enough to handle relief loads from the equipment during a fire scenario.

Crude oil is removed from the cavern by existing pumps and water injection system. Water used for injection into the cavern is first used as a cooling media in the crude oil coolers. No additional return header or closed cooling water system is required for this configuration. No additional wells are needed to maintain drawdown readiness.

Basis

The following basis was used to evaluate this option:

- Ambient air is 95 ^{o}F.
- Air cooling results in a process outlet temperature of 120 ^{o}F.
- Oil drawdown rate is 515,000 bpd.
- Sour cavern BC19 was selected to establish equipment sizes for cost estimating.
- Water enters the cavern at the bottom; oil leaves the cavern at the top.
- Existing cavern pumps and exchangers are utilized.
- The amine unit is the smallest packaged unit commercially available with a rated circulation rate of 10 gpm.
- The refrigeration package is rated at approximately 10 ton.
- Recovery of propane is greater than 95% and is limited by the BPP of 14.7 psia at 93 ^{o}F.
- Opex is based on 4% of TIC for equipment.
- Electrical cost is based on an average yearly cost of $0.03235/Kw-hr.
- Operating and electrical costs are based on a single drawdown.
- Provision is made for a circulation header for intermittent equipment runs to maintain reliability.
- Labor required for intermittent equipment runs is $900,000/yr. (8 trained operators, ½ instrument technician, ½ rotating equipment technician).

Assumptions & Constraints

Assumptions:

- All caverns can be degassed to meet drawdown requirements.

- Eliminates the need to work over wells.

Constraints:

- Larger equipment requires more plot space which increases the difficulty of siting. Also lessens the probability that it will be mobile enough to use at other sites.
- Equipment reliability will be difficult to maintain when equipment must stand idle for extended periods between drawdowns.
- Duplication of equipment would be required for simultaneous drawdown from multiple sites containing oil unable to meet drawdown requirements.

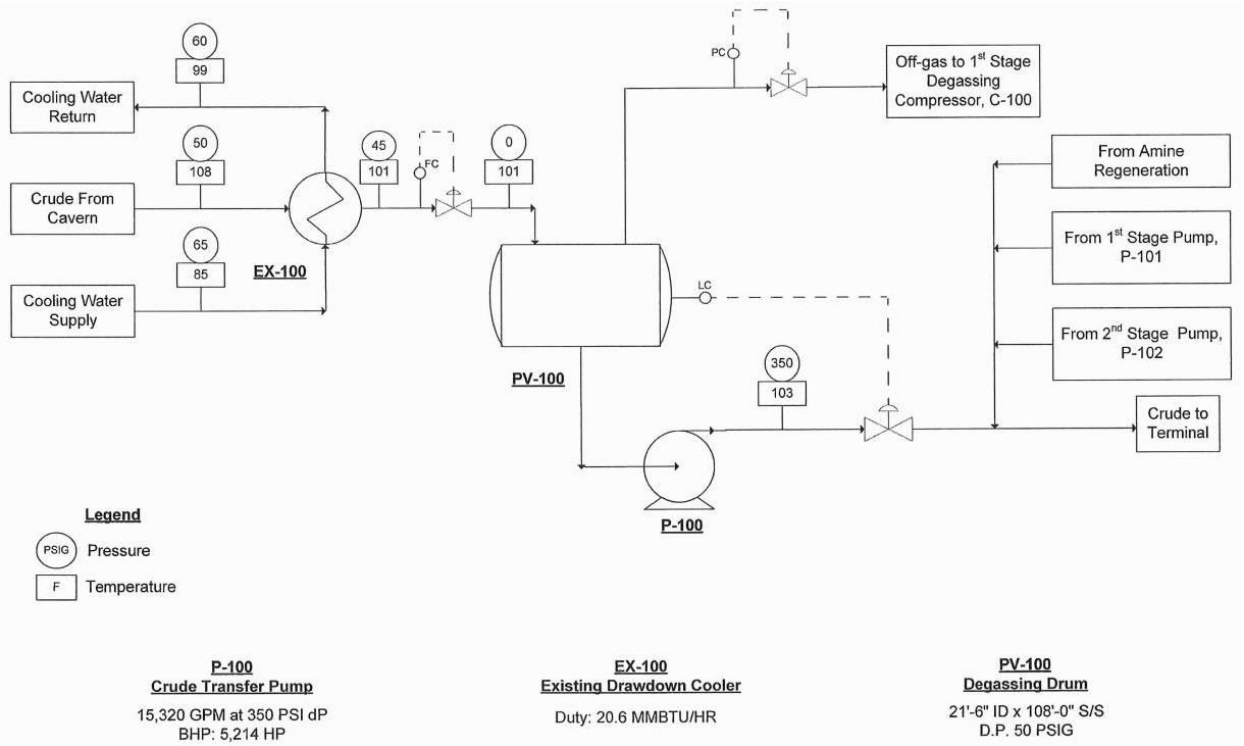


Figure 9 – Drawdown Degassing Schematic

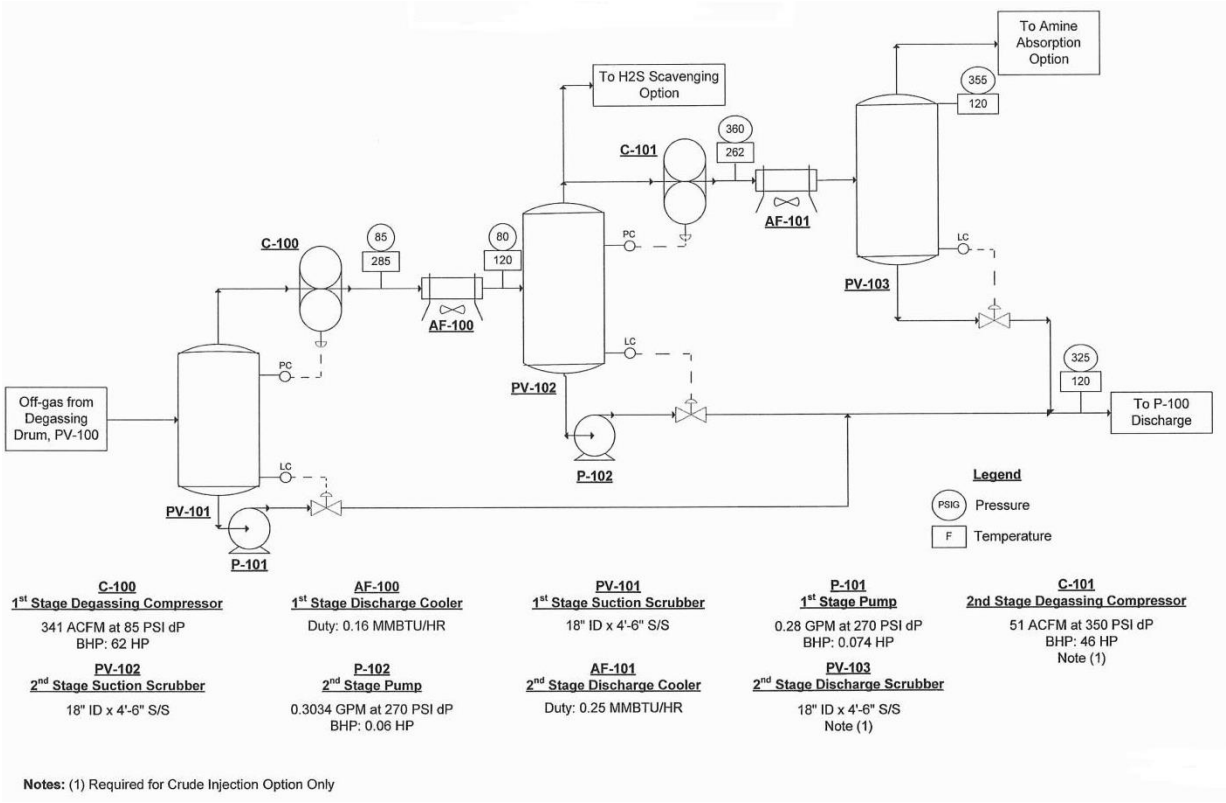


Figure 10 – Compression Drawdown Degassing Schematic

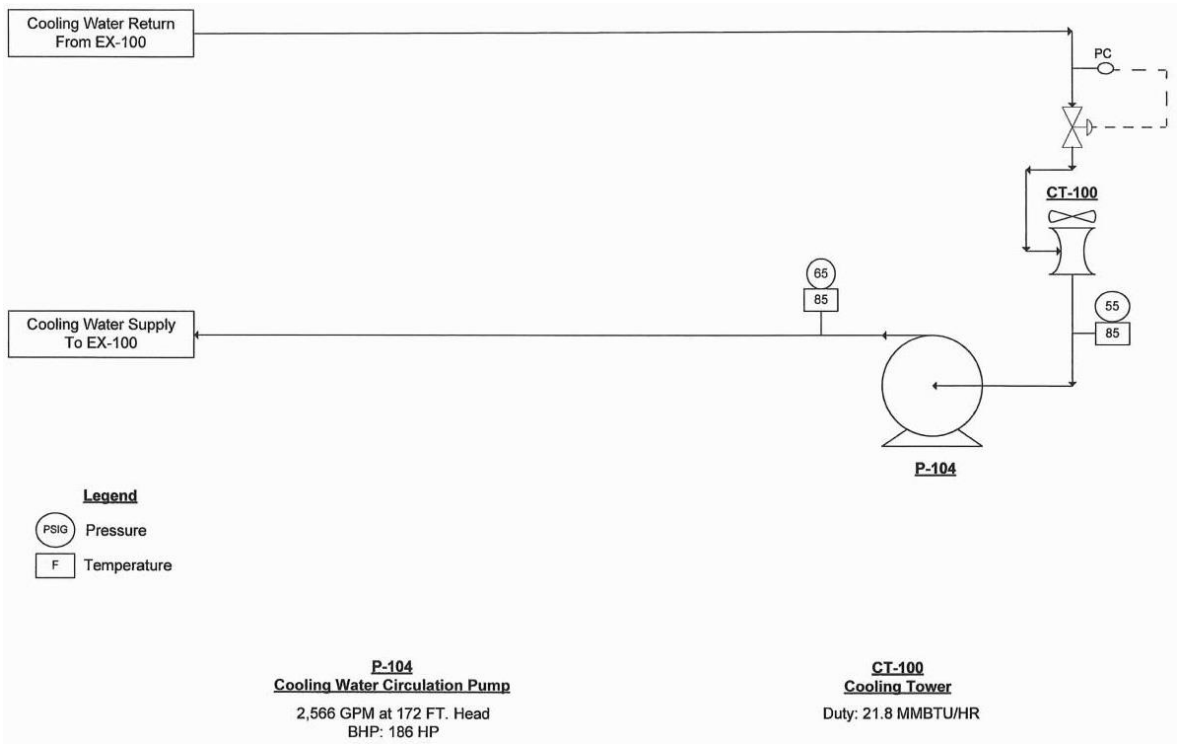


Figure 11 – Cooling Water System Drawdown Degassing Schematic

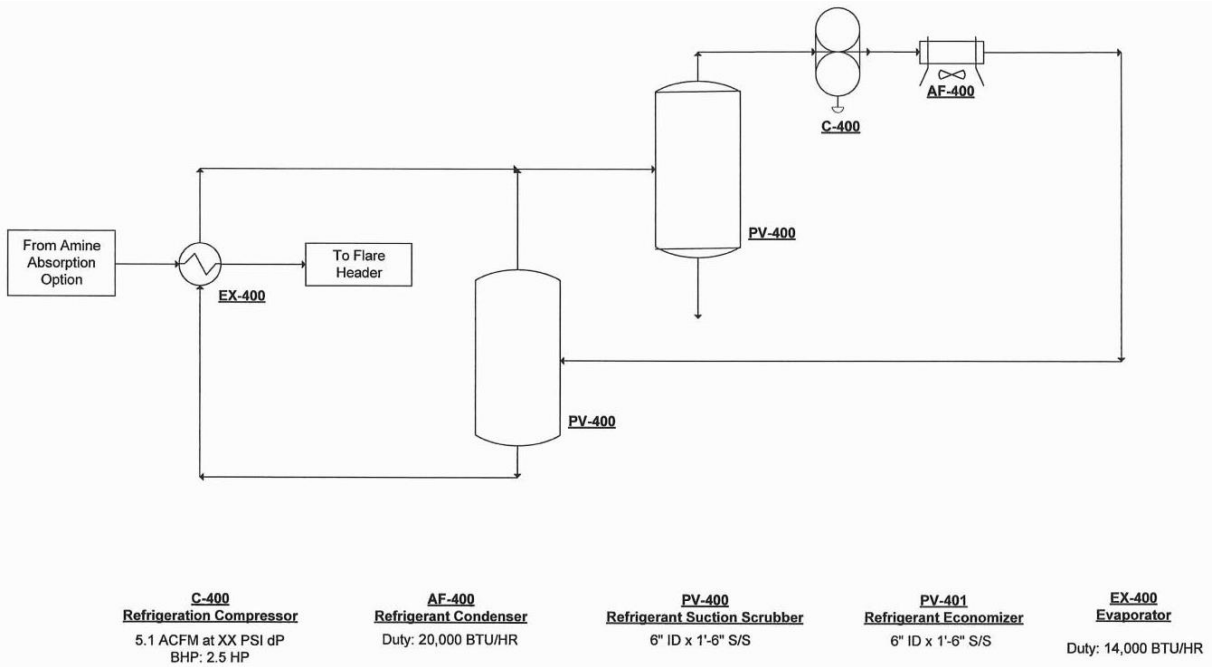


Figure 12 – Refrigeration Drawdown Degassing Schematic

PART 2 – Configuration Alternatives for Degassing Options

A. Mitigate H_2S Emissions

1. Liquid Scavenger Injection into Crude

H2S can be rendered non-volatile in solution by complexation and/or reaction with a liquid scavenger. The use of liquid scavengers injected directly in the crude during drawdown has been approved by the Louisiana state regulators as an interim measure to cope with the exposure hazard of H2S in the shipping and handling of high BPP crude. The cost of liquid scavenger injection is quite high from an operating standpoint unless sophisticated sulfur analyzers and injection rate control are implemented to avoid overfeed and scavenger waste. Although specifically allowed for Drawdown, this method of mitigation is also applicable to In-Storage processing. One of the objectives of this study is to eliminate the use of liquid scavenger.

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage or Drawdown options.

Constraints:

- Approved as interim measure to chemically fix H_2S in exported crude oil.

2. Amine Treating with Acid Gas Reinjection into Crude

H_2S can be selectively removed from the off-gas for disposal by means of absorption into a physical or chemical solvent. Most commonly, this is done with contact with a regenerable amine solution. The H_2S rich off-gas is contacted with a circulating amine solution across an absorption column wherein the H_2S is selectively absorbed into the amine, liberating an off-gas depleted of H_2S for further process. The H_2S loaded amine is then circulated across a regenerator column where the H_2S and other soluble gases are stripped out as a separate H_2S rich gas stream for reinjection into the crude oil. The stripped amine solution, lean in H_2S, is recycled back to the absorption column to reuse. The capital investment associated with amine contacting systems is relatively low due to the small size required. With selection of a thermally and chemically stable amine tailored to the process, the process is very robust. With proper operator training and H_2S monitoring, the hazards associated with handling an H_2S stream are addressed. From an environmental standpoint, routing the H_2S back to the crude for delivery to downstream refineries which are better equipped to environmentally process H_2S into sulfur is appealing. This option is currently used in the Degas II plant design.

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage or Drawdown options.
- Continuous operation with respect to scavenger use.
- Generates no new process waste streams.
- Avoids many of the safety and environmental issues associate with alternative methods of handling and disposal of H_2S.

Constraints:

- Requires third party monitoring of amine quality to ensure smooth operation.

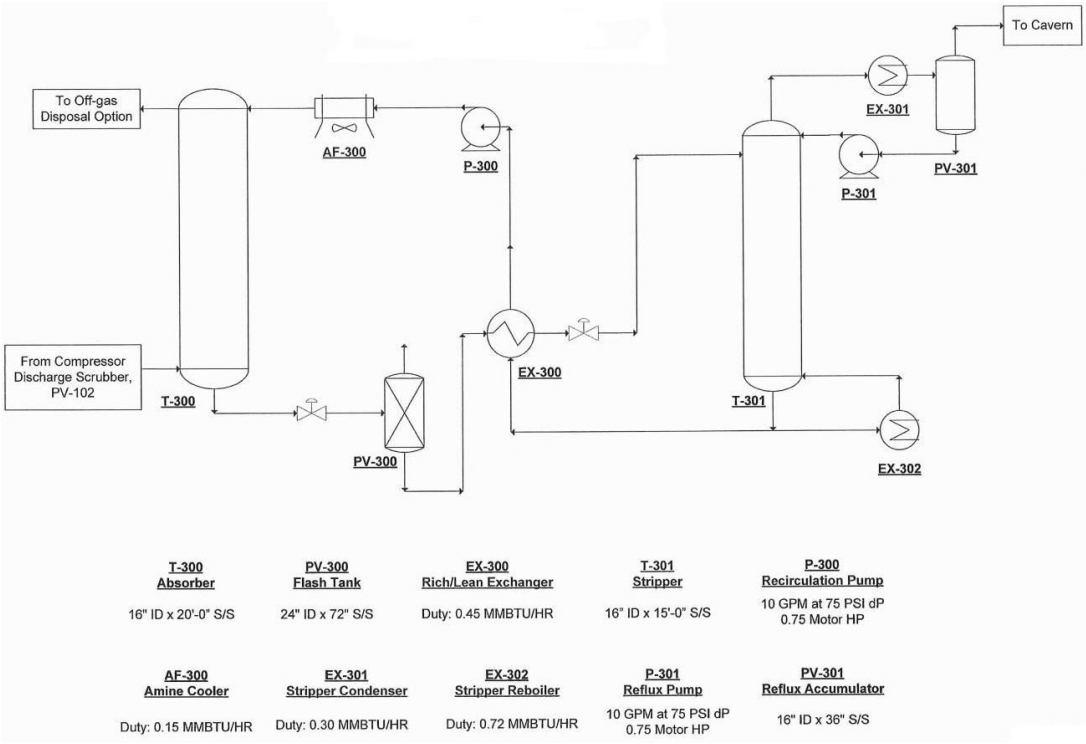


Figure 13 – Amine Absorption In-Storage Degassing Schematic

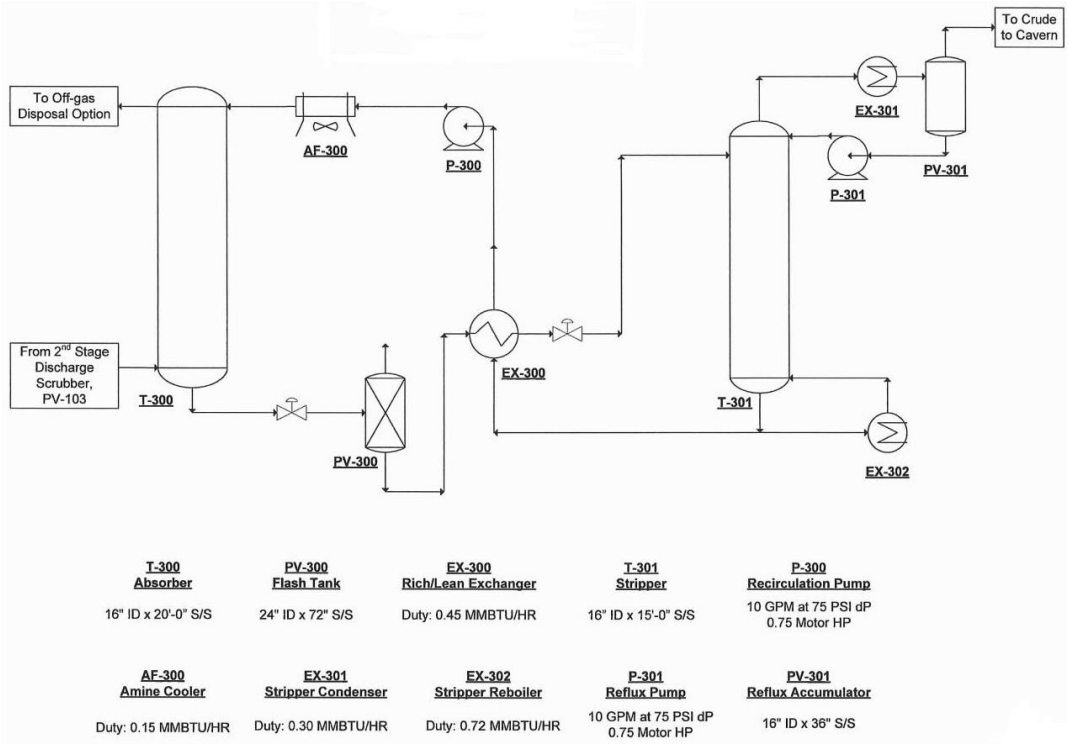


Figure 14 – Amine Absorption Drawdown Degassing Schematic

3. Solid Bed Scavenger

H2S can be selectively removed from the off-gas by adsorption onto a solid bed scavenger with subsequent reaction to chemically “fix” the H2S into the solid for offsite reprocessing or disposal. Solid material scavengers have been available for a number of years. The oldest of these is iron sponge, a hydrated iron oxide. This type of material is difficult to handle and can react exothermically with air when dumped with the potential to catch fire. It is not suitable for use in the current environment. Other iron based scavengers have been developed that utilize a ceramic base which increases the scavenger cost but decreases the disposal handling problems. These types of scavengers are best suited to small scale requirements such as that produced by the In-Storage processing option.

For the Drawdown option a larger scale scavenging system may be required. This type of system would be based on iron-redox whereby the H2S is converted to elemental sulfur. A suitable catalyst is circulated to absorb the H2S and air is used to regenerate the catalyst by conversion of the sulfur to its elemental form.

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage or Drawdown options.

Constraints:

- Scavenger not typically re-generable.
- Requires third party change out of spent scavenger on periodic basis.
- Waste generation and disposal are not appealing from an environmental standpoint.
- Metals reclamation from spent scavenger required to make use.

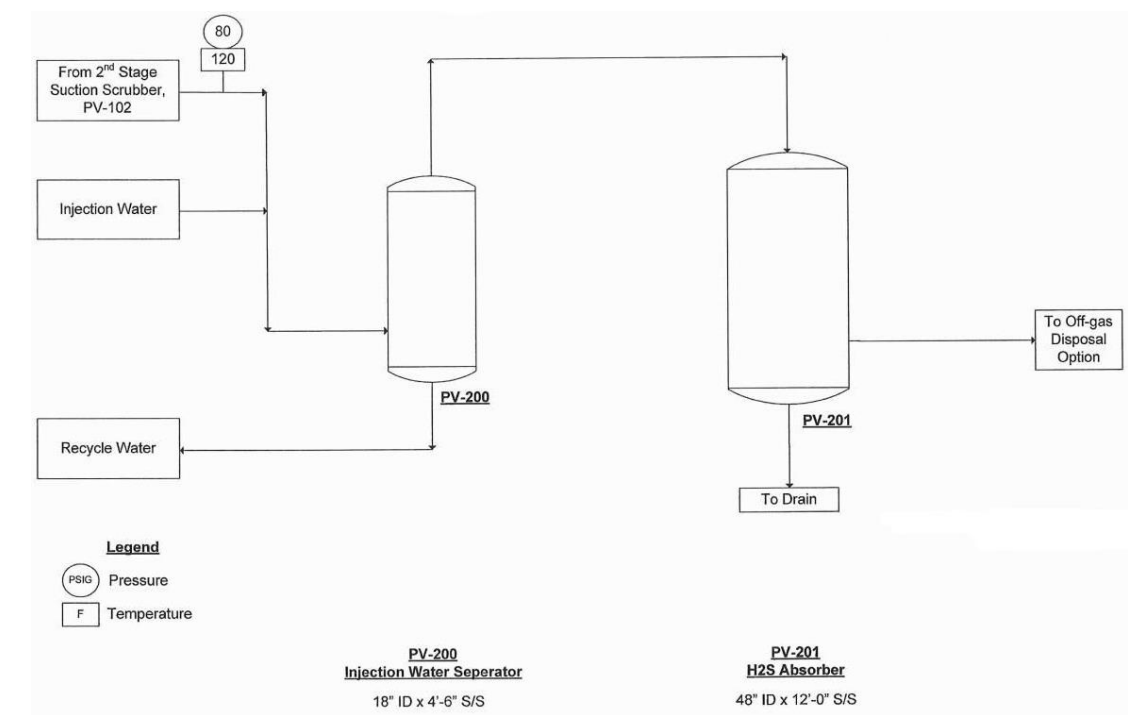


Figure 15 – Solid Bed Scavenger In-Storage Degassing Schematic

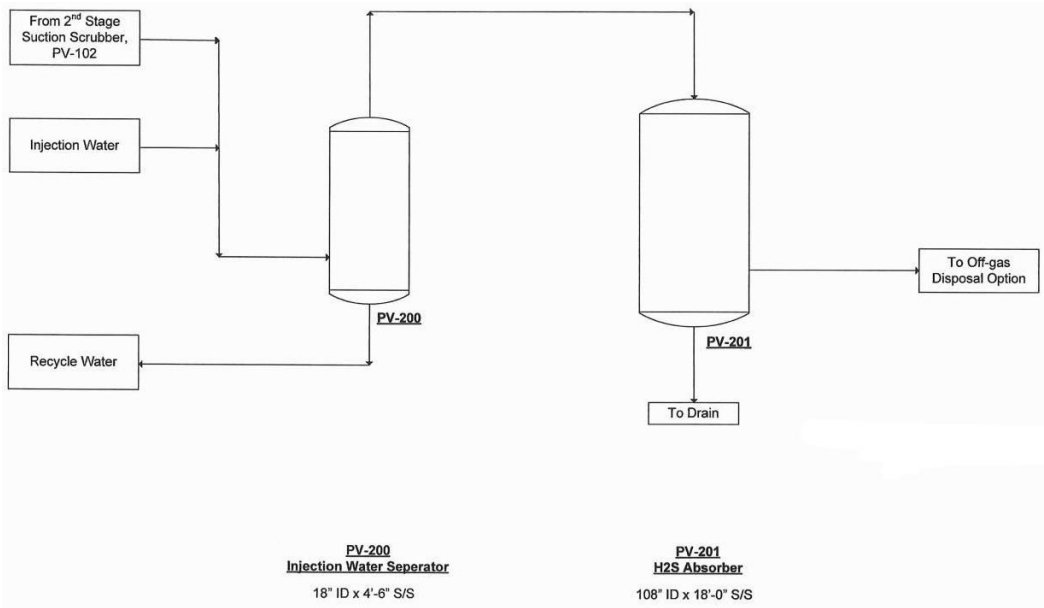


Figure 16 – Solid Bed Scavenger Drawdown Degassing Schematic

4. Incineration

Disposal of gas containing any amount of H_2S can be achieved by compression or incineration and is the most commonly practiced method of treated gas disposal. Direct incineration of H_2S rich off-gas or off-gas of reduced H_2S concentration with greater than 99.9 % H_2S destruction efficiency remains a viable option subject to the emissions permitting issues. This alternative must be reviewed for the impact of permitting a source that would emit almost 300 tons of sulfur dioxide per year.

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage or Drawdown options.
- Requires combustion or incineration equipment designed for high H_2S thermal destruction efficiency.

Constraints:

- Subject to permit limits on NO_x and SO_x emissions.
- Not appealing from an environmental standpoint for the disposal of H_2S rich streams.
- Better suited to disposal of H_2S lean (treated) streams to minimize emissions form an environmental standpoint.

B. Removal and Disposal of Gas On-Site

Compression and refrigeration are both integral parts of the process for either the off-gas incineration option or the power generation option necessary for degassing.

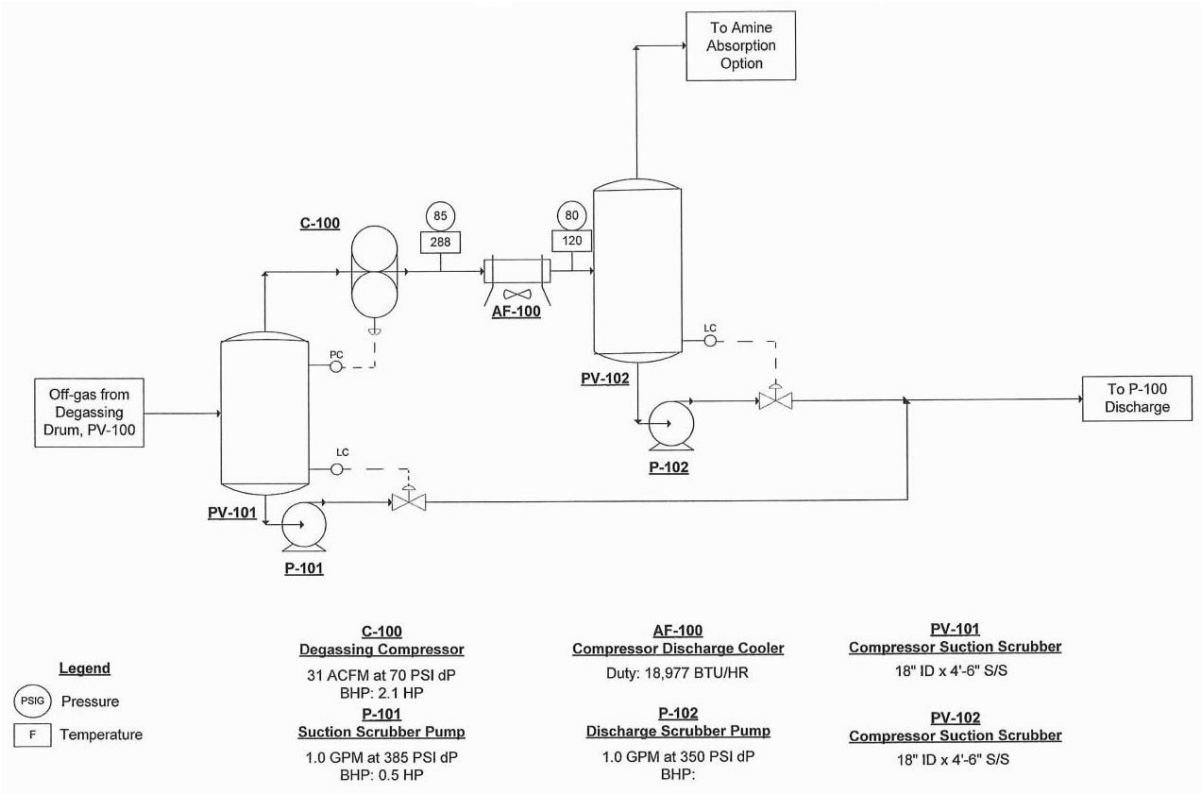


Figure 17 – Compression In-Storage Degassing Schematic

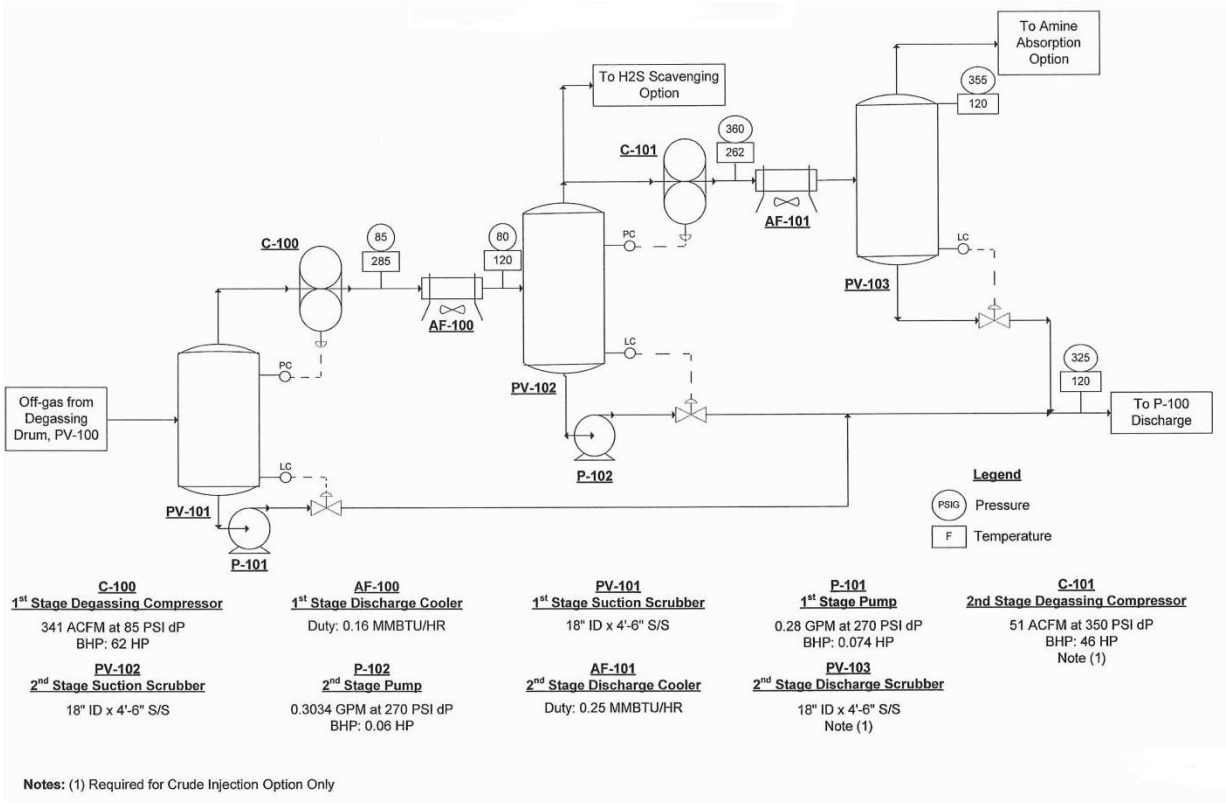


Figure 18 – Compression Drawdown Degassing Schematic

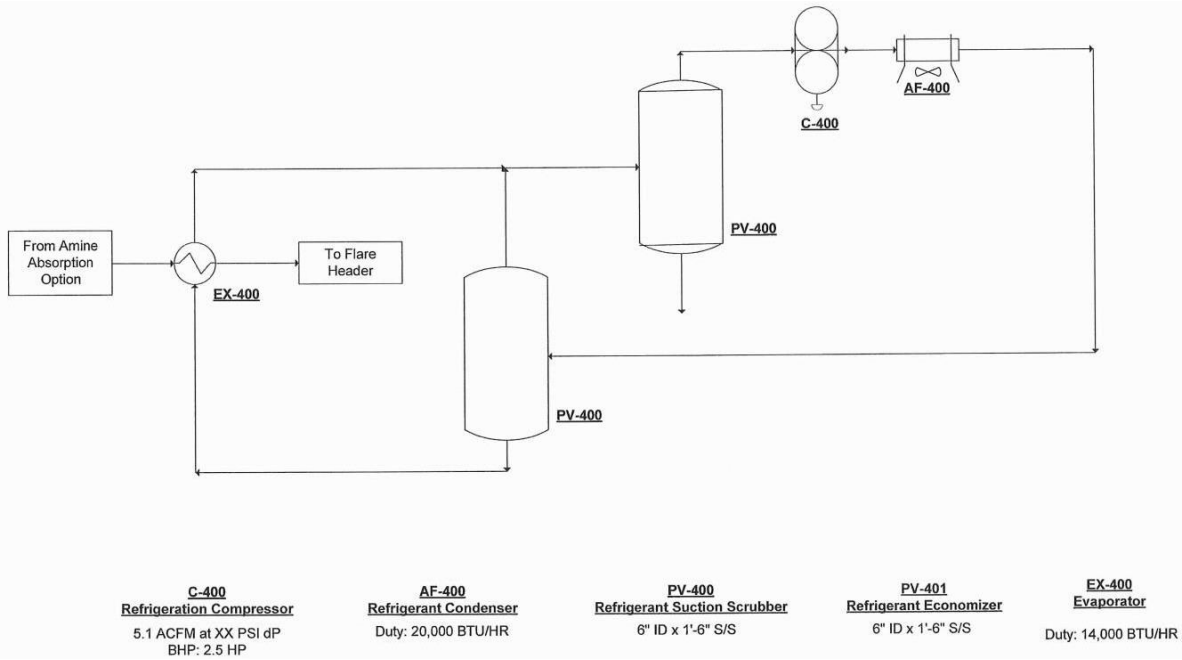


Figure 19 – Refrigeration In-Storage Degassing Schematic

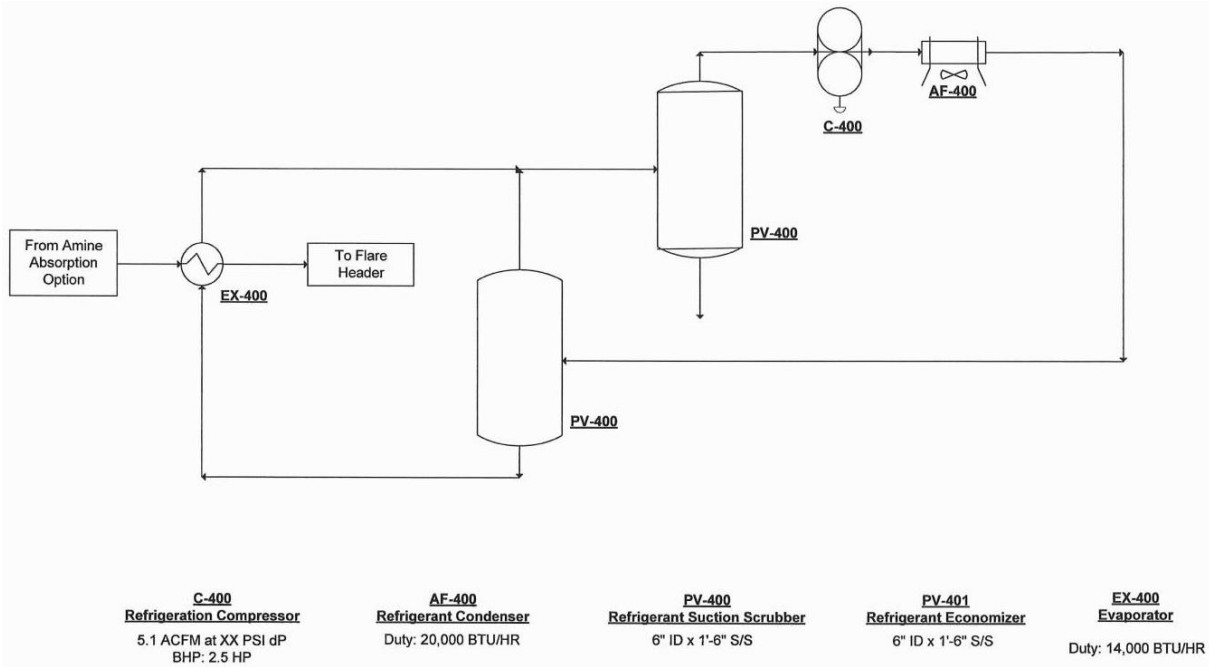


Figure 20 – Refrigeration Drawdown Degassing Schematic

1. Off-Gas Incineration

Incineration can be considered as an effective means for disposing of sweetened (H_2S lean) off-gas. Thermal oxidation is a proven process which will combust hydrocarbon material with high thermal destruction efficiency while meeting stringent NO_x emissions requirements. Even so, permit requirement reviews are needed to determine the impact for both the rather low emissions produced by the In-Storage Option and the higher volumes produced by the Drawdown Option.

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage or Drawdown options.

Constraints:

- Subject to permit limits on NO_x and SO_x emissions.
- May require amendment to Bayou Choctaw air emissions permit.
- May require purchase of credits to offset emissions.

2. Generate Power

The sweetened gas supply available is of a low rate but can be used in smaller turbine generator sets for the generation of electrical power. As seen in Figure 21, a range of power generation alternatives are available. The off-gas supply available in the In-Storage Option has sufficient heating value to fuel the smallest of the micro-turbines shown. In the Drawdown case the off-gas would be able to fuel the turbines at the upper end of the scale shown. Unfortunately, the fuel quality is not sufficiently high in methane content to serve as a suitable fuel. Outside fuel gas would have to be imported to the site to blend down the off-gas with high methane content fuel gas. The blended fuel would be sufficient to fuel the micro-turbine to generate a majority of the power required by either the In-Storage or Drawdown cases, as shown in Table 6. The blended fuel would be sufficient to fuel the micro-turbine to generate a majority of the power required by either the In-Storage or Drawdown cases. This fuel source may be required anyway if the H_2S is recovered by circulating amine. It would serve as a source of heat for regeneration of the amine, in this case. The costs associated with increasing microturbine reliability through design and sparing would also

have to be considered. Internal combustion engines may offer an alternative to microturbines for the generation of electrical power, subject to similar “lean burn” and reliability considerations. The issues associated with operating this equipment must be considered as well. For example, given the shorter duration of Drawdown, start-up and operation of power generation equipment may prove too problematic to pursue.

If refrigeration is added to the process to increase the propane recovery without exceeding the BPP, the off-gas rate can be substantially reduced. The remaining off-gas stream is, then, too small to be considered for power generation and is eliminated by disposal in a flare system.

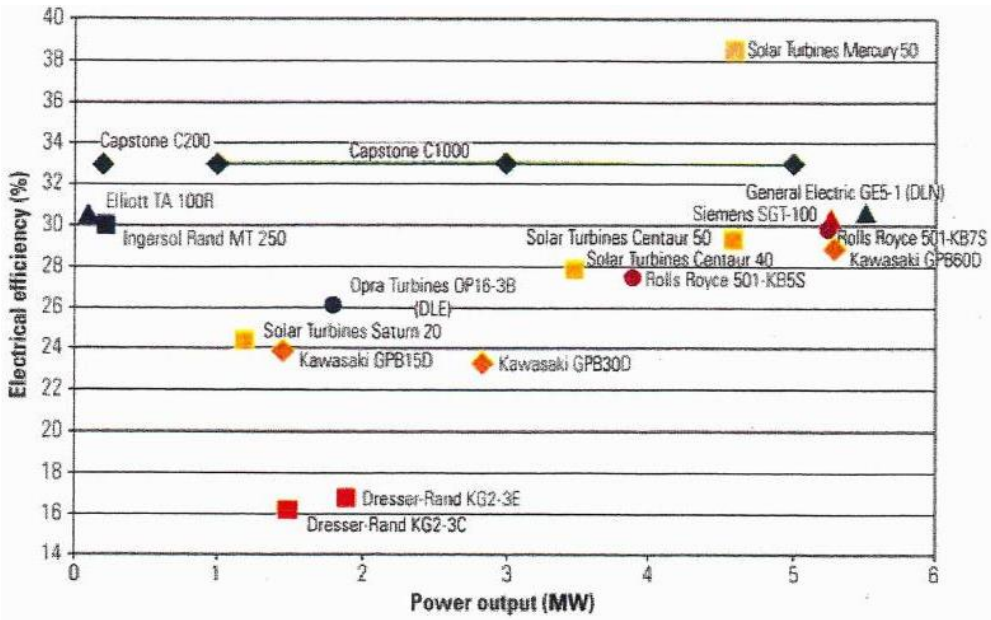


Figure 21 – Turbine Driven Generator Sizes by Manufacturer

	Power from Grid at Drawdown	In-Storage Power from Grid
Consumers	**BHP**	**BHP**
P-100	5214	914.5
AF-100	5	5.0
AF-101	5	5.0
AF-300	0.5	0.5
C-100	62	3.9
C-101	46	N/A
CT-100	120	20.0
P-101	0.07	0.4
P-102	N/A	0.3
P-104	186	86.4
P-300	0.73	0.7
P-301	0.73	0.7
C-400	44.2	2.5
BL-100	30.00	15.0
Total	**5714**	**1037**
	KW	**KW**
Total Consumers	4261	774
Generator GT-400	2796	959
Power from Grid	**1465**	**(185)**

Table 6 – Power Generation Supply and Demand

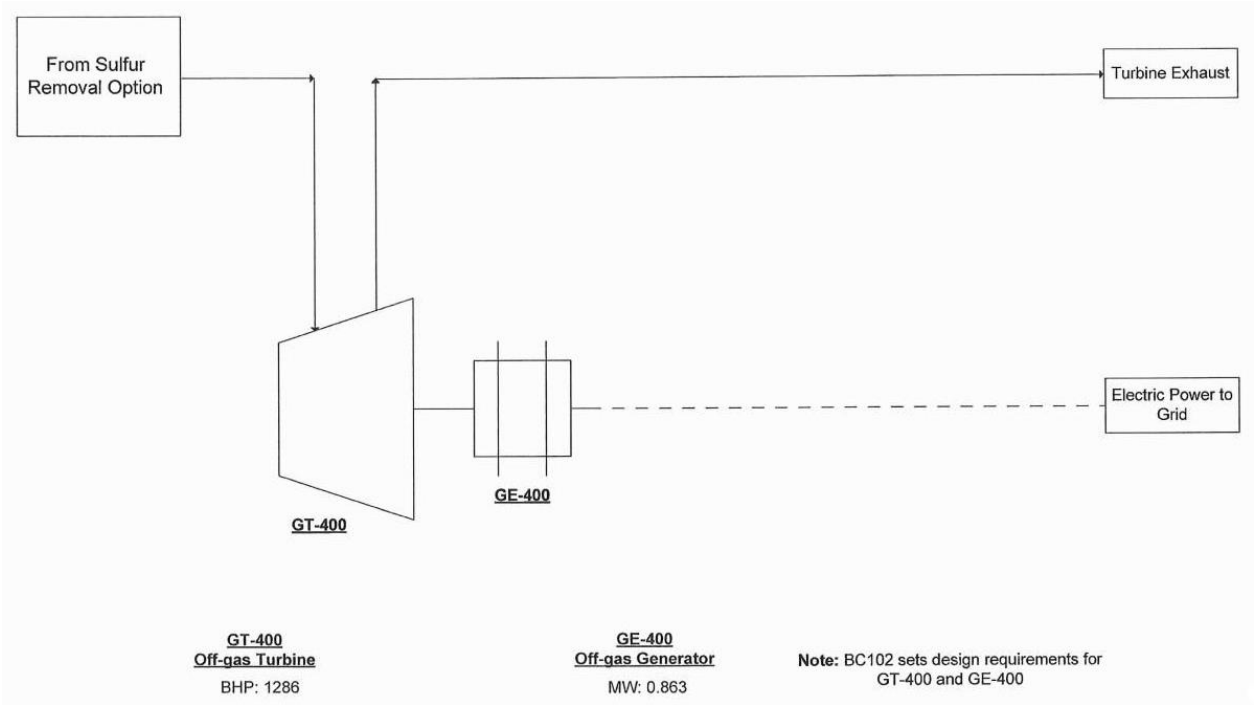


Figure 22 – Power Generation In-Storage Degassing Schematic

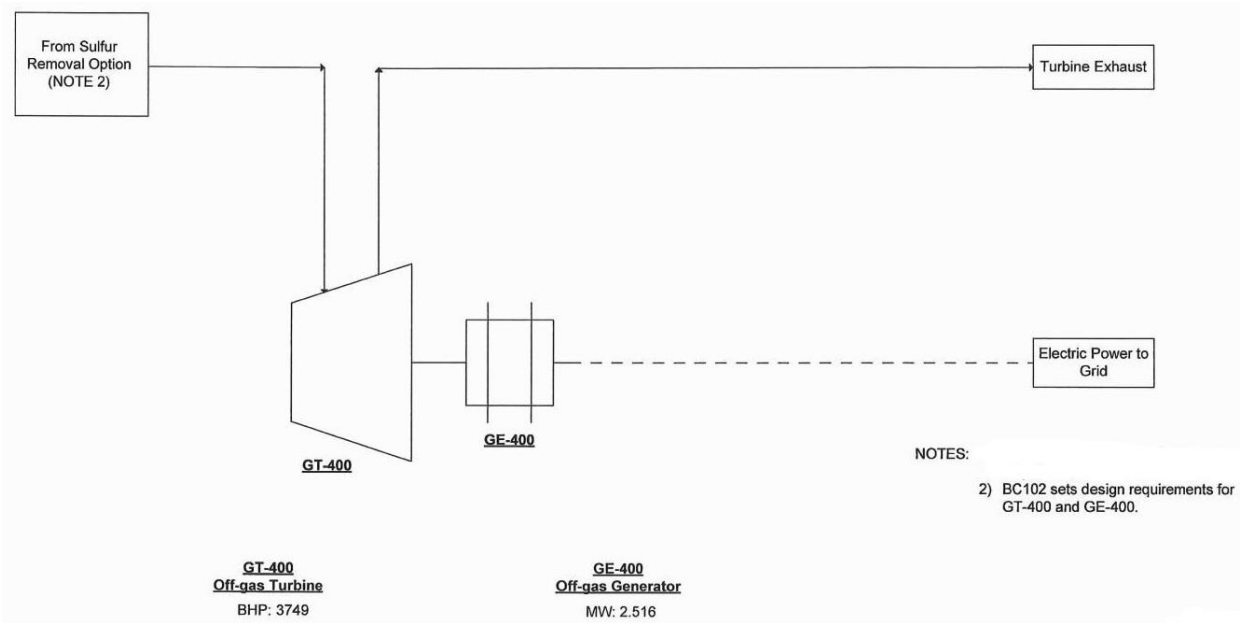


Figure 23 – Power Generation Drawdown Degassing Schematic

Assumptions & Constraints

Assumptions:

- Applicable to In-Storage option only.
- Philosophically more appealing than simply incinerating gas.

Constraints:

- Requires composition adjustment by blending with purchased fuel gas for combustion in lean gas turbines or reciprocating engines.
- Cannot be applied to the Drawdown option with reasonable reliability.

C. Crude Oil Cooling

1. Use Existing Heat Exchangers

The existing Drawdown coolers are capable of cooling 515 MBD of crude oil from a temperature of 121 ^{o}F to 97 ^{o}F using 85 ^{o}F cooling water based on the DynMcDermott report of 30 October, 2010. When cooling water at a temperature of 85 ^{o}F is used, the Drawdown cooler outlet will reach a temperature of 97 ^{o}F with Drawdown from cavern BC102 at a rate of 300 MBD. This outlet temperature is much lower than the 103 ^{o}F required to recover 95% of the propane from cavern BC102, so the existing exchangers have sufficient surface area to cool the crude prior to the single stage of flash used to degas the crude. Although compression and cooling may be required for the off-gas recovery, they are not required to meet the propane recovery criteria. Liquid recovered as a result of cooling the compressed gas only increases the propane recovery when the liquid is combined back with the crude. The bubble point pressure of the blended crude can be maintained below the required 14.7 psia at 93 ^{o}F.

Assumptions & Constraints

- The exiting heat exchangers provide sufficient surface area if water is cooled to 85 ^{o}F.

2. Wet Surface Air Cooling

Cooling water temperature required for the single stage flash is 85 ^{o}F. The maximum wet bulb temperature for the BC location is 78 ^{o}F based on data taken from the 2005 ASHRAE handbook in Appendix D. Wet Surface Air Cooling can accommodate a 7 ^{o}F approach to design and is a reasonable choice for cooling the crude for the In-Storage Option. A cost analysis between a conventional cooling tower and a WSAC would be required for this same decision to be applied to the Drawdown Option.

Assumptions & Constraints

- Applicable to In-Storage or Drawdown options.

3. Lake Water Cooling

Cavern Lake can provide water at temperatures suitable for cooling to the required 103 ^{o}F at the inlet of the degassing drum as indicated in DynMcDermott's 30 October, 2010 report. However, returning the water to the lake at a higher temperature will have negative environmental consequences. The potential for contamination of the water should the exchangers begin leaking also could have a negative impact on the lake water quality if returned to the lake. In accord with current practices to avoid these environmental issues, the lake water cannot be circulated back to the lake. Either the lake water must be restricted to a cooling tower water basin to recirculate the water through a cooling tower or routed once-through the exchangers into the caverns to displace the crude. The first solution works for both the In-Storage and Drawdown scenarios although it requires additional investment. The second solution only works for the Drawdown option which requires injecting the water into the cavern to displace the crude oil as demonstrated in current operations.

Assumptions & Constraints

Assumptions:

- Suitable for once-through cooling of crude oil in Drawdown option when water routed to cavern as brine in line with current practice.
- Suitable for In-Storage or Drawdown options with installation of cooling tower and recirculating water system.

Constraints:

- Not suitable for once-through cooling of crude oil in In-Storage option given threats of high outfall water temperature and potential oil leakage into outfall.

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

Part 1 - Vapor Pressure Management Options

A. Cavern Lake Water Cooling

Cavern Lake is located at the boundary of the Bayou Choctaw site and is considered for use as the cooling media for an in-storage circulation system. Water would be pumped from the lake by new water circulation pumps which use the existing water distribution system to reach each of the cavern locations. At each cavern location a new crude circulation pump and cooler would be installed to maintain segregated inventories. The water from the existing inlet header passes through the cooler and returns to the lake in a new return header. Oil from the cavern is drawn through the existing tubing string by the crude circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern would be equipped with a new well so that they would remain drawdown ready during the cooling cycle.

B. Aquifer Water Cooling

The Plaquemine Aquifer lies beneath the Bayou Choctaw site at a depth of between 60 ft. and 500 to 600 ft. and is a potential source of cooling water. Temperatures in the aquifer are cold enough to provide sufficient cooling for the cavern inventory. To develop this water source producing wells would be drilled within the boundaries of the property and spaced in a way to optimize the supply of water. To dispose of the water returning from the intermediate water coolers a set of injection wells would be drilled. The location selected would provide the maximum amount of water before thermal contamination from the injection wells reaches the producing wells. Each producing water well is equipped with a downhole pump to supply water to exchange heat with a secondary closed loop cooling system, thereby isolating the cavern coolers from the aquifer water. This closed loop circuit passes water through the intermediate water coolers for cooling as it exchanges heat with the cooler water from the aquifer. The cooled water then circulates through the cavern coolers to cool the crude oil from the caverns. Water which leaves the cooler returns to the inlet of the intermediate water coolers to complete the closed loop circuit. The existing water distribution system to the wells is utilized as part of the intermediate water supply system. A new aquifer water supply and return header system would be required to provide cooling water to each one of the cavern locations. As in the Cavern Lake option, each cavern is equipped with a crude oil circulation pump and crude oil cooler. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during cooling.

C. Cooling Tower Cooling

Another option for providing a supply of cooling water to the individual caverns is by cooling the water in a cooling tower and then supplying it to the various caverns in a closed loop system. A closed loop system would provide water from the cooling tower basin and pump the supply to each of the caverns. It would pass through the tube side of the cavern cooler and return to the cooling tower by way of the return header system. The cooling tower, then, utilizes the air brought in by fans to cool the water by evaporation. Water must be added to the system to replace the water lost by evaporation. Water must also be withdrawn from the system to prevent solid build-up within the equipment. The water added must also provide for this amount of blowdown in addition to the water lost by evaporation. Oil from each cavern is circulated through the existing tubing string by the oil circulation pumps. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

D. Chilled Water Cooling

A chilled water system utilizes refrigeration to reduce cooling water temperatures below those that can be achieved with a conventional cooling tower. Several types of refrigerant are available that can achieve the desired temperatures. One common one in use is ammonia. All refrigerant systems will require a compressor with a condenser to produce a liquid refrigerant. The refrigerant is then passed through an expansion valve which drops the temperature in the chiller coil to the desired level. Heat from the circulating chilled water is removed in the chiller by vaporization of the refrigerant. From the chiller the vaporized

refrigerant returns to the suction of the compressor where the pressure is increased sufficiently to repeat the cycle. A condenser utilizes water from a conventional cooling tower to cool and condense the refrigerant from the compressor discharge. This cooling water is circulated through the cooling tower by pump in a closed loop system. The water that is chilled in the refrigerant chiller is circulated by pump through the crude oil cooler. The return water is circulated back to the chiller where the temperature is reduced by the refrigerant in a closed loop.

Each cavern is equipped with its own refrigeration package, circulation pump, and cooler for temperature maintenance. The chilled water is circulated through the existing water distribution system to the oil cooler. The water from the inlet header passes through the cooler and returns to the chiller. Oil from the cavern is drawn through the existing tubing string by the oil circulation pump. It is returned to the cavern through the existing water injection tubing string. Each cavern is equipped with a new well so that they remain drawdown ready during the cooling cycle.

For initial cool down of cavern inventory two refrigeration packages with circulation pumps and cooler are required. One package is semi-portable and is relocated at each cavern location requiring cool down. After all six caverns have been cooled, the semi-portable unit serves as a spare unit for the other six refrigeration packages.

E. In-Storage Degassing

A single process package would be utilized for degassing the six caverns at BC. The equipment is packaged to make it portable for use at other SPR sites. With this process crude oil from cavern storage would be circulated through a cooler to reduce the temperature prior to separation of the volatile vapor in a two-phase separator at near atmospheric pressure. The off-gas from this degassing separator is compressed and cooled to recover the heavier components from the off-gas stream and thereby reduce the shrinkage of the crude processed. An air cooled exchanger is used as the source of cooling. The outlet of the air cooled exchanger is collected in a vapor/liquid separator and the off-gas is sent to an amine unit for recovery of hydrogen sulfide. The liquid from the separator is combined with the liquid from the degassing separator and is transferred by pump back to the cavern. The hydrogen sulfide from the amine unit is combined with the off-gas product for disposal. The amine package consists of a contactor and regenerator so regenerated amine can be circulated by pump in a closed loop system. The off-gas from the amine contactor is further condensed by propane refrigerant to remove additional heavy components for injection back into the crude. The small amount of off-gas and hydrogen sulfide that remains after recovery of the heavier components is sent to a high efficiency flare for final disposal by combustion. The flare is elevated and is sized to handle the larger relief loads from the equipment during a fire scenario.

Oil from the cavern is drawn through the existing tubing string by the oil circulation pump and returned to the cavern through the existing water injection tubing string. A new oil return header will bring the degassed crude back to the suction side of the crude circulation pump. A closed loop cooling water system with a cooling tower is used to cool down the crude in a new exchanger before degassing. Each cavern would be equipped with a new well so that they remain drawdown ready during the cooling cycle.

F. Drawdown Degassing

Due to the larger size of the degassing equipment required for drawdown, the equipment would be located for dedicated use at BC. With this process crude oil from cavern storage would be drawn down through the existing crude cooler to reduce the temperature prior to separation of the volatile vapor in a two phase separator at near atmospheric pressure. The off-gas from this degassing separator is compressed and cooled to recover the heavier components from the off-gas stream and thereby reduce the shrinkage of the crude processed. An air cooled exchanger is used as the source of cooling for condensation of the off-gas. Two stages of compression and cooling are required for sufficient reduction of the off-gas rate. The outlet of the second stage air cooled exchanger is collected in a vapor/liquid separator and the off-gas is sent to an amine unit for recovery of hydrogen sulfide. The liquids from each of the compressor discharge separators are combined with the liquid from the degassing separator which is transferred by pump to the pipeline supplying crude to the terminal. The hydrogen sulfide that is recovered from the amine unit is injected back into the crude from the degassing separator. The amine package consists of a contactor and regenerator with amine circulated by pump in a closed loop system. The off-gas from the amine contactor is further condensed by propane refrigerant to remove additional heavy components for injection back into the crude. The small amount of off-gas that remains after recovery of the heavier components is sent to a

high efficiency flare for final disposal by combustion. The flare is elevated and is large enough to handle relief loads from the equipment during a fire scenario.

Crude oil is removed from the cavern by existing pumps and water injection system. Water used for injection into the cavern is first used as a cooling media in the crude oil coolers. No additional return header or closed cooling water system is required for this configuration. No additional wells are needed to maintain drawdown readiness.

Part 2 – Configuration Alternatives for Degassing Options

A. Mitigate H_2S Emissions

1. Liquid Scavenger Injection into Crude

H2S can be rendered non-volatile in solution by complexation and/or reaction with a liquid scavenger. The use of liquid scavengers injected directly in the crude during drawdown has been approved by the Louisiana state regulators as an interim measure to cope with the exposure hazard of H2S in the shipping and handling of high BPP crude. The cost of liquid scavenger injection is quite high from an operating standpoint unless sophisticated sulfur analyzers and injection rate control are implemented to avoid overfeed and scavenger waste. Although specifically allowed for Drawdown, this method of mitigation is also applicable to In-Storage processing. One of the objectives of this study is to eliminate the use of liquid scavenger.

2. Amine Treating with Acid Gas Reinjection into Crude

H_2S can be selectively removed from the off-gas for disposal by means of absorption into a physical or chemical solvent. Most commonly, this is done with contact with a regenerable amine solution. The H_2S rich off-gas is contacted with a circulating amine solution across an absorption column wherein the H_2S is selectively absorbed into the amine, liberating an off-gas depleted of H_2S for further process. The H_2S loaded amine is then circulated across a regenerator column where the H_2S and other soluble gases are stripped out as a separate H_2S rich gas stream for reinjection into the crude oil. The stripped amine solution, lean in H_2S, is recycled back to the absorption column to reuse. The capital investment associated with amine contacting systems is relatively low due to the small size required. With selection of a thermally and chemically stable amine tailored to the process, the process is very robust. With proper operator training and H_2S monitoring, the hazards associated with handling an H_2S stream are addressed. From an environmental standpoint, routing the H_2S back to the crude for delivery to downstream refineries which are better equipped to environmentally process H_2S into sulfur is appealing. This option is currently used in the Degas II plant design.

3. Solid Bed Scavenger

H2S can be selectively removed from the off-gas by adsorption onto a solid bed scavenger with subsequent reaction to chemically “fix” the H2S into the solid for offsite reprocessing or disposal. Solid material scavengers have been available for a number of years. The oldest of these is iron sponge, a hydrated iron oxide. This type of material is difficult to handle and can react exothermically with air when dumped with the potential to catch fire. It is not suitable for use in the current environment. Other iron based scavengers have been developed that utilize a ceramic base which increases the scavenger cost but decreases the disposal handling problems. These types of scavengers are best suited to small scale requirements such as that produced by the In-Storage processing option.

For the Drawdown option a larger scale scavenging system may be required. This type of system would be based on iron-redox whereby the H2S is converted to elemental sulfur. A suitable catalyst is circulated to absorb the H2S and air is used to regenerate the catalyst by conversion of the sulfur to its elemental form.

4. Incineration

Disposal of gas containing any amount of H2S can be achieved by compression or incineration and is the most commonly practiced method of treated gas disposal. Direct incineration of H2S rich off-gas or off-gas of reduced H2S concentration with greater than 99.9 % H2S destruction efficiency remains a viable option subject to the emissions permitting issues. This alternative must be reviewed for the impact of permitting a source that would emit almost 300 tons of sulfur dioxide per year.

B. Removal and Disposal of Gas On-Site

Compression and refrigeration are both integral parts of the process for either the off-gas incineration option or the power generation option necessary for degassing.

1. Off Gas Incineration

Incineration can be considered as an effective means for disposing of sweetened (H_2S lean) off-gas. Thermal oxidation is a proven process which will combust hydrocarbon material with high thermal destruction efficiency while meeting stringent NO_x emissions requirements. Even so, permit requirement reviews are needed to determine the impact for both the rather low emissions produced by the In-Storage Option and the higher volumes produced by the Drawdown Option.

2. Generate Power

Incineration can be considered as an effective means for disposing of sweetened (H2S lean) off-gas. Thermal oxidation is a proven process which will combust hydrocarbon material with high thermal destruction efficiency while meeting stringent NOx emissions requirements. Even so, permit requirement reviews are needed to determine the impact for both the rather low emissions produced by the In-Storage Option and the higher volumes produced by the Drawdown Option.

C. Crude Oil Cooling

1. Use Existing Heat Exchangers

The existing Drawdown coolers are capable of cooling 515 MBD of crude oil from a temperature of 121 ^{o}F to 97 ^{o}F using 85 ^{o}F cooling water based on the DynMcDermott report of 30 October, 2010. When cooling water at a temperature of 85 ^{o}F is used, the Drawdown cooler outlet will reach a temperature of 97 ^{o}F with Drawdown from cavern BC102 at a rate of 300 MBD. This outlet temperature is much lower than the 103 ^{o}F required to recover 95% of the propane from cavern BC102, so the existing exchangers have sufficient surface area to cool the crude prior to the single stage of flash used to degas the crude. Although compression and cooling may be required for the off-gas recovery, they are not required to meet the propane recovery criteria. Liquid recovered as a result of cooling the compressed gas only increases the propane recovery when the liquid is combined back with the crude. The bubble point pressure of the blended crude can be maintained below the required 14.7 psia at 93 ^{o}F.

2. Wet Surface Air Cooling

Cooling water temperature required for the single stage flash is 85 ^{o}F. The maximum wet bulb temperature for the BC location is 78 ^{o}F based on data taken from the 2005 ASHRAE handbook in Appendix D. Wet Surface Air Cooling can accommodate a 7 ^{o}F approach to design and is a reasonable choice for cooling the crude for the In-Storage Option. A cost analysis between a conventional cooling tower and a WSAC would be required for this same decision to be applied to the Drawdown Option.

3. Lake Water Cooling

Cavern Lake can provide water at temperatures suitable for cooling to the required 103 ^{o}F at the inlet of the degassing drum as indicated in DynMcDermott's 30 October, 2010 report. However, returning the water to the lake at a higher temperature will have negative environmental consequences. The potential for contamination of the water should the exchangers begin leaking also could have a negative impact on the lake water quality if returned to the lake. In accord with current practices to avoid these environmental issues, the lake water cannot be circulated back to the lake. Either the lake water must be restricted to a cooling tower water basin to recirculate the water through a cooling tower or routed once-through the exchangers into the caverns to displace the crude. The first solution works for both the In-Storage and Drawdown scenarios although it requires additional investment. The second solution only works for the Drawdown option which requires injecting the water into the cavern to displace the crude oil as demonstrated in current operations.

Comparison of Alternatives

Cost Comparison*

Part 1 - Vapor Pressure Management Options	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$70,953,247**	**$255,402,748**
Alternative B	**$24,130,017**	**$153,355,752**
Alternative C	**$72,935,851**	**$208,671,493**
Alternative D	**$127,994,994**	**$295,337,791**
Alternative E	**$34,705,326**	**$39,878,846**
Alternative F	**$56,313,125**	**$75,452,645**

Part 2 - Configuration Alternatives for Degassing Options	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A2	**$2,552,612**	**$2,608,812**
Alternative A3	**$502,112**	**$3,525,309**
Alternative B2	**$4,086,878**	**$3,284,375**

**Costs included in the original Bayou Choctaw Degas CDR were Total Construction Cost only. Cost reported in this table are increased by appropriate Class V Estimate Contingency and Design/Program Management/Construction Management standard markups to be consistent with the Total Estimated Cost (TEC) and Life Cycle Cost (LCC) reported on each Analysis of Alternatives in this consolidated Conceptual Design Report.*

Recommended Alternative

The recommended preferred alternative to BPP management for crude oil stored at Bayou Choctaw is Alternative E (Part 1), In-Storage crude oil degassing featuring closed loop cooling (cooling tower or wet surface air cooler). This is combined with Alternative A2 (Part 2), a single stage flash to remove light ends with subsequent amine treating of the off-gas to generate sweetened gas for incineration and H2S rich acid gas for reinjection into the degassed crude. The off-gas is minimized by maximizing the propane recovery through compression and refrigeration of the off-gas.

BC-MM-1360

Upgrade BC North-South Bridge and Roadway

VCI Project Engineer: Jason McCrossen

Recommended Alternative:

Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with concrete box culvert roadway; Replace East-West Bridge with concrete box culvert roadway

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Improve the North-South Bridge and roadway to allow workover rigs to access caverns BC-19 and BC-101. This project is to maintain the same level of security as exists now. In addition, to meet mission need, the East-West Bridge and Bailey Bridge will also be evaluated to be enhanced and/or replaced. In addition, upgrade the Brine Disposal Roadway Bridge and culvert.

Functional Requirements

The access road and bridge have multiple problems in terms of width and load bearing capacity. This necessitates that the well pads be accessed via adjacent property owners, a situation that can give rise to conflicts and restrict access. This roadway improvement task would ensure immediate, site controlled access to the well pads. It is absolutely imperative that the well pads be accessible from within the site and by vehicles the size of work-over rigs (~100,000 lbs).

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carrol	DOE, Systems Engineer
Jason McCrossen	VCI, Project Engineer
Marc Gross	FFPO, Manger Design Engineering

Team Members

Zack Bergeron	VCI, Civil Engineer
Cory Jacob	VCI, Civil Designer
John Walker	VCI, Mechanical Engineer
Don Helms	VCI, Mechanical Designer
Russ Romero	FFPO, Site Director
Kevin Williams	FFPO, Sr. Site Engineer
Mark Blouin	FFPO, Manager Site Construction

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Design could call for 50-year life vs 25-year life and the potential for green material.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

If the site roadway is not improved SPR access to its caverns for maintenance will depend upon the goodwill of the abutting property owners.

This alternative has been eliminated because it does not meet the Mission Needs of full access to the caverns well pads via the North-South and East-West bridges.

Viability: No Further Analysis

B. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with Wider and Higher Capacity Bridge; Replace East-West Bridge with Higher Capacity Bridge.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South bridge and replace with a wider, larger capacity bridge that provides access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge. Replace with a higher capacity bridge.

Viability: Continue Analysis

C. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with concrete box culvert roadway; Replace East-West Bridge with concrete box culvert roadway.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South Bridge and replace with a wider concrete box culvert roadway that provide access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge leaving only the bridge supports for the pipe rack. Replace with concrete box culvert roadway and bank erosion protection.

Viability: Continue Analysis

D. Retro Fit East-West Bridge to Accommodate Work Over Rig

Replace pipe rack with independent support; then demo the E/W bridge & fix bank erosion; construct new all concrete Waskey Bridge with concrete piles to support workover rig loading. Add temporary bridge on Hwy 1148 for Cavern 102 access only if necessary.

This alternative has been eliminated due to the additional maintenance and inspection required of a bridge.

Viability: No Further Analysis

E. Increase Bailey Bridge Capacity by Adding Supports/Replace Bailey Bridge with Higher Capacity Bridge

The existing bridge can be strengthened by adding additional supports. Issue is the wooden structure below the Bailey Bridge. Investigation will have to be done to determine if the Bailey Bridge is resting on the wooden structure below or if during deflection, the bridge is in contact with the structure. This would be a very cost effective method if the wooden structure is not an issue. Remove existing Bailey Bridge and remove wooden structure. Replace with a higher capacity Bailey Bridge and enhance roadway leading up to bridge. Would temporarily shut down access to Brine Disposal Wells (BDW) from BC site.

This alternative has been eliminated due to the need to remove the existing Bailey Bridge and then the need to enhance and then reinstall. It is more economical to install a new higher capacity bridge that meets the Mission Need.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, D, and E are eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with Wider and Higher Capacity Bridge; Replace East-West Bridge with Higher Capacity Bridge.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South bridge and replace with a wider, larger capacity bridge that provides access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge. Replace with a higher capacity bridge.

Assumptions & Constraints

With the construction of the Bailey Bridge in advance, there is no loss of access to the wells. This alternative will not interfere with site operations and pose minimal security threat. In addition, this will allow for less traveling distance for the work-over rig, saving fuel, time, and money and providing for a safer work environment. Temporary access via private property would have to be obtained until work is completed.

Benefits & Effectiveness

This alternative would eliminate the need to use private property to access caverns BC-19 and BC-101 and BC-102.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Larger and Wider Road with Concrete Box Culverts In-Lieu of a Bridge

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Would require a period of time that the workover rig cannot access caverns.	Determine an acceptable period of time that direct access can be restricted. Access is available via alternative routes.	High – Low	Low Risk Hazard
Security fence removal at North-South Bridge.	Temporary fence with card reader will be installed during construction.	Low – High	Low Risk Hazard

B. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with concrete box culvert roadway; Replace East-West Bridge with concrete box culvert roadway.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South bridge and replace with a wider concrete box culvert roadway that provide access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge leaving only the bridge supports for the pipe rack. Replace with concrete box culvert roadway and bank erosion protection.

Assumptions & Constraints

With the construction of the Bailey Bridge in advance, there is no loss of access to the wells. No inspections required for a roadway as with a bridge. This alternative will not interfere with site operations and pose minimal security threat. In addition, this will allow for less traveling distance for the work-over rig, saving fuel, time, and money and providing for a safer work environment. Temporary access via private property would have to be obtained until work is completed.

Benefits & Effectiveness

This alternative would eliminate the North-South and East-West bridge that would need upkeep, and would provide a pipe rack independent from any other structure. It would also assure access for workover rigs to caverns BC-19 and BC-101 while providing a 25-year solution.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replace East/West Bridge with a Culvert Roadway

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Replacing pipe racks may damage existing pipes crossing bridge.	Place temporary pipe supports before removing existing pipe rack.	Low – High	Low Risk Hazard
Would require a period of time that the workover rig cannot access caverns.	Determine an acceptable period of time that direct access can be restricted. Access is available via alternative routes.	High – Low	Low Risk Hazard
Security fence removal at North-South Bridge.	Temporary fence with card reader will be installed during construction.	Low – High	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with Wider and Higher Capacity Bridge; Replace East-West Bridge with Higher Capacity Bridge.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South bridge and replace with a wider, larger capacity bridge that provides access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge. Replace with a higher capacity bridge.

B. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with concrete box culvert roadway; Replace East-West Bridge with concrete box culvert roadway.

Remove existing Bailey Bridge and replace with a higher capacity Bailey Bridge.

Reconstruct the existing Bailey Bridge adjacent to the North-South Bridge for temporary access. Remove the existing North-South bridge and replace with a wider concrete box culvert roadway that provide access for the work over rig for a 25-year period. This will include a wider road, one that is suitable for the work over rig turning radius.

Use temporary access from Hwy 1148 and demolish existing East-West Bridge leaving only the bridge supports for the pipe rack. Replace with concrete box culvert roadway and bank erosion protection.

Comparison of Alternatives

Core Team Member Ratings:

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Important*	*Less Important*
Alternative A	*Adequate*	*Adequate*	*Good*	*Good*	*Adequate*	*Excellent*
	Good	*Adequate*	*Good*	*Good*	*Adequate*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Excellent*	*Excellent*
Alternative B	*Good*	*Good*	*Good*	*Good*	*Good*	*Excellent*
	Good	*Excellent*	*Good*	*Good*	*Good*	*Excellent*
	Excellent	*Excellent*	*Good*	*Good*	*Excellent*	*Excellent*

Cost Comparison:

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$4,121,611**	**$4,270,962**
Alternative B	**$5,319,455**	**$5,338,408**

Recommended Alternative

B. Replace existing Bailey Bridge with new higher capacity Bailey Bridge; Replace North-South Bridge with concrete box culvert roadway; Replace East-West Bridge with concrete box culvert roadway.

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. While the initial cost of the box culverts in Alternative B are higher than the bridges in Alternative A, the expected life cycle costs of inspecting and maintaining the bridges in Alternative A lead to slightly higher costs over the 25-year design life. The key factors in choosing Alternative B, both technically and from a cost standpoint, was the ease of operating and maintaining the recommended improvements in Alternative B because box culvert roadways, once constructed, are less likely to receive damage from large equipment movements while also requiring less life cycle inspection and maintenance costs.

BC-MM-1361

Replace and Relocate Hydraulic Security Barriers

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Design an Employee Parking Area Entrance with Wafer Access Entry

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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Recommended Alternative 10

I. PROJECT CONCEPT

Mission Need

Replace and/or relocate Hydraulic Security Barrier (HSB) used for site access control to locations commensurate with their intended function of intrusion deterrence and not traffic control.

Functional Requirements

The HSB is to meet the Department of Energy (DOE) Order 473.3 A. security parameters and have a functional design (used as intended). Physical barriers serve as the demarcation of the site security area. Activated barriers must be used to deter and delay unauthorized access. Barriers are also used to support and prevent stand-off attacks as well as control/deny potential avenues of approach. At a minimum, analysis is required to determine protection measures against Vehicle Borne Improvised Explosive Devices (VBIEDs). Controls for motorized gates (HSBs) must be located within protective force posts/facilities and designed to facilitate manual operation during power outages. The following are functional requirements for the HSB on the Strategic Petroleum Reserve (SPR) site:

- All potential vehicle approach routes to identified target areas must have barriers installed that will preclude an adversary from reaching the target.
- Speed reducing barriers must be used to slow adversary vehicles to achieve site specific threat/target system response requirements.
- Requirements must be consistent with the operation of the facility and protection goals as documented in the vulnerability assessment (VA).

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Corb Elsbury	VCI, Project Engineer
Marc Gross	FFPO, Manager Design Engineering

Team Members

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Patrick Shepherd	DOE, Project Engineer
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Ron Johnson	FFPO, Sr. Director Security & Emergency Prep
Thomas Guillory	FFPO, Manager Protection & Physical Security
Todd Demaris	FFPO, Sr. Protection Physical Security
Russ Romero	FFPO, Site Director
Mike Berthelot	FFPO, Site Security Specialist
Kevin Williams	FFPO, Sr. Site Engineer
Samuel Gauthe	FFPO, Manager Site Operations
Mark Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. Safety is of the greatest importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems. The Site Security Specialist shall coordinate with the site leadership and contractor to accommodate for down time to particular assessment systems during construction.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations.

Weight: Less Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Leave existing barriers in place and implement a robust preventive maintenance plan to preclude downtime. The current system was constructed in ~2004, and therefore, is not a viable option due to life

cycle replacement needs. When operability testing shows degraded system performance, the typical site maintenance schedule is disrupted.

Viability: No Further Analysis

B. Reprogram HSB and Replace Existing HSB Component Parts

The current HSB shall be reprogrammed to allow for separate use of the security drop arm and HSB. This will allow for the HSB to be left in the down position, depending on security posture levels. The HSB internal component parts shall be replaced for this alternative.

Viability: Continue Analysis

C. Design an Employee Parking Area Entrance with Wafer Access Entry

Relocate the employee parking area entrance for use by badged employees to an alternate location. Replace HSB internal component parts and install a security wafer reader accompanied with intercom and fixed camera.

Viability: Continue Analysis

D. Install an Electric Powered HSB

An electric powered HSB that is engineered to meet the Department of State and U.S. Army K12/L3 (15,000 pounds @ 50 mph) crash certifications, shall be installed to replace the existing hydraulic powered Nasatka Steel-Plate Barrier System. The electric barrier alternative will require excavation, complete electrical retrofit, and battery bank installation (back-up power). The electric powered barrier did effectively address the problem set of replacing outdated equipment, however, the alternatives study group felt maintenance would still be an issue since the use of the barrier would not be changed. Therefore, this alternative is not considered a viable option.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and D are eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Reprogram HSB and Replace Existing HSB Component Parts

The HSB shall be reprogrammed to allow for separate use of the security drop arm and HSB (steel wedge barrier). This will allow for the HSB to be left in the down position, depending on security posture levels. The HSB internal component parts shall be replaced to address end of life cycle conditions for this alternative.

The existing HSBs were integrated into the site access control system at the same time that onsite parking was moved outside the site perimeter (~2004). The HSBs are located in such a way that every vehicle, whether entering or exiting the site, to include employee parking, must pass through the HSB. As a result, the HSBs suffer from high failure rates and high maintenance costs as well as repeated incidents of vehicle damage and potential risks to personnel; this is due to serving the function of a traffic control gate rather than their intended function of intrusion deterrence. In the current configuration, the Protection Force (PF) potentially operates the security drop arm and steel wedge barrier in excess of ~200 times a day. Issues concerning unscheduled maintenance repairs and service calls are costly and likely will continue after refurbishment due to continued repetitive use. The Nasatka Security Company (manufacturer and proprietor of the current barriers in use on the SPR) provides options to alleviate the challenge with the existing configuration. Offered are services providing reprogramming and installation of a color liquid crystal display (LCD) touch screen with updated barrier programming options; completely encrypted for security.

Replacing all internal component parts provides a very cost effective way to prolong the life cycle of the existing Nasatka HSBs. The Nasatka HSBs are proprietary and interior components must be replaced from their spare parts listing.

Assumptions & Constraints

- The existing HSB model is not too old to be reprogrammed.
- Vulnerability Assessments (VA) may require the HSB to operate as before, as a traffic device – returning the problem set to the original concern of overuse.
- This alternative requires the HSB to be refurbished twice over the 25-year lifecycle cost analysis.
- If the existing HSB is too old to be reprogrammed, the replacement of component parts will remedy this issue.
- Site security shall make minimum re-writes to any entrance security procedures.

Benefits & Effectiveness

The site shall reprogram the HSB that will allow for overall improved security and safety measures over the life of the HSB. The information below summarizes mission support and the benefits and effectiveness of reprogramming the existing HSB and replacing parts that are at their life cycle end.

- Reprogramming allows for the separate use of the security drop arm and HSB steel wedge gate, thereby allowing the PF latitude to decide HSB positioning based on security postures (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows for HSB steel wedge gate to remain in down position during determined security postures but still control access to the site (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows barriers to be used for its intended design of an intrusion detergent and not a traffic control device (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).

Risk & Mitigation Factors

Some potential risks associated with re-programming the existing HSB and replacing component parts include reducing security posture during construction and maintaining the HSB, and failure of the HSB internal components. The table below summarizes the mentioned risks with the correlating mitigation

strategy. The table also describes the likelihood of occurrence at the site as well as how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Re-Programming the Existing HSB and Replacing Parts			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Reducing security posture during construction.	Move K-12 rated barriers into place (chicane) while component parts are replaced on HSB.	High - Medium	Medium Risk Hazard
Vulnerability Assessments require the HSB to perform as a traffic control device.	Implement a robust maintenance program and plan for HSB refurb ~2 times over its next life cycle.	High-High	High Risk Hazard
The HSB require routine maintenance.	Design a strategic maintenance schedule/procedure and plan.	Low - Medium	Low Risk Hazard
Visitor or vendor “piggy backs” during employee entrance.	Programming the HSB ensures the security drop arm lowers after each vehicle; fixed camera observation allows for the “E-up” option when situation dictates.	Low - Low	Low Risk Hazard

B. Design an Employee Parking Area Entrance with Wafer Access Entry

Design an additional parking lot entrance at the employee parking area that shall include installing wafer entry apparatus (K12-rated security drop arm, wafer entrance/exit reader, intercom and fixed camera) and K-rated jersey barriers for badged DOE employees. Large vehicles and incoming visitors continue to use the existing HSB entrance, thus allowing the HSB steel wedge gate and security drop arm to remain in the current programmed configuration. Replace HSB component parts that are identified as having reached the end of their life cycle.

The existing HSBs were integrated into the site access control system at the same time that onsite parking was moved outside the site perimeter (~2004). The HSBs are located in such a way that every vehicle, whether entering or exiting the site, to include employee parking, must pass through the HSB. As a result, the HSBs suffer from high failure rates and high maintenance costs as well as repeated incidents of vehicle damage and risk to personnel; this is due to serving the function of a traffic control gate rather than their intended function of intrusion deterrence. In the current configuration, the Protection Force (PF) potentially operates the security drop arm and steel wedge barrier in excess of ~200 times a day. Issues concerning unscheduled maintenance repairs and service calls are costly. This alternative potentially reduces the HSB to an operating pace of ~10 per day for deliveries and those requiring site vehicle entry.

The current employee parking area perimeter fence contains an additional gate which is secured and rarely used. An additional employee entrance is easily designed utilizing this existing gate in conjunction with the security wafer concept. Virtually the same configuration exists at the DOE office complex parking area located at Building 900 in New Orleans, Louisiana; the additional entrance allows the PF flexibility to screen visitors and vendors while allowing for expeditious employee entrance operations simultaneously. Employees approach the security drop arm, scan their security wafer (issued by site or New Orleans security office), the security drop arm raises and the employee proceeds through a chicane (replicates the use of the steel wedge barrier) of K12 rated barriers to their parking space. The security drop arm shall be programmed to drop after each employee vehicle, allowing for the PF to positively identify each employee by wafer as well as camera recognition prior to entry.

Replacing all internal component parts provides a very cost effective way to prolong the life cycle of the existing Nasatka HSBs. The Nasatka HSB components are proprietary and must be replaced from their parts listing.

Assumptions & Constraints

Assumptions:

- The site may experience a small realignment of parking spaces.
- The existing additional gate at the employee parking lot is sufficient and easily converted to an employee only entrance.
- Security wafers are attained in a timely manner in order not to disrupt entrance operations.
- Component part refurb eliminates costly/unscheduled maintenance.
- Vulnerability Assessment (VA) shall define final detailed design.

Constraints:

- Bayou Choctaw design for the new employee entrance (real estate).

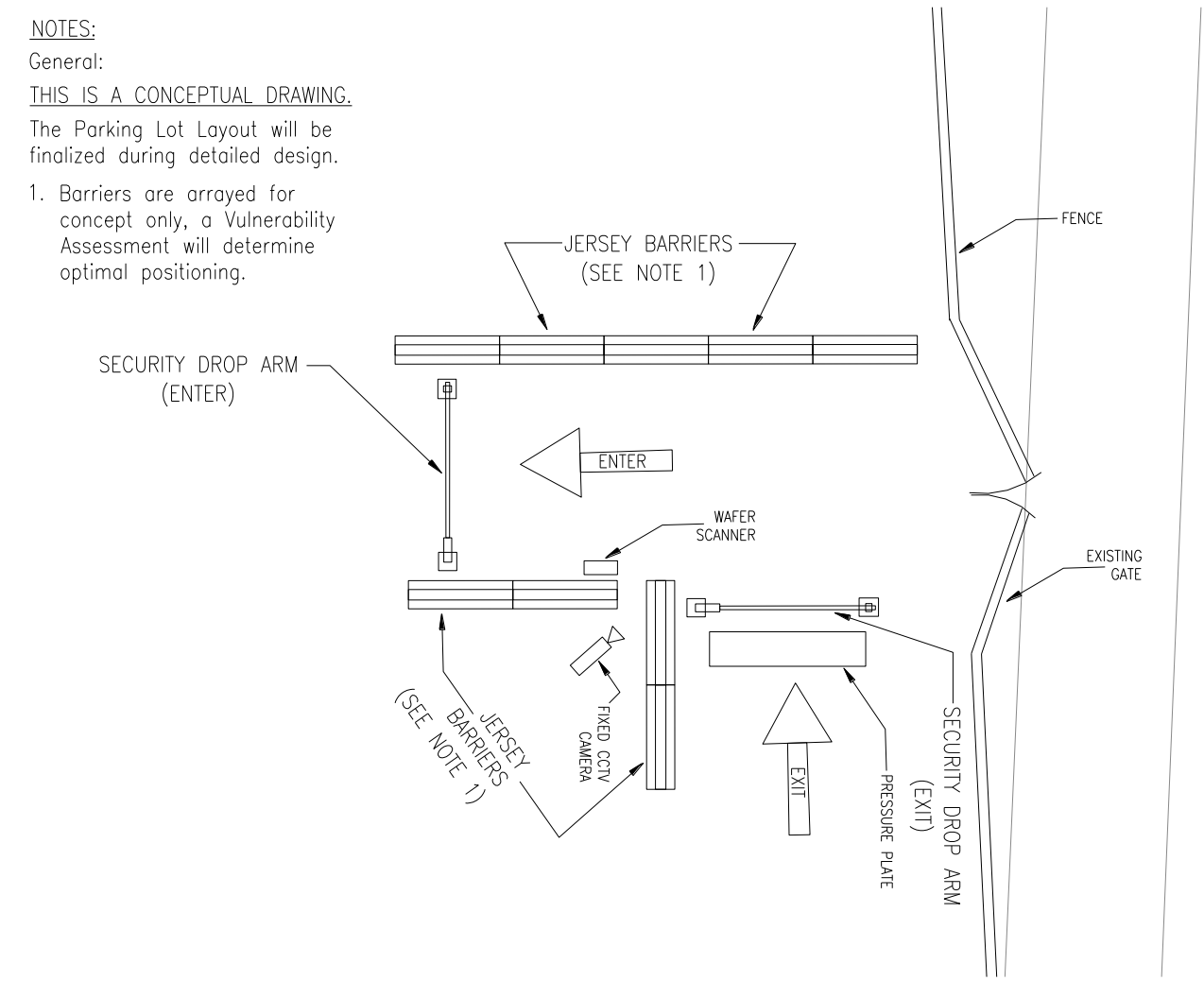

Figure 1 – Conceptual Employee Parking Lot Entrance and Exit Layout

Benefits & Effectiveness

The addition of a security wafer apparatus that will allow for improved security and safety measures. The information below summarizes the benefits/effectiveness as wells as addressing specific site mission needs by redesigning the current parking area with wafer entry apparatus.

- Visitors and large vehicles continue to use the existing HSB entrance, employees use alternate employee entrance; resulting in less HSB use and expedited employee entrance operations (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows for the HSB to be used for its primary purpose, intrusion deterrence (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Less frequent use of the HSB prolongs the life cycle of operating components and costly unscheduled maintenance (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with adding a parking area with a wafer entry apparatus include reducing security posture during construction, failing of the wafer apparatus, maintaining the wafer entry apparatus and HSB, and failing of the HSB internal

components. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Adding a Parking Area with a Wafer Entry Apparatus

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reducing security posture during construction.	Move K-12 rated barriers into place (chicane) while component parts are replaced on HSB.	High - Medium	Medium Risk Hazard
Wafer entry apparatus fails.	Employees use original HSB entrance until fixed.	Low - Low	Low Risk Hazard
Both the wafer entry apparatus and the HSB require routine maintenance.	Design a routine maintenance schedule; an existing PF plan exists to avoid this security risk.	Low - Medium	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Reprogram HSB and Replace Existing HSB Component Parts

The current HSB shall be reprogrammed to allow for separate use of the security arm and HSB (raise & lower); allowing for the HSB to be left in the down position depending on security posture levels. The HSB, in the down position option, allows for less wear and tear on the equipment, as well as using the barrier as it was intended – for security and not a traffic control device. Replacing the HSB component parts that are identified as having reached the end of their life cycle and conducting re-programming of the barrier mechanism allows separate use of the barrier and the security arm.

B. Design an Employee Parking Area Entrance with Wafer Access Entry

Design an additional parking lot entrance at each employee parking area that includes, installing wafer entry apparatus, security drop arm, intercom and K-rated barriers accompanied with a security camera for badged employees; large vehicles and visitors continue to use the existing HSB entrance (the HSB remains in the up position at all times otherwise). Replace HSB component parts that are identified as having reached the end of their life cycle.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Less Important*	*Less Important*
Alternative A	*Good*	*Good*	*Good*	*Excellent*	*Excellent*	*Good*
	Good	*Good*	*Good*	*Excellent*	*Excellent*	*Good*
	Good	*Good*	*Good*	*Good*	*Excellent*	*Adequate*
Alternative B	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Excellent*	*Adequate*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$397,417**	**$756,701**
Alternative B	**$709,210**	**$709,210**

Recommended Alternative

B. Design an Employee Parking Area Entrance with Wafer Access Entry

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. The key factor in the higher technical rating was that Alternative B best solves the actual problem of reducing the number of times the HSB needs to raise and lower on a given day. The initial cost of Alternative A was significantly lower, however, the life cycle cost of Alternative A was higher than Alternative B. With the initial investment cost savings of Alternative A negated by the increased life cycle costs, Alternative B is the recommended preferred alternative.

BC-MM-1364; BC-MM-1531

Replace Fire Water Pumps and Below Grade Fire Water Distribution Piping

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Replace Fire Water Pumps/Drivers and Controllers

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The fire water distribution system includes fire water pumps and underground fire water piping. The purpose of the fire water distribution system is to provide required fire water supply to automatic fire protection systems and manual firefighting equipment. A reliable fire water distribution system is critical to the safe operation of the crude oil storage sites and to the protection of life and property. The fire water pumps are over 20 years old and are approaching the end their useful life. The jockey pump currently operates very near pump dead head, resulting in excessive pump repairs in the sum of $60,000 every two to three years. The maintenance and unreliability of the pumps will continue to increase over time, which may cause the pumps to be unavailable during a fire.

The intent of the mission is to replace two (2) fire water pumps, one (1) jockey pump, and the associated drivers at Bayou Choctaw (BC) in Louisiana. Although other Strategic Petroleum Reserve (SPR) sites are experiencing multiple repairs and maintenance on existing perma-strand fiberglass piping, the Bayou Choctaw site does not have any perma-strand fiberglass piping as concluded during Gate 1 of this Analysis of Alternatives (AoA). Therefore, this AoA will only apply to replacing the two (2) fire water pumps and one (1) jockey pump along with their associated drivers. The pumps and associated drivers are located in Pump House Building 416 Raw Water Intake Structure (RWIS) (Figure 1). Building 416 has removable roof panels for pump removal.

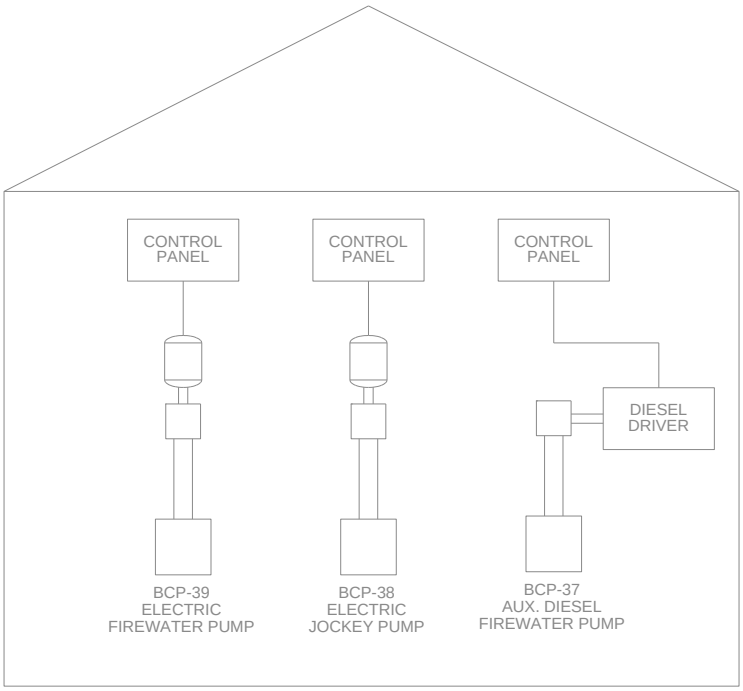

Figure 1 – Fire Water Pump House Building 416 Raw Water Intake Structure

Functional Requirements

Fire water pump capacities are required to meet fire water demands for fire hazards listed in Design Level III Criteria. The following are the functional requirements for the fire water demands at the SPR site:

- Wellhead water supplies shall be 2,000 gallons per minute (gpm) at a pressure sufficient to allow the installed monitor streams to reach the wellheads. This shall be a minimum of 100 pounds per square inch gauge (psig) at the monitor.
- Where deluge water spray systems are installed on open pads, they shall be hydraulically calculated to provide a density of at least 0.30 gpm/square foot on all protected equipment plus exposed piping and valves within 25 feet.

- Where foam deluge spray systems are installed on open pads, they shall be hydraulically calculated to provide a density of at least 0.30 gpm/square foot on all protected equipment, adjacent pad, and exposed piping within 5 feet.
- Replacing fire water pumps will ensure adequate fire water supply is available for automatic fire protection systems and manual firefighting equipment.
- The jockey pump shall operate on manufacturers pump curves to maintain sufficient water pressure in the underground fire water distribution system.
- New fire water pumps shall be compatible, Underwriter's Laboratory (UL) listed, and Factory Mutual (FM) approved with existing pump controllers.
- The electric fire water pump (2000 gpm @ 145 psi) is the primary fire water pump, and the diesel pump (2000 gpm @ 145 psi) is the 100% back-up. The jockey pump (50 gpm @ 145 psi) maintains the pressure in the fire water distribution system. The site determined that the jockey pump continuously operates at dead head, resulting in excessive wear on the motor and shaft. Therefore, the horsepower and impeller size will increase by approximately 20%.
- NFPA 25, Standards for the Inspection, Testing, and Maintenance of Water-based Fire Protection Systems (2014 Edition) outlines periodic inspections, testing, and maintenance activities for water supplies for fire protections. Section 7.3.1.1 indicates that the purpose of the full flow tests is to establish both absolute friction loss results and comparative friction loss results over time. These two sets of results can be used to determine the condition of the pipe at a fixed point in time and the rate of degradation of the system. Regardless of which alternative is selected, a comprehensive inspection and flow test are required following the implementation of the selected option.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
Stephen Brothers	FFPO, Principal Operations System Engineer

Team Members

Anthony Bonadona	VCI, Project Engineer
Tim Matey	VCI, Fire Protection Engineer
Rachel Gray	VCI, Process Engineer
Scott Voelkerding	VCI, Fire Protection Engineer
Lisa Eldredge	FFPO, Principal Operations System Engineer
Buddy Delaune	FFPO, Principal Mechanical Engineer
Steve Carlson	FFPO, Sr. Fire Protection Specialist-Compliance
Kevin Williams	FFPO, Sr. Site Maintenance Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely. The site's ability to address safety and security concerns during implementation shall not be impacted. A robust Contractor Work Plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Ease of Operations

The selected alternative is similar to the existing fire water system and equipment (pumps, drivers, controllers) and, when implemented, will result in a system that is easily operable without significant additional training.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing fire water pump equipment, resulting in commonality of similar systems for future maintenance and sparing consideration. Maintenance operations will require less attention, and the new pumps will have an accompanying manufacturer's service warranty.

Weight: Important

Constructability during Ongoing Oil Deliveries

A secondary pumping capability, in addition to the fire water pumps, is provided for the fire water distribution system. The selected alternative can be implemented with little or no impact to ongoing oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations.

Weight: Important

Sustainability

The selected alternative will have the motor sized to conserve on energy usage. New fire water pumps shall be compatible, Underwriter's Laboratory (UL) listed, and Factory Mutual (FM) approved with existing pump controllers.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

It was determined that the Bayou Choctaw site does not have any perma-strand fiberglass pipe, and the results of a visual re-test of the system suggested the piping system was acceptable. It is recommended that a "Contingency Fund" (20% of underground fire water piping) be maintained. The cost should be included in the selected alternative for the "Pump Replacement" to provide for potential "Pipe Replacement" of any piping that may be identified as impaired subsequent to the system test associated with the Fire Water Pumps Replacement.

A. Status Quo

The status quo consists of doing nothing by continuing to operate and maintain the existing fire water pumps. However, this is a very high risk alternative. Since, the fire water pumps are the main fire water supply for the fire protection systems, the do nothing approach is not considered a valid alternative. The fire water pumps are over 20 years old and approaching the end of their useful life. The maintenance and unreliability of the fire water pumps will continue to increase over time and may not be available during a fire and/or emergency.

Viability: No Further Analysis

B. Replace Fire Water Pumps/Drivers Only

This alternative consists of replacing only the fire water pumps/drivers along with the jockey pump/controller at the Bayou Choctaw site. The fire water pump (pump/driver) replacement ONLY limits the selection of fire water pumps used with the existing pump controllers. Replacing the fire water pumps requires that the pump selected is UL listed and/or FM approved with the existing controllers. Depending on how many pumps are approved with the existing controllers, a sole source may be required for the pump selection. A new jockey pump/controller will be selected to ensure pressure is maintained in the underground fire water distribution system along with the pump operating within acceptable limits of the pumps performance curves. The size and type of replacement fire water pumps shall meet or exceed current fire water system criteria found in SPR Fire Hazards Analysis dated 12/2/13 and SPR Flow Testing of Fire Protection Water Supplies Rev 1 dated 6/15/12.

Viability: Continue Analysis

C. Replace Fire Water Pumps/Drivers and Controllers

This alternative consists of replacing the pumps/drivers and controllers at the Bayou Choctaw site. Replacing the fire water pumps/drivers and associated controllers allows a UL listed/FM approved fire water pump configuration. The size and type of replacement fire water pumps shall meet or exceed current fire water system criteria found in SPR Fire Hazards Analysis dated 12/2/13 and SPR Flow Testing of Fire Protection Water Supplies Rev 1 dated 6/15/12.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A, is eliminated from further consideration. The remaining alternatives, B and C, are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Common Assumptions & Constraints

- A secondary pumping capability, in addition to the fire water pumps, is provided. The site's raw water pump system is directly connected to the fire water distribution system. This system is configured such that valves connecting the two systems can be changed manually to allow the raw water pumps to pump into the fire water distribution system. The same condition is true for the site's flush water booster pumps. These pumps are located downstream of the High Pressure Pump Pad area and provide a remote location for boosting the system should either the fire water pumps and/or the raw water pumps become inoperable or impaired. A third alternative pumping capability for work around as pumps and drivers are replaced includes renting a diesel driven pump.
- Jockey pump currently operates very near pump dead head, resulting in excessive pump repairs every two to three years.
- Current fire water pump connections to the fire water distribution piping will remain unchanged.
- Removable roof panels are operational to allow pump replacement. (Vertical Turbine Pumps)
- New jockey pump/controller selection will meet fire water distribution system requirements, while meeting optimum pump performance.

A. Replace Fire Water Pumps/Drivers Only

This alternative consists of replacing only the fire water pumps and drivers along with the jockey pump/controller at the Bayou Choctaw site. Fire water pump/driver replacement ONLY requires the new fire water pumps and drivers to be UL listed and/or FM approved with the existing Metron Controllers. Existing controllers were replaced approximately 7 years ago. During the upcoming replacement (one pump at a time), the existing pump/driver will be removed, and a new pump/driver installed. The new pumps/drivers will be connected to the fire water system, and all electrical connections will be made to existing controllers.

Although the site is just changing pumps and drivers, per NFPA 20, the fire water pump performance is determined as a fire water pump unit, which consists of pumps/drivers and controllers, and shall perform as one unit.

To obtain UL/FM approval on the fire water pump unit, all diesel and electric criteria shall be compatible with the existing controllers on-site. Some parameters, which the new pump drivers must match with existing controllers, are transfer switch, surge arrestors, driver horsepower, over current protection, and motor starter. This will limit the selection of the fire water pumps/drivers, which may only have a sole source.

Assumptions & Constraints

Assumptions:

- The controllers are functioning properly with existing pumps/drivers.
- Current pump/controller configurations are UL listed/FM approved.

Constraints:

- Replacing only the pump/driver requires extensive field-testing to ensure the new pumps/drivers and controllers are performing as one unit in accordance with NFPA 20.

Benefits & Effectiveness

Replacing the fire water pumps and drivers will ensure adequate fire water supply is available for automatic fire protection systems and manual firefighting equipment, which meet the fire water demands for fire hazards as described in the Design Level III Criteria.

Replacing Jockey pump/controller ensures adequate pressure is maintained in the fire water distribution, while meeting optimum pump performance.

Risk & Mitigation Factors

Replacing ONLY the pumps and drivers at the site will come with some associated risks such as the number of manufacturers available, the installation/field test and commissioning with existing controllers, the safety at the site during installation, and the loss of the fire water pump capacity.

Changing only the pumps and drivers at Bayou Choctaw limits the selection of fire water pumps and drivers that will be compatible with the existing controllers. During the development of the Life Extension 2 (LE 2) CDR, contacts were made concerning Metron Fire Water Pump Controllers. As of November 14, 2011, all of the assets of Metron's Fire Water Pump Controller Division were purchased by Hubbell Incorporated. Due to this acquiring of assets, there were concerns about obtaining future parts and servicing availability.

The jockey pump/controller selection criteria (gpm/psi) are important to avoid dead heading the pump, resulting in excessive wear and costly maintenance.

Replacing fire water pumps and drivers only will come with associated risks. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Fire Water Pumps/Drivers Only			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Number of manufacturers of pumps/drivers to select from is reduced.	Sole Source.	Medium - Medium	Medium Risk Hazard
Installation/Field Testing and Commissioning for new pumps/drivers with existing controllers extended.	Replace one pump at a time, and ensure the secondary pumping capability, raw water booster pumps, and flush water booster pumps are available if called upon to supply the fire water distribution systems.	High - Medium	Medium Risk Hazard
Safety while installing new fire water pumps and drivers.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site near fire water pump house.	Medium - Medium	Medium Risk Hazard
Loss of the fire water pumps capacity while pumps are being replaced.	Replace one pump at a time. Ensure the secondary pumping capability, raw water booster pumps and flush water booster pumps are available if called upon to supply the fire water distribution systems or rent a skid mounted diesel fire water pump.	High - High	High Risk Hazard
Undersized jockey pump.	Ensure jockey pump size is appropriate.	High - High	High Risk Hazard

B. Replace Fire Water Pumps/Drivers and Controllers

This alternative consists of replacing the fire water pumps/drivers and controllers along with jockey pump/controller at the Bayou Choctaw site. The fire water pumps/drivers and controllers replacement requires the new fire water pumps/drivers and controllers to be UL listed and/or FM approved. During the upcoming replacement (one pump at a time), existing pumps/drivers and controllers will be removed, and the new pumps/drivers and controllers will be installed. The new pumps and drivers will be connected to the fire water system, and all of the electrical connections will be made to the new controllers and the main fire alarm system.

The new jockey pump/controller selection will meet fire water distribution system requirements, while meeting optimum pump performance.

During detailed design, the site will determine if skid-mounted pumps/diesel drivers and controllers are possible.

Benefits & Effectiveness

The replacement of fire water pumps/drivers and controllers allows for multiple benefits and addresses current mission needs. Replacing the fire water pumps/drivers and controllers allow for:

- The availability of adequate fire water supply for automatic fire protection systems and manual firefighting equipment.
- No restriction on the selection of fire water pumps, and no sole source required.
- Diesel fire water pumps can be prepackaged (skid mounted) and factory tested, resulting in quick installation.
- Pumps, drivers, and controllers tested and certified by manufacturer prior to delivery.

Risk & Mitigation Factors

Replacing the fire water pumps/drivers and controllers at the site will come with associated risks such as safety during installation and possible loss of the fire water pump capacity. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Fire Water Pumps/Drivers and Controllers

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while installing new fire water pumps/drivers and controllers.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site near the fire water pump house.	Medium - Medium	Medium Risk Hazard
Loss of fire water pump capacity while pumps are being replaced.	Replace one pump at a time. Ensure the secondary pumping capability, raw water booster pumps, and flush water booster pumps are available if called upon to supply the fire water distribution systems or rent a skid mounted diesel fire water pump.	High - High	High Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Fire Water Pumps/Drivers Only

This alternative consists of replacing only the fire water pumps and drivers along with jockey pump/controller at the Bayou Choctaw site.

B. Replace Fire Water Pumps/Drivers and Controllers

This alternative consists of replacing the fire water pumps/drivers and controllers along with jockey pump/controller at the Bayou Choctaw site.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Ease of Operations**	**Ease of Maintenance**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Important*	*Important*	*Important*	*Important*
Alternative A	*Excellent*	*Adequate*	*Adequate*	*Adequate*	*Excellent*
	Excellent	*Adequate*	*Adequate*	*Excellent*	*Excellent*
	Good	*Adequate*	*Excellent*	*Excellent*	*Excellent*
Alternative B	*Excellent*	*Excellent*	*Excellent*	*Adequate*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Good	*Excellent*	*Excellent*	*Excellent*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$637,283**	**$1,016,197**
Alternative B	**$1,032,321**	**$1,445,190**

Recommended Alternative

B. Replace Fire Water Pumps/Drivers and Controllers

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. Alternative A has a lower investment cost and life cycle cost. The key deciding factors between alternatives on a technical basis is the day-to-day operations and ease of maintenance, which is significantly better with Alternative B. The cost differential between alternatives is mainly due to additional scope provided in the alternative, which provides the better operational performance and easier maintenance reflected in the technical ratings. Therefore, Alternative B is the recommended preferred alternative, with the benefits of operational and maintenance considerations outweighing the higher investment and life cycle cost.

BC-MM-1461

Replace Oil-in-Water Monitor

VCI Project Engineer: Lorna Madison

Recommended Alternative:

New UV Fluorescence Monitors

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Oil-in-Water Monitor Instrumentation installed in the Brine Return Line at Bayou Choctaw (BC) must be replaced in order to detect and eliminate oil breakthrough into the Brine Pond and subsequent oil carryover into the remainder of the brine handling system in order to address environmental and safety standards.

Functional Requirements

The following are the functional requirements for the replacement of the Oil-in-Water Monitor at Bayou Choctaw:

- Monitors must be installed farther upstream than the current monitor in cavern header piping for individual wellheads to provide early warning and timely response to oil breakthrough due to wellhead string failure in order to minimize site environmental impact.
- Monitor selection shall provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.
- Monitor selection shall provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of the Life Extension 2 (LE 2).
- Monitor installation plans shall consider providing alternative means of cavern depressurization/fill in a safe manner during installation.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
Stephen Brothers	FFPO, Principal Operations System Engineer

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Randy Bridges	FFPO, Process and Security Systems Control
Bob Sevcik	FFPO, Director - Environmental Department

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Monitors must be installed farther upstream than the current monitor in cavern header piping at the individual wellheads to provide early warning and timely response to oil breakthrough to minimize environmental impact. Monitor selection shall provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.

Weight: Most Important

Ease of Maintenance

The selected alternative features technology which exhibits the necessary detector sensitivity and compatibility with existing controls' hardware and which can be readily serviced and maintained on-site alongside existing equipment. Monitor selection shall provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of LE 2.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely and have the ability to address Safety and Security concerns during implementation. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Constructability during Ongoing Oil Deliveries

The selected alternative is able to be implemented with little or no impact to ongoing oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations. Monitor installation plans shall consider providing alternative means of cavern depressurization/fill in a safe manner during installation.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Water monitors/interface instrumentation installed in the brine return line at the Bayou Choctaw site shall be replaced in order to ensure that the required oil/hydrocarbon content criteria in the brine pond are met.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo consists of continuing to use the existing Oil-in-Water monitor at Bayou Choctaw. Current practice for detecting oil breakthrough to the brine side on cavern wellhead string failure in time to prevent significant oil contamination of the brine system is not effective. Operators are trained to successfully check for pressure equalization across the wellhead to detect a string break in a blocked-in, no-flow scenario. However, the currently installed instrumentation for detection of oil breakthrough under flowing conditions is not effective. The currently installed system has failed to detect entrained oil content in the header system multiple times due to issues with monitor type, monitor installation, monitor maintenance, and installed location of the monitor. Based on experience to date, the single monitor is currently installed too close to the end of the line into the brine pond to protect the brine piping from accumulating significant quantities of oil with breakthrough of that oil into the brine pond where it registers as an environmental excursion. Continuing to operate the existing Oil-in-Water Monitor does nothing to reduce the incidence of environmental excursion with oil breakthrough into the brine pond and downstream brine systems.

Viability: No Further Analysis

B. Flowmeters

This alternative consists of conducting a pilot study using the existing flowmeters on site to see if they can detect oil in water. This pilot study would be conducted before any other alternative being pursued to monitor oil in water. The pilot study is pending.

Should the pilot study determine that the flowmeters are not capable of detecting oil in water, then an alternative technology would be selected from the list below to pursue reliable detection of oil in water. Alternate technology selection necessitates a second pilot test to prove the capabilities of the alternate technology in the field.

Viability: Continue Analysis

C. New UV Fluorescence Monitors

This alternative consists of installing new ultraviolet (UV) fluorescence based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. Brine quality, line velocity, temperature, suspended solids, and organic matter do not affect measurement by UV fluorescence based monitors. These monitors are highly accurate, providing instantaneous and continuous measurement. They have the required sensitivity with range of detection from 0–10 parts per million (ppm) to 0–150 ppm oil-in-water. They are self-cleaning and require low maintenance. They are available for an in-line and a loop/side stream type installation.

Viability: Continue Analysis

D. New UV Absorption Monitors

This alternative consists of installing new UV absorption based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of organic materials including bacteria, yeast, and algae will interfere with the performance of these meters. Compensation, filtering, or frequent zeroing is required to successfully operate these monitors. This monitor type cannot be recommended as a reliable Oil-in-Water Monitor for Bayou Choctaw brine operations on account of these potential interferences and the extra care required to maintain performance of this instrument in service.

Viability: No Further Analysis

E. New Calorimetry Monitors

This alternative consists of replacing the existing monitor/system with calorimetry based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids will interfere with the performance of these meters. Compensation, filtering, or frequent zeroing is required to successfully operate these meters. Catalyst

addition is required for color transformation/recognition, and a database of standards of colors must be collected and defined for each different hydrocarbon and application. Moreover, this does not provide the user with the ppm oil detection sensitivity required.

Viability: No Further Analysis

F. New Light Scatter Monitors

This alternative consists of replacing the existing monitor/system with nephelometry (light scatter) based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids, trace chemicals, and color bodies will interfere with the performance of these meters in the absence of sample stabilization to give a false high hydrocarbon reading. Compensation and filtering techniques are required to offset potential interferences. This monitor type cannot be recommended as a reliable Oil-in-Water Monitor for Bayou Choctaw brine operations.

Viability: No Further Analysis

G. New Microscopy Monitors

This alternative consists of replacing the existing monitor/system with microscopy (imaging) based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. Brine quality, line velocity, temperature, suspended solids, and organic matter do not affect measurement of these monitors. These monitors are highly accurate, providing instantaneous and continuous measurement. They have the required sensitivity with range of detection of up to 1000 ppm oil-in-water and the ability to detect particle and droplet size information e.g. Dv10, Dv50, and Dv90 data. The above features can be combined with other analyses like florescence and spectral analyses for the best available reliability in measurement techniques.

Viability: Continue Analysis

H. New Radar, Acoustic, Capacitance, or Energy Absorption Monitors

This alternative focuses on alternative technology selection from a list of options which are typically characteristic of interface level control and not oil-in-water measurement. This includes options such as radar, microwave, acoustic, and capacitance, energy absorption, etc. The monitor of choice among these would be installed at each individual wellhead to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids and organics will interfere with the performance of these meters. Compensation, filtering, recalibration, or frequent zeroing is required to successfully operate these meters. These meters lack the required sensitivity for gaging oil breakthrough. They typically measure oil concentrations on the percent level rather than the ppm level desired for detecting oil breakthrough. These meters are better suited to gaging oil water interface levels than for detecting oil entrainment into system flows. These monitor types cannot be recommended for reliable oil-in-water monitoring service for Bayou Choctaw brine operations.

Viability: No Further Analysis

I. New Technology

This alternative consists of replacing the existing monitor/system with new technology that is still in its testing phase such as laser-based monitors. Although newer technology may be available, insufficient field testing has been performed and communicated to establish such technology as commercially reliable and robust options for application here. Therefore, new technology lacking full proving in the field is not considered a viable alternative here.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on the initial analysis of the alternatives, alternatives A, D, E, F, H and I are eliminated from further consideration as unacceptable or infeasible for replacing the Oil-in-Water Monitors. The remaining alternatives, B, C, and G, are examined below as alternatives A, B, and C, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Common Assumptions & Constraints

- Monitor selection will provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of the Life Extension 2 (LE 2).
- Monitor technology must be commercially field proven for consideration for this application.
- Additional field testing on site is generally recommended to confirm technology selection for oil-in-water monitoring on site.
- Monitors will be installed farther upstream than the current monitor in cavern header piping at the individual wellheads to provide early warning and timely response to oil breakthrough due to wellhead string failure to minimize site environmental impact.
- Monitor selection will provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.
- Monitor installation plans will consider providing alternative means of cavern depressurization/fill in a safe manner during installation.
- Monitors will meet the required environmental and safety standards.

A. Flowmeters

This alternative will evaluate the existing installed flowmeters to detect oil in water under flowing conditions.

Assumptions & Constraints

- The flowmeters are installed and fully operational.
- The flowmeters will be performance tested in the field to confirm whether they can reliably detect oil breakthrough into water.
- The flowmeter pilot study will be conducted first before any alternative technology is considered.
- If the flowmeter fails to detect oil in water, the next best alternative from the list of alternatives below will be selected, and a pilot test will be performed to determine its viability.

Benefits & Effectiveness

The use of the current flowmeters installed at the site allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of conducting a pilot test and using the current flowmeters.

- The pilot test will allow the site to test whether current equipment installed on-site is able to detect oil in water.
- If the pilot test shows that the flowmeters are adequate, no new equipment will need to be purchased.

Risk & Mitigation Factors

Conducting a pilot test on the currently installed flowmeters will come with associated risks. The table below describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Using the Flowmeters/Conducting a Pilot Test

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while conducting the pilot test.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Flowmeters do not reliably detect oil in water.	Conduct performance test in the field to establish whether they work. If they don't provide the desired results, proceed with selection and testing of alternative technology.	Medium - Medium	Medium Risk Hazard

B. New UV Fluorescence Monitors

This alternative will replace the existing monitors/system with UV fluorescence based monitors/system.

Assumptions & Constraints

Assumptions:

- New ultraviolet UV fluorescence monitors are installed at each individual wellhead.
- The monitors can detect from 0–10 parts per million (ppm) to 0–150 ppm oil-in-water.
- UV florescence monitors are self-cleaning and low maintenance.

Constraints:

- Meter recalibration may be required from time to time for changes in ratios of Aliphatic/Aromatic vs. Total Hydrocarbon (HC).
- Performance testing of a single monitor installed in the field is required to confirm this technology selection before committing to purchase of additional monitors.
- Monitor life requires periodic field servicing and periodic replacement over the estimated 25-year life of the Life Extension 2 (LE 2).

Benefits & Effectiveness

The replacement of the existing monitors/system with UV fluorescence based monitors/system allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of installing new monitors/system on-site.

- The UV fluorescence based monitors/system will eliminate the risk of getting oil into the brine pond.
- Process Parameters, Total Suspended Solids (TSS), and Organic Matter cannot influence or affect the measurement of UV fluorescence based monitors.
- The monitors/system are highly accurate, providing instantaneous and continuous measurement.
- The monitor/system have a good range of detection from 0–10 parts per million (ppm) to 0–150 ppm oil-in-water.

Risk & Mitigation Factors

Replacing the existing monitors/system with UV fluorescence based monitors/system will come with associated risks. The table below describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing the Existing Monitors/System with UV Fluorescence Monitors

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new monitors/system.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
UV florescence monitors not compatible with oil.	Supply analyzer vendors adequate information on the chemical/physical properties of the oil and brine	Medium - High	Medium Risk Hazard
UV florescence monitors incorrectly calibrated.	Ensure the monitors are calibrated for the correct ratios of Aliphatic/ Aromatic vs. Total Hydrocarbon.	Medium - High	Medium Risk Hazard
UV florescence monitors installed too far from wellheads.	Ensure location of the monitors will provide adequate oil detection and response time from site personnel.	Medium - High	Medium Risk Hazard

C. New Microscopy Monitors

This alternative will replace the existing monitors/system with microscopy based monitors/system.

Assumptions & Constraints

Assumptions:

- New Microscopy monitors are installed at each individual wellhead.
- Microscopy monitors are the best technology available.
- The detection is up to 1000 ppm oil-in-water and particle and droplet size information e.g. Dv10, Dv50, and Dv90 data.

Constraints:

- Microscopy monitors are more suitable for water injection type work.
- Microscopy monitors analyses side stream only.
- Performance testing of a single monitor installed in the field is required to confirm this technology selection before committing to purchase of additional monitors.
- Monitor life requires periodic field servicing and periodic replacement over the estimated 25-year life of the Life Extension 2 (LE 2).

Benefits & Effectiveness

The replacement of the existing monitors/system with microscopy based monitors/system allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of installing new monitors/system on-site.

- The microscopy based monitors/system will eliminate the risk of getting oil into the brine pond.
- Process Parameters, Total Suspended Solids, and Organic Matter cannot influence or affect the measurement of Microscopy monitors.
- The monitors/system are highly accurate, providing instantaneous and continuous measurement.
- The monitors/system have a good range of detection of up to 1000 ppm oil-in-water, and the ability to detect particle and droplet size information e.g. Dv10, Dv50, and Dv90 data.
- The microscopy based monitors/system can be combined with other analyses like florescence and spectral analyses for the best available reliability in measurement techniques.

Risk & Mitigation Factors

Replacing the existing monitors/system with microscopy based monitors/system will come with associated risks. The table below describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing the Existing Monitors/System with Microscopy Based Monitors			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Safety while removing and installing the new monitors/system.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Microscopy monitors not compatible with oil.	Supply analyzer vendors adequate information on the chemical/physical properties of the oil and brine.	Medium - High	Medium Risk Hazard
Microscopy monitors incorrectly calibrated.	Ensure the monitors are calibrated for the correct concentration (ppm) and particle/droplet size.	Medium - High	Medium Risk Hazard
Microscopy monitors installed too far from wellheads.	Ensure location of the monitors will provide adequate oil detection and response time from site personnel.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Flowmeters

This alternative will utilize the existing flowmeters currently installed to monitor oil in water.

B. New UV Fluorescence Monitors

This alternative will replace the existing monitors/system with ultraviolet fluorescence based monitors for oil in water.

C. New Microscopy Monitors

This alternative will replace the existing monitors/system with microscopy based monitors for oil in water.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Ease of Operations**	**Ease of Maintenance**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Good*	*Adequate*	*Excellent*	*Good*
	Excellent	*Good*	*Good*	*Excellent*	*Good*
	Excellent	*Good*	*Excellent*	*Excellent*	*Excellent*
Alternative B	*Good*	*Excellent*	*Excellent*	*Good*	*Excellent*
	Excellent	*Good*	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*
Alternative C	*Good*	*Adequate*	*Good*	*Good*	*Excellent*
	Excellent	*Good*	*Adequate*	*Good*	*Excellent*
	Good	*Adequate*	*Good*	*Good*	*Excellent*

Cost Comparison:

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$312,842**	**$000,000**
Alternative B	**$4,174,122**	**$4,647,225**
Alternative C	**$3,860,563**	**$4,333,666**

Recommended Alternative

B. New UV Fluorescence Monitors

Based on the technical evaluation of the Core Team Members, Alternative B was rated overall higher on the evaluation criteria. Alternative A has a significantly lower investment cost and life cycle cost followed by Alternative C and Alternative B. Alternative A has a significant risk of technically not meeting the mission need and functional requirements and therefore is not recommended. Alternative B was rated significantly higher overall than Alternative C on the evaluation criteria. Therefore, Alternative B is the recommended preferred alternative, with the significant benefits of operational considerations outweighing the higher investment and life cycle cost.

BC-MM-1526

Replace Physical Security CCTV Assessment System

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Replace CCTV System (Digital)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Replace the all existing physical security Closed Circuit Television (CCTV) assessment systems with latest technology at Bayou Choctaw on the main site, Raw Water Intake Structure (RWIS), Electrical Sub-Station (ESS), Raw Water Injection Pump Pad (RWIPP) and any additional areas deemed necessary by Vulnerability Assessment (VA) consisting of perimeter and critical area fixed nose-to-tail cameras, Pan Tilt Zoom (PTZ) cameras for use as part of the surveillance and intrusion detection alarm assessment system.

Functional Requirements

The SPR assessment system must meet DOE Order 473.3 A. requirements and USNRC Intrusion Detection Systems and Subsystems Technical Information, March 2011, Office of Nuclear Security and Incident Response.

- Cameras and lighting must be effective in all weather conditions and all lighting conditions; lighting must compliment and not interfere with effectiveness of the assessment system.
- Central Alarm Station (CAS) monitors/screens shall be of sufficient size, picture quality and refresh rates to provide an accurate display of persons or animals without undue eye strain or inability to determine images.
- The CCTV assessment system shall be configured as an element of the total Intrusion Detection System (IDS) along with the required complimentary lighting.
- Lighting shall allow for the fast and reliable assessment of alarms from either the CCTV system or Protection Force (PF) personnel as defined in the Site Security Plan (SSP).
- The system must have the capability to automatically switch to the camera associated with an alarm event and clearly display the event for operator assessment.
- Video assessment coverage must be complete (e.g., no gaps between zones or areas that cannot be assessed due to shadows or objects blocking the camera's field of view).
- CCTV systems shall use real time signal or near real time transmission of camera views.
- Alarms shall be enabled to assess immediately by either the PF or by a remote central alarm monitoring station personnel using a network connected CCTV management system; ergonomics shall be considered.
- CCTV assessment cameras used as primary assessment for alarms shall be fixed (i.e., not pan or tilt) with fixed focal length lenses or zoom capability.
- All cameras must be compatible with the existing Alarm Display and Annunciation System (ADAS) at the site. Close coordination with the ADAS system integrator is required as part of this study. It is understood that technical upgrades to the ADAS system may be required.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

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III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. Safety is of the utmost importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Ease of Operation

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Continue to maintain existing analog cameras at Bayou Choctaw. Maintaining the current system, requires additional maintenance repairs and of greater importance, the security assessment system will continue to degrade. The current analog technology residing on the site is antiquated and does not function at optimal capacity in its current configuration.

It is the opinion of the Government security team that increasingly scarce repair parts will become nonexistent within the next two (2) years. Assessment capabilities will eventually be degraded to the point that the site fails to meet DOE Order 473.3 A. and USNRC Intrusion Detection System requirements if the CCTV system remains analog.

Viability: No Further Analysis

B. Replace CCTV System (Analog)

Replace all existing fixed and Pan-Tilt-Zoom (PTZ) physical security Closed Circuit Television (CCTV) assessment system cameras (~86) (hardware, software and monitors included) on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed. Install latest generation analog cameras on the perimeter and critical structures; replacement of video transmission lines, video servers and monitors will be required. Digital IP encoders are required to allow viewing remotely by NOLA DOE and M&O staff during emergencies. Intelligent video capabilities at the camera or at the server are recommended upgrades.

Viability: Continue Analysis

C. Replace CCTV System (Digital)

Replace all existing fixed and Pan-Tilt-Zoom (PTZ) physical security Closed Circuit Television (CCTV) assessment system cameras (~86) (hardware, software and monitors included) on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed. Install latest generation digital IP cameras on the perimeter and critical structures; replacement of video transmission lines, video servers and monitors will be required. Digital IP encoders are required to allow viewing remotely by NOLA DOE and M&O staff during emergencies. Intelligent video capabilities at the camera or at the server are recommended upgrades.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A is eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace CCTV System (Analog)

Replace all fixed (~86) analog cameras with the latest generation of analog camera technology. Replacing older model analog cameras and components at Bayou Choctaw will reduce the amount of maintenance difficulties, sparing/stocking challenges, and repair parts issues. The existing fixed day/night cameras require long fields of view which possess no zoom capability, therefore reducing intrusion detection efforts. Poor quality images captured by the analog camera systems are inadequate for retrieving detail or attempting a positive identification.

The site continues to experience repair and replacement difficulties. Maintenance and Operations (M&O) personnel are challenged with antiquated components and in some cases, repair is beyond Instrumentation & Electrical (I&E) personnel capabilities and training.

Replace the existing fixed analog CCTV system (cameras, monitors, cabling, and digital video recorders - DVR) with the latest generation technology of Pelco cameras or approved equal at Bayou Choctaw. Replace all fixed (~71 Pelco ExSite Series camera or approved equal), Pan-Tilt-Zoom (PTZ) (~15 Pelco ExSite Series camera or approved equal), physical security Closed Circuit Television (CCTV) assessment system cameras on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed at Bayou Choctaw. Intelligent video analytic capabilities at the cameras or at the servers are recommended upgrades. Fixed cameras shall be equipped with image stabilization, auto iris, and zoom capabilities required in accordance with DOE Protection Order 473.3 A. and USNRC Intrusion Detection Systems and Subsystems Technical Information.

The Pelco ExSite Series analog cameras are integrated camera systems that meet stringent explosion proof and dust-ignition proof requirements. The ExSite Pan/Tilt Series combines a receiver, pan/tilt, and enclosure in a single, easy-to-install system, but also includes an Integrated Optics Package (IOP). The ExSite Fixed Series can be installed in a standard or inverted position and features manually adjustable 200 degrees of pan and 180 degrees of tilt positioning. The Integrated Optics Package contains an autofocus camera and lens module with configurable features. These explosion proof camera systems (fixed and pan/tilt camera systems) shall include an optional programmable window wiper and washer/wipe sequence under a single command. Any cameras currently mounted on wooden utility poles (~5) shall be mounted on square tapered 7-gauge, steel hinged poles, 30’ in length. Each newly installed camera pole shall be properly grounded and have a lightning air terminal on top of the pole.

Lighting is critical for optimal performance and shall be addressed in the ongoing lighting upgrade efforts; white light is one of the critical essentials (illumination-white light, camera and lens) needed at the front end of every CCTV system.

Assumptions & Constraints

Assumptions:

- Camera types and lighting replacements shall be compatible (done during detailed design).
- A site modeling determination shall be conducted prior to camera installation to establish detailed requirements and potentially gained efficiencies.
- New equipment installation shall not hinder emergency generator capability.

Constraints:

- Construction dates of lighting projects (~2020 project); lighting and camera specifications must be compatible for optimal performance (CCTV replacement is tentatively scheduled for ~2023).
- The primary limitation is not only the analog technology, but the fact that analog cameras have to comply with analog TV standards, producing decoding errors as the camera attempts to resolve images; the result is blurring and inaccurate rendering of colors.
- Wireless analog is very unreliable and poor quality, and any underground cables are extremely prone to lightning.

- Analog is a 50-year-old technology, very sensitive to interference and analog cameras generally do not accommodate big distances, getting them to work over broad ranges is difficult.
- The major disadvantage of analog cameras comes down to image quality; problematic with applications that demand high security and the need to re-encode the signal to IP for transmission to remote offsite monitoring and alarming stations.

Benefits & Effectiveness

Replacing all cameras with new analog cameras will allow for better security and safety measures while eliminating difficulty of maintenance and operability. Maintenance procedures will streamline as characteristics of systems are updated to a new camera system, allowing effective diagnosis and triage. The information below summarizes the benefits and effectiveness of replacing all analog cameras on site with current technology as well as addressing the mission needs of the site.

- Maintenance procedures are reduced with all new components. All new equipment shall be installed and accompanied with manufacturer warranties and product training.
- The potential for the re-use of existing cabling that is still serviceable allows for cost reduction during installation.
- The CCTV assessment system will function at acceptable capacity, providing the PF response enough time to assess areas and intruder incursions.
- Meets the DOE Protection Order 473.3 A. requirements.

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with replacing all of the analog cameras on site include reduced security posture during construction, rapidly advancing technology and the lack of training of employees. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replace with Analog Cameras

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Rapidly advancing CCTV technology, analog becomes outdated.	Implement a rigid 5-year life cycle replacement interval.	High - High	High Risk Hazard
May require training on the new system.	Minimize the length of training by making the training comprehensive, easy to follow and hands on.	High - Low	Low Risk Hazard
Site Security posture is degraded during installation.	Work closely with NOLA and site security to alleviate gaps in security, potentially compensatory PF options.	High - High	High Risk Hazard
Existing cabling infrastructure is not serviceable and needs to be replaced.	Must survey all existing camera locations and the existing cable for suitability for re-use.	Medium - High	Medium Risk Hazard

B. Replace CCTV System (Digital)

The existing analog CCTV systems are experiencing issues related to obsolescence and maintenance. Digital IP CCTV systems have been installed for the cameras at Big Hill and West Hackberry sites and are experiencing higher performance and improved maintenance rates. The existing assessment system consists of an assortment of analog cameras of varying makes and models. Some cameras have issues communicating with current servers and finding compatible cameras is becoming increasingly difficult. Infra-red (IR) cameras are ineffective because of on-site and off-site lighting. Currently, the fixed day/night cameras have long fields of view with no zoom capability, potentially causing threat identification challenges. Current antiquated camera technology increases down time and increases repair/replacement costs, and sparing issues for Fluor Maintenance and Operations (M&O) is difficult. Assessment capabilities will degrade to the point of failure to meet DOE Order 473.3 A. requirements if the CCTV system shortcomings are not addressed. Extensive damage could result from undetected intrusion. The CCTV system includes technology that utilizes Infrared (IR) and Thermal (TH) cameras as well as cameras using conventional illumination.

A digital camera digitizes the video signal using a specialized encoder that contains an onboard IP encoder and web management interface. This allows the IP camera to act as a network device, thus allowing captured video images to be viewed not only through an existing network, but also through a web browser that can be accessed through the Internet; thus allowing NOLA and authorized users to view the specific site video images as needed. Digital IP encoders are not required to allow viewing remotely by NOLA DOE and M&O staff during emergencies as the video feed from the camera is already IP encoded. Intelligent video capabilities at the camera or at the server are recommended upgrades to allow for video analytics. Video analytic capabilities allow for the CCTV system to set parameters for alarm conditions. Replacement of video transmission lines, video servers, and monitors will likely be required to support an IP over Ethernet network connection to the CCTV system.

This alternative proposes to replace the existing CCTV system (cameras, monitors, cabling, and digital video recorders - DVR) cameras (~86) with the latest generation technology of Pelco cameras or approved equal at Bayou Choctaw. Digital cameras require a Network Video Recorder – NVR versus a DVR (input from the network versus direct connection). Replace all fixed cameras with (~71) the Pelco ExSite IP EHXME Series camera or approved equal. Replace all pan/tilt/zoom (PTZ) cameras (~15) with the Pelco ExSite IP IPSXME Series camera or approved equal. Install these cameras on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed on Bayou Choctaw.

The Pelco ExSite IP Series cameras are fixed and pan/tilt/zoom, explosion proof IP cameras designed to meet the rigorous requirements for hazardous locations with integrated camera/lens/receiver for safe and efficient installation. These cameras feature low-light technology, multiple compression formats and both upright and inverted operation for optimal image quality, performance, and reliability. The Pelco Exsite IP is not only explosion proof but capable of recording, managing, configuring, and viewing multiple live streams. This explosion proof camera system (fixed and pan and tilt camera systems) shall include an optional programmable window wiper and washer/wipe sequence under a single command.

Dome cameras were not suggested replacements for two (2) important reasons. Fitting on camera illumination to a dome camera is more difficult (requiring significant additional lighting efforts) than fitting illumination to a fixed or PTZ system; lighting cannot be fitted to follow the movement of the camera. Therefore, it is assumed dome cameras lack optimal night-time performance requirements needed unless each dome camera is retrofitted with its own lighting assembly. Secondly, dome cameras are extremely sensitive; typically, they are outfitted with smoked domes, integral zoom lenses, and higher F-stop ratings (aperture speed) which reduce light transmission needed for optimal performance.

Any cameras currently mounted on wooden utility poles (~5) shall be mounted on square tapered 7-gauge, steel hinged poles, 30’ in length. Each newly installed camera pole shall be properly grounded and have a lightning air terminal on top the pole.

Lighting is critical for optimal performance and shall be addressed in ongoing lighting upgrade efforts; white light is one of the critical essentials (illumination-white light, camera and lens) needed at the front end of every CCTV system.

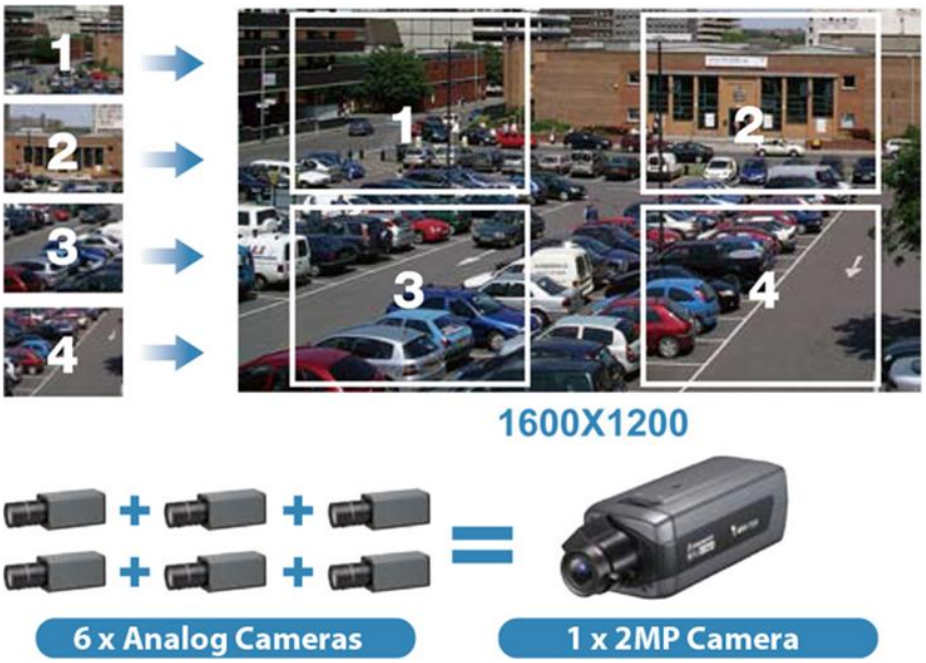

Figure 1 – One (1) Digital Camera Can Cover the Same Area as Six (6) Analog Cameras

Assumptions & Constraints

Assumptions:

- Camera types and lighting replacements shall be compatible (done during detailed design).
- Eventually IP CCTV will be the standard for CCTV systems, providing a longer term solution than analog.
- New digital high definition camera technology will allow for a reduced number of cameras (fixed) to cover a given field of view.
- A site modeling determination shall be held to establish detailed requirements and potentially gained efficiencies.
- The existing network backbone can handle the increase in bandwidth needed for a digital camera replacement alternative.

Constraints:

- Construction dates of lighting projects (~2020 project); lighting and camera specifications must be compatible for optimal performance (CCTV replacement is tentatively scheduled for ~2023).

Benefits & Effectiveness

Replacing all cameras with digital IP technology will allow for optimal security and safety measures while eliminating difficulty for maintenance and operability. Maintenance procedures will streamline as characteristics of new systems are installed, allowing effective diagnosis and triage.

The information below summarizes the benefits and effectiveness of replacing all cameras on site with digital IP technology as well as addressing the mission needs of the site.

- Replaces antiqued technology and camera equipment; detection, classification, and identification are achieved in the most expeditious and accurate manner.

- A new high definition digital IP camera can cover a much wider area than a standard definition analog camera. (See Figure 1)
- One Cat5e cable can be used to send multiple cameras back to the NVR, saving time and money spent on running multiple cables for analog; IP system installs require significantly less wiring than an analog system.
- High definition digital IP cameras can provide up to 25% more resolution than analog and are especially better at capturing objects that are moving and running, even at high speed.
- Difficult maintenance procedures are all but eliminated with all components having “like” characteristics and troubleshooting techniques.
- The CCTV assessment system will function at optimal capacity, providing the PF response speeds fast enough to assess areas and intruder incursions without latency; the biggest advantage with a megapixel IP CCTV system is extremely high resolution pictures.
- Optimal viewing capacity and zoom capabilities, potentially reducing the total number of cameras and ancillary equipment needed to accomplish the DOE protection mission (~6 analog cameras are required to get the same resolution as one 2 megapixel digital IP camera).
- A digital IP camera can be wired to the nearest network switch where it uses the existing network infrastructure using either UTP or single mode fiber depending on distance.
- Eliminating the need to re-encode an analog camera feed to IP for remote viewing reduces the amount of encoders, servers and matrix switches that analog signal cameras require.
- The use of an IP encoded CCTV signals allows for greater flexibility for integration with IDS, access control and video analytics.
- Consistently meet the DOE Protection Order 473.3 A. requirements, negating DOE Headquarters security assessment inspection shortcomings/findings.

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with replacing all of the cameras on site include reduced security posture during construction, rapidly advancing technology and the lack of new equipment training for employees. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing All Cameras (Digital)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Rapidly advancing CCTV technology.	Implement a rigid 5-year life cycle replacement interval.	Low - Low	Low Risk Hazard
Digital IP cameras will require equipment modifications to current ADAS system at the site.	Upgrade BC ADAS (require NVR and additional encoders vs existing DVR) in conjunction with upcoming ADAS upgrade projects at WH and BM.	Medium - Medium	Medium Risk Hazard
May require training on the new system.	Minimize the length of training by making the training comprehensive, easy to follow and hands on.	High - Low	Low Risk Hazard
Site Security posture is degraded during installation.	Work closely with NOLA and site security to alleviate gaps in security, potentially compensatory PF options.	High - Low	Low Risk Hazard
Existing cabling infrastructure is not serviceable and needs to be replaced.	Must survey all existing camera locations and the existing cable for suitability for re-use.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace CCTV System (Analog)

Replace all existing fixed, Pan-Tilt-Zoom (PTZ) physical security Closed Circuit Television (CCTV) assessment system cameras with latest analog technology (hardware, software and monitors included) on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed.

B. Replace CCTV System (Digital)

Replace all existing fixed, Pan-Tilt-Zoom (PTZ) physical security Closed Circuit Television (CCTV) assessment system cameras with the latest generation digital technology (hardware, software and monitors included) on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), and any additional identified areas of security coverage needed.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Security During Construction**	**Ease of Operations**	**Ease of Maintenance**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Important*	*Less Important*	*Less Important*
Alternative A	*Excellent*	*Adequate*	*Adequate*	*Adequate*	*Excellent*	*Excellent*
	Good	*Good*	*Adequate*	*Good*	*Excellent*	*Good*
	Excellent	*Good*	*Good*	*Good*	*Excellent*	*Adequate*
Alternative B	*Excellent*	*Adequate*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Good	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Good*	*Excellent*	*Good*	*Excellent*	*Adequate*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$5,194,796**	**$10,207,600**
Alternative B	**$5,815,969**	**$11,594,645**

Recommended Alternative

B. Replace CCTV System (Digital)

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. The key factors in the higher technical rating were the better day-to-day operability and capability of the digital cameras, with a corresponding better ability to maintain. The initial cost and life cycle cost of Alternative A was slightly lower than Alternative B. Alternative B is the recommended preferred alternative, with the better performance characteristics of digital over analog being worth significantly more than the slightly higher initial investment and life cycle costs.

BC-MM-308

Upgrade Outdoor Lighting

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Replace All Utility Poles, All Lights and Associated Cabling (LED)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Lighting at SPR sites is integral to providing increased security and safety of site personnel and facilities. The project intent is to provide more sustainable, reliable, and lower maintenance lighting service to the cavern and building areas as well as frequently used roadways. Specifically, this project looks at adding new lighting in areas that are under-lighted, replacing existing lights with energy efficient types, removing lights in areas that no longer need them, installing low-maintenance poles, installing new wiring in duct banks or conduit, and installing a switch near the Recovery Pump Exercise (RPX) pad.

Functional Requirements

Lighting levels to meet Design Level III Criteria and DOE Order 473.3 A. requirements.

- Perform a lighting survey to identify areas where lighting is inadequate or no longer needed; use light modeling programs using methods recommended by the Illuminating Engineering Society (IES).
- Adequately light each work area, parking area and walkways whenever an employee is present (OSHA 1915.82(a) (2).
- Compliment the lighting systems with the electro optical/closed circuit television (CCTV) assessment system.
- Allow for the rapid and reliable assessment of alarms from either the CCTV system or Protective Force (PF) personnel.
- Install maintenance free utility poles with protected cabling.
- Consider energy efficient lighting.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

A diverse group of individuals was selected to participate in this analysis to provide technical advice and operational experience.

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Corb Elsbury	VCI, Project Engineer
Marc Gross	FFPO, Manager Design Engineering

Team Members

Samuel Washington	DOE, Lead General Engineer
Patrick Shepherd	DOE, Project Engineer
Damon Bruno	DOE, Site General Engineer
Rachel Gray	VCI, Process Engineer
Ron Johnson	FFPO, Sr. Director Security & Emergency Prep
Thomas Guillory	FFPO, Manager Protection & Physical Security
Todd Demaris	FFPO, Sr. Protection Physical Security
Russ Romero	FFPO, Site Director
Mike Berthelot	FFPO, Site Security Specialist

Kevin Williams	FFPO, Sr. Site Engineer
Samuel Gauthe	FFPO, Manager Site Operations
Mark Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. Maintenance operations will require less attention as new equipment replaces legacy equipment.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. The site's ability to address Safety and Security concerns during implementation shall not be impacted. Safety is of the greatest importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo consists of continuing to maintain the ~30-year old high pressure sodium (HPS) lighting systems and to use portable lighting, when needed, in areas not well lit. This alternative includes accepting the risk of wooden pole (~50) deterioration/failure, safety risks, and unscheduled maintenance/repair costs; lighting at Bayou Choctaw is at the end of its useful life. The determination that wooden poles are extremely susceptible to the predominantly wet, humid environment as well as woodpecker damage make them less than a viable option. Cabling associated with lighting is ~20-years old and will continue to be at risk of being severed and/or malfunctioning as ongoing major maintenance operations on the SPR continue.

Recent inspections from the Enterprise Assessment (EA) Team from DOE Headquarters found the SPR perimeter fence detection system lacked adequate scene illumination and was deficient in the number of light poles, fixtures, and light shielding. All of these issues negatively affect the PF's ability to assess and track intruder locations. The use of color cameras at nighttime, particularly when a scene is illuminated with HPS lamps, is problematic. The status quo will continue to provide for low visibility for night maintenance operations/security and allow for the risk of the deterioration/failure of wooden light poles. Areas of the site deemed inadequately lighted hinder maintenance efforts as well as pose a safety risk for night shift employees. The degraded ability of the PF to assess intruder location and intent due to poor lighting conditions will continue.

Viability: No Further Analysis

B. Replace Designated Utility Poles, All Lights and Associated Cabling (LED)

The (LED) alternative consists of replacing designated wooden utility poles used for mounting lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, Raw Water Intake Structure (RWIS), Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering light-emitting diodes (LED) lighting as a suitable replacement.

Viability: Continue Analysis

C. Replace Designated Utility Poles, All Lights and Associated Cabling (Induction)

The (Induction) alternative consists of replacing designated wooden utility poles used for mounting lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, RWIS, Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering induction lighting as a suitable replacement.

Viability: Continue Analysis

D. Replace Designated Utility Poles, All Lights and Associated Cabling (High Intensity Discharge - HID)

The HID alternative consists of replacing designated wooden utility poles used for mounting lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, RWIS, Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering high intensity discharge lighting as a suitable replacement.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A is eliminated from further consideration. The remaining alternatives, B, C, and D are examined below as alternatives A, B, and C, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

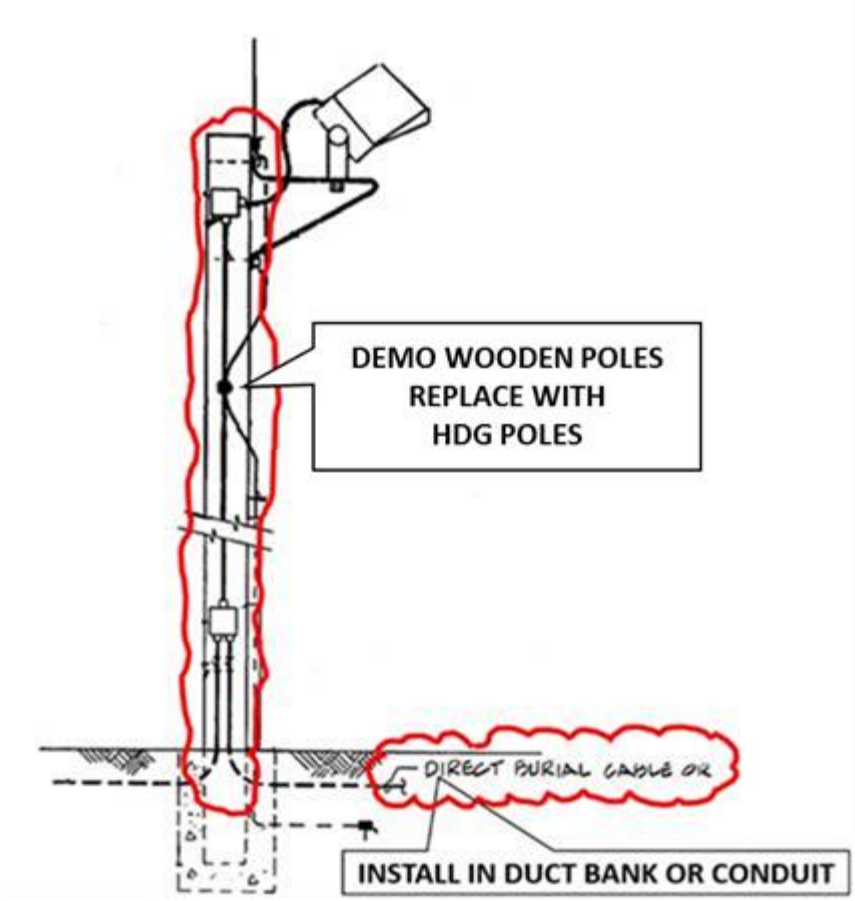

Figure 1 – Changes to Existing Light Poles

This figure demonstrates the procedure common to all three alternatives; all creosote wooden poles supporting lighting shall be demolished and associated cabling installed in duct bank, conduit or existing cable trays vs directly buried.

A. Replace Designated Utility Poles, All Lights and Associated Cabling (LED)

The (LED) alternative consists of replacing all lighting and fixtures with LED technology while replacing designated wooden utility poles (~50) and associated cabling at Bayou Choctaw.

A recent lighting evaluation conducted at Bayou Choctaw determined there were ~24 light deficient areas, ~11 of those on roadways. A lighting evaluation shall be performed to confirm the light deficient areas and also determine where lighting is no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting; the DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc), 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 fc for cavern areas.

Department of Energy modeled uniformity comparisons of LED, Induction, and HPS produced results that suggested LED lighting displayed a 2:1 advantage in placement; this study was conducted using new luminaries, equal wattage, identical new utility poles and spaced for optimal performance. Visual uniformity comparisons of LED, Induction, and HPS suggests that LED at maximum lux (luminous flux per unit area) of 27 lm/W (Lumens/Watt) characteristics performed better than Induction (11.2 lm/W) and HPS (24 lm/W). Negating obstacles such as above ground tanks and large buildings, it is reasonable to plan for a wooden pole replacement number to be much closer to ~25 versus the existing ~50 wooden pole replacement count. Additionally, assumptions may be made on the previously identified light deficient areas ~24 to estimate for the half that number, ~12.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing HPS and Induction lighting at Bayou Choctaw; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All wooden roadway pole replacements (~7) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining wooden utility poles (~17) shall be replaced with a more durable material than wood such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used in situations where a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined.

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- LED lighting reduces the need for poles and additional lighting fixtures by half.
- Lighting and new camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, unprotected cabling shall be installed in existing cable trays vs installing new duct banks or conduit.
- LED lighting at maximum burning hours (100K) retains 85% lumen output.
- LED fixtures are widely available with multiple light patterns and correlated color temperatures (CCT); available from 2000 to 10,000; eliminating light pollution (washout).

Constraints:

- A large amount of cabling associated with lighting is directly buried.
- Existing power sources for all new utility pole installation (Brine Disposal Road).
- Available/existing cable trays within a suitable distance for use.

Benefits & Effectiveness

Identifying site lighting deficiencies, replacement of utility poles, old cabling, lights and fixture replacement with LED technology allows for multiple benefits and addresses current mission needs. Replacing the utility poles and addressing the lighting deficiencies also allows for optimal security and safety, which best supports the requirements described in DOE 473.3 A.

- Improved visibility for night maintenance (safety) and security operations; LED lights are instantly turned on with no warm up (DOE 473.3 A., Attachment 3, Section A 3-35 [3][b]).
- Allows for better PF intruder assessment capabilities due to the rapid and reliable assessment of alarms (DOE 473.3 A., Attachment 3, Section A 3-35 [3][a]).
- Improved lighting will complement the CCTV assessment system, allowing for improved security (DOE 473.3 A., Attachment 3, Section A 3-36 [3][g]).
- Alleviates safety risks from deteriorating wooden utility poles and increases performance of poles in poor weather (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Cabling with duct bank or conduit is the industry standard and prevents inadvertent cutting of cables, which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Deficiencies found by the EA Team, DOE Headquarters are addressed and corrected (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Employees feel safer with more adequately lighted areas; allows for a safe work environment per OSHA guidelines (DOE 473.3 A., Attachment 3, Section A 3-36 [3][h]).
- LED provides the ability to focus on exact luminous areas, allowing for a safer work environment (DOE 473.3 A., Attachment 3, Section A 3-36 [3][f]).
- LED lighting is more energy efficient (~44%) than HPS, easier to maintain and has a longer life cycle than the existing high pressure sodium (HPS) lighting; meeting DOE sustainability mandates. (U.S. DOE Solid State Lighting Technology Demonstration, June 2010)
- Color Rendering Indexes (CRI) of 60-90.
- LED lighting provides higher lighting acuity value per lumen/watt; 135 Lumens/watt.
- Extremely long life span, 100K hours at 70 Watt hours.
- No toxic materials used in manufacturing; low to no recycling costs.

Risk & Mitigation Factors

With new LED lighting, cabling and utility pole upgrades at the site come associated risks. Potential risks associated with replacing wooden utility poles, lights and cabling, as well as determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting in areas where poles are being replaced. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Utility Poles and Determining Lighting Deficiencies (LED)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard

Risk and Mitigation Strategies for Replacing Utility Poles and Determining Lighting Deficiencies (LED) (continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new poles, lighting, and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the poles, lighting, or cables.	Medium - Medium	Medium Risk Hazard
Loss of lighting in areas while poles are being replaced.	Prepare a strategic plan for minimizing the effects, and use portable lighting as necessary.	High - Medium	Medium Risk Hazard
Lighting technology required to address both lighting and security (CCTV) needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - High	Medium Risk Hazard

B. Replace Designated Utility Poles, All Lights and Associated Cabling (Induction)

The (Induction) alternative consists of replacing all lighting and fixtures with Induction lighting technology while replacing designated wooden utility poles (~50) and associated cabling at Bayou Choctaw. A lighting evaluation shall be performed to identify areas where lighting is inadequate or no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting; the DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc), 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 fc for cavern areas.

A recent lighting evaluation conducted at Bayou Choctaw determined there were ~24 light deficient areas, ~11 of those on roadways. A lighting evaluation shall be performed to confirm the light deficient areas and also determine where lighting is no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting. A Department of Energy gateway study (June 2010) concluded Induction lighting used 6% less energy than HPS. HPS maintenance requires lamp replacement on average of every 5 years, ballasts every 15 years, igniters every 20 years, the housing every 25 years and photocell every 15 years. Induction lighting is nearly maintenance free for the rated bulb/ballast, exhibits a high color rendering index (CRI) of 80+ (HPS CRI is ~20-22) that produces vivid colors versus the yellowing (washout) associated with HPS and induction contains just slightly less amalgam (mercury). Induction lighting is found to operate much cooler (150F-180F than HPS (450-750F) presenting less environmental impact. Induction visual acuity (seeable lumens) is 191 lm/W while HPS has only 67 lm/W.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing lighting; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All wooden roadway pole replacements (~11) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining wooden utility poles (~39) shall be replaced with a more durable material than wood such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used in situations where a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined.

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- Lighting and new camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, new cabling shall be installed in existing cable trays vs installing in new duct banks or conduit.
- Most cabling associated with lighting is located in conduit or directly buried.

Constraints:

- Possible existing power sources for all new utility pole installation.
- Available/existing cable trays within a suitable distance for use.
- Induction lighting is a mercury hazard; high recycling costs.
- Induction lighting is difficult to control optically, limitations in beam patterns.
- Very large in size compared to LED retrofit units.

Benefits & Effectiveness

The replacement of all utility poles and cabling, existing lighting, and identifying site lighting deficiencies allows for multiple benefits and addresses current mission needs. Replacing the utility poles and determining lighting deficiencies also allows for security and safety, which supports the requirements described in DOE 473.3 A.

- Improved lighting will complement the CCTV assessment system, allowing for improved security (DOE 473.3 A., Attachment 3, Section A 3-36 [3][g]).
- Alleviates safety risks from deteriorating wooden utility poles and increases performance of poles in poor weather. (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Cabling with duct banks or conduit is the industry standard and prevents inadvertent cutting of cables, which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Requires relatively low maintenance efforts; Green Light Source.
- Rated lifespan 60K hours (to 70% lumens, limited by ballast life); lamp and power supply are recommended as replaced at the same time.
- Color Rendering Index (CRI) of 80 and Correlated Color Temperature (CCT) of 3000K.

Risk & Mitigation Factors

With new induction lighting, cabling and utility pole upgrades at the site come associated risks. Potential risks associated with replacing wooden utility poles, lights and cabling, as well as determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting in areas where poles are being replaced. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Utility Poles/Lighting and Determining Lighting Deficiencies (Induction)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new poles, lighting, and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the poles, lighting, or cables.	Medium - Medium	Medium Risk Hazard
Loss of lighting in areas while poles are being replaced.	Prepare a strategic plan for minimizing the effects, and use portable lighting as necessary.	High - Medium	Medium Risk Hazard
Lighting technology needed to address both lighting and security needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - High	Medium Risk Hazard
Induction lighting contains mercury.	Maintenance on induction lighting should be conducted after complete cool down; address in an updated maintenance procedure.	Medium - High	Medium Risk Hazard

C. Replace Designated Utility Poles, All Lights and Associated Cabling (High Intensity Discharge - HID)

The High Intensity Discharge (HID) alternative consists of replacing all lighting and fixtures with HID lighting technology while replacing designated wooden utility poles (~50) and associated cabling at Bayou Choctaw. A recent lighting evaluation conducted at Bayou Choctaw determined there were ~24 light deficient areas, ~7 of those on roadways. A lighting evaluation shall be performed to confirm the light deficient areas and also determine where lighting is no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting; the DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc), 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 fc for cavern areas.

The most common types of HID are mercury vapor lamps, metal halide lamps and HPS; HPS being the most common on the SPR. HID lighting lamps produce an arc for intense light, therefore requiring ballasts. HID ballast technology is old and highly inefficient, requiring time to establish the electric arc and is not easily controlled or dimmable while LED and Induction lighting can be integrated into a remote monitoring and dimming control system.

Mercury vapor lamps, the oldest types of high-intensity discharge lighting, were formerly used for street lighting, but are now only rarely used for that purpose. Nearly all new lamps sold in North America today for street lighting are either metal halide or LEDs, which have also displaced mercury vapor lamps in sports arenas and gymnasiums. Mercury vapor lamps provide about 50 lumens per watt, but ballast loss can reduce the system efficacy to about 30 lumens per watt, which is not competitive with LEDs.

Metal halide lamps produce a bright, white light with the best color rendition among high-intensity (HID) lighting types. They are used to light large indoor areas, such as gymnasiums and sports arenas, and outdoor areas, such as parking lots. Metal halide lamps are similar in construction and appearance to mercury vapor lamps. The addition of metal halide gases to mercury gas within the lamp results in higher light output, more lumens per watt, and better color rendition than from mercury gas alone.

High-pressure sodium (HPS) lighting is a type of HID lighting used for street and outdoor area lighting, parking garages, and some industrial applications. Although HPS lamps can be efficient and long-lasting, they typically have poor color rendering compared to other lamp types, and are being displaced by LEDs in many applications.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing lighting; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All wooden roadway pole replacements (~7) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining wooden utility poles (~43) shall be replaced with a more durable material than wood such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used where use of a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined (HID).

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- Lighting and new camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, cabling shall be installed in existing cable trays vs installing new duct banks or conduit.
- Most cabling associated with lighting is located in conduit or directly buried.

Constraints:

- Possible existing power sources for any new utility pole installation (Brine Disposal Road).
- Available/existing cable trays within a suitable distance for use.
- Source efficiency is typically 120 lumens/watt or higher. However, losses from trapped light, protective covers and lenses, inefficient ballasts and unfavorable operating temperature typically result in a measured system efficiency of 30 lumens/watt or less.
- HID lights are fragile and have a warm up (15-20 seconds) during ignition.
- Contains mercury; relatively higher recycling cost.

Benefits & Effectiveness

The replacement of wooden utility poles and identifying site lighting deficiencies allows for multiple benefits and addresses current mission needs. Replacing the utility poles and determining lighting deficiencies also allows for optimal security and safety, which best supports the requirements described in DOE 473.3 A.

- Alleviates safety risks from deteriorating wooden utility poles and increases performance of poles in poor weather. (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Cabling with duct bank or conduit is the industry standard and prevents inadvertent cutting of cables, which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Employees feel safer with more adequately lighted areas; allows for a safe work environment per OSHA guidelines (DOE 473.3 A., Attachment 3, Section A 3-36 [3][h]).

Risk & Mitigation Factors

With new upgrade at the site come associated risks. Some potential risks associated with replacing utility poles and determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting in areas where poles are being replaced. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Utility Poles and Determining Lighting Deficiencies (HID)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new poles, lighting, and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the poles, lighting, or cables.	Medium - Medium	Medium Risk Hazard
Loss of lighting in areas while poles are being replaced.	Prepare a strategic plan for minimizing the effects, and use portable lighting as necessary.	High - Medium	Medium Risk Hazard
Lighting technology needed to address both lighting and security (CCTV) needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - High	Medium Risk Hazard

VII. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace All Utility Poles, All Lights and Associated Cabling (LED)

The (LED) alternative consists of replacing wooden utility poles used for mounting lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, Raw Water Intake Structure (RWIS), Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering light-emitting diodes (LED) lighting as a suitable replacement on Bayou Choctaw.

B. Replace All Utility Poles, All Lights and All Cabling (Induction)

The (Induction) alternative consists of replacing wooden utility poles used for mounting lights and light fixtures with lights along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, Raw Water Intake Structure (RWIS), Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering Induction lighting as a suitable replacement at Bayou Choctaw.

C. Replace All Utility Poles, All Lights and Associated Cabling (High Intensity Discharge)

The (HID) alternative consists of replacing wooden utility poles used for mounting lights and light fixtures with lights along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, Raw Water Intake Structure (RWIS), Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering high-intensity discharge lighting as a suitable replacement at Bayou Choctaw.

Comparison of Alternatives

Core Team Member Ratings:

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
Alternative B	*Excellent*	*Good*	*Good*	*Good*	*Good*	*Excellent*
	Excellent	*Good*	*Good*	*Excellent*	*Good*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Good*	*Excellent*
Alternative C	*Good*	*Adequate*	*Good*	*Good*	*Good*	*Excellent*
	Marginal	*Adequate*	*Good*	*Excellent*	*Adequate*	*Excellent*
	Excellent	*Adequate*	*Good*	*Good*	*Adequate*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$1,690,962**	**$1,724,824**
Alternative B	**$2,688,493**	**$2,741,533**
Alternative C	**$2,639,417**	**$2,708,070**

Recommended Alternative

A. Replace All Utility Poles, All Lights and Associated Cabling (LED)

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria. The initial cost and life cycle cost of Alternative A were both lowest of the alternatives. Therefore, Alternative A is the recommended preferred alternative based on both technical and cost factors studied in the alternative analysis.

BC-MM-437

Sewage Treatment Plant

VCI Project Engineer: Jason McCrossen

Recommended Go Project:

Construct a New Treatment Plant Which Meets the Current Flow Requirement of Bayou Choctaw

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

To replace existing, outdated, sewage treatment tanks. The tanks have reached their expected service life of 30 years. The tanks should be extended aeration or activated sludge design type and constructed above ground to preclude confined space. There are two tanks with a total of 3,000 Gallons Per Day (GPD) (1,500 GPD each). The average daily flow in 2003 was about 1,600 for both. Bayou Choctaw can easily handle another 12 people for planned site expansion with 47 regular workers.

Functional Requirements

Due to the size and age of the existing tanks, new tanks are to be constructed to meet the needs of the Bayou Choctaw site. In addition, flooding of the below ground tanks from high tides have the potential to "wash out" the content of the existing sewage tanks. The new tanks will be raised above the 100 year Base Flood Elevation (BFE). In addition, the existing tanks must stay in service during construction with only as minimal cut over time, possibly on the weekend.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for Go/No Go Projects has been standardized for all Go/No Go AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Jason McCrossen	VCI, Project Engineer
Marc Gross	FFPO, Manger Design Engineering

Team Members

Zack Bergeron	VCI, Civil Engineer
Cory Jacob	VCI, Civil Designer
John Walker	VCI, Mechanical Engineer
Don Helms	VCI, Mechanical Designer
Russ Romero	FFPO, Site Director
Kevin Williams	FFPO, Sr. Site Engineer
Mark Blouin	FFPO, Manager Site Construction

III. SELECTION CRITERIA

Formal selection criteria will not be applicable in a Go/No Go Project.

IV. ALTERNATIVES IDENTIFICATION

Alternatives Identification is not applicable in a Go/No-Go Project.

V. ALTERNATIVES ANALYSIS

Continue to maintain existing plant and risk flooding from high tides. Existing plant is oversized and does not meet the current needs of the Bayou Choctaw site.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Construct a New Treatment Plant Which Meets the Current Flow Requirement of Bayou Choctaw

Construct a new above ground treatment plant specifically designed for the Bayou Choctaw load. Tanks to be above the 100 year BFE to mitigate the risk of any future flooding. Plant to be design to quickly cut over from existing plant with minimal down time. Effluent can be grey water which can provide ecosystem restoration benefits and Annual Habitat Units (AHU) can be calculated to offset any required mitigation during construction. All required permitting would be required and obtained in the Environmental Assessment. Discharging grey water can save the SPR significant money while providing AHU.

VI. ALTERNATIVE SELECTION

Recommended Go Project

A. Construct a New Treatment Plant Which Meets the Current Flow Requirement of Bayou Choctaw

Construct a new above ground treatment plant specifically designed for the Bayou Choctaw load. Tanks to be above the 100 year BFE to mitigate the risk of any future flooding. Plant to be design to quickly cut over from existing plant with minimal down time. Effluent can be grey water which can provide ecosystem restoration benefits and Annual Habitat Units can be calculated to offset any required mitigation during construction. All required permitting would be required and obtained in the Environmental Assessment. Discharging grey water can save the SPR significant money while providing AHU.

Cost

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$1,332,021**	**$1,360,353**

BC-MM-769, BC-MM-824

Install Brine Disposal Tank System

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Continue to Use Existing Brine Pond with Modifications

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The current mission requirement for Bayou Choctaw is to meet the SPR Level I Brine Disposal rate of 110,000 barrels per day (110MBD).

Functional Requirements

The functional requirements for the Bayou Choctaw brine disposal system is to be capable of disposal of 110,000 barrels per day of brine on a sustained basis. The brine disposal system consists of a pond, pumps, piping, and injection wells. This project will focus on the upstream portion of the brine disposal system, i.e. brine containment once the brine is released from the cavern(s). In order to achieve the most efficient brine disposal system, the specific gravity of the brine released from the caverns should not be diluted with sources of fresh water or rain water. This allows for ease of injection into the BC brine disposal well. Additionally, the brine should be void of any organic material to prevent plugging of the brine filters and/or perforated section of the sub-surface injection casing.

The brine disposal system should address the following objectives:

- Maximize specific gravity of fluid being pumped to the disposal wells with a minimum specific gravity of 1.10.
- Minimize any organic material in the fluid.
- Minimize or eliminate sources of fresh water (storm water or rain water) that is currently introduced into the brine pond.
- Brine containment needs a large surface area to allow for off-gassing of any vapors.

This Project is one component of a series of Projects to upgrade the Brine Disposal System at Bayou Choctaw in accordance with SPR Level I Criteria. Other projects that are part of the completed Brine Disposal System that are affected by this BC-MM-769, 824 project are: BC-MM-770, BC-MM-771, BC-MM-775 and BC-MM-1344. Lighting requirements for the Brine Disposal Facilities are identified in Project BC-MM-308.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Damon Bruno	DOE, Site General Engineer
Sam Washington	DOE, Lead General Engineer
Laren Tushim	VCI, Mechanical Engineer
John Walker	VCI, Mechanical Engineer
Janet Robert	FFPO, Director, Facilities Design and Integrity
Marc Gross	FFPO, Manager, Design Engineering
Russ Romero	FFPO, Site Director

Samuel Gauthe	FFPO, Manager, Site Operations
Marc Blouin	FFPO, Manger, Site Construction
Larry Martinez	FFPO, Manager, Site Maintenance
Stacie Hess	FFPO, Principal Operational Systems Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Additionally, the selected alternative conforms with and is compatible with other brine disposal system projects.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo alternative is to continue to cycle brine pond water to/from a storage cavern to increase salinity. This alternative is currently being used at Bayou Choctaw to achieve the desired results, i.e. increasing the salinity. This involves pumping the brine pond water (low in specific gravity) into a cavern to move oil to another cavern to produce brine from that cavern and back into the pond. This injection of the water into the 1st cavern results in some undesirable leaching of that cavern and is not recommended for long term use. Additionally, this operation involves quite a bit of operational equipment and electric power to perform.

Viability: No Further Analysis

B. Cover Brine Pond

This alternative would consist of a properly designed cover over the entire area of the existing brine pond and would measure approximately 2 acres in area. The roof material would need to be designed for a 25-year life. The main purpose would be to eliminate sources of rain water, approximately 60 inches per year. The supporting structure could also offer to serve as a platform for an array of solar cells for power generation.

Building a roof over the existing brine pond is feasible and would eliminate rainwater from entering the pond. The roof structure would need to be supported along the edges (north and south sides) of the pond and along the center. The sides and ends could be kept open particularly on the east end to accommodate pond cleaning requirements. The roof would be a metal, vented (either ridge vent or powered vent) roof. The sides would not be closed thus allowing the pond to be vented on all four sides. A determination would need to be made if this installation would create a Class 1 Division 2 area if there was an upset event and oil was inadvertently released to the pond.

Viability: Continue Analysis

C. Construct New Brine Tanks

This alternative would be to construct two, new, atmospheric pressure brine tanks of an appropriate volume to hold brine in prior to being pumped into the brine disposal wells. The tanks could be open top or covered. The tanks would not address the functional requirement of a large surface area to allow for off-gassing of any vapors unless the tanks were very large in area. This alternative would either result in taking the existing pond out of service for an extended period of time or would require selecting a suitable location for constructing two new tanks. If two new tanks were selected, a determination would need to be made to determine if the existing brine booster pumps could be re-used or if the installation of two new pumps is required in order to have brine disposal capability during construction of the new tanks.

A new brine tank(s) would have to be sized to support oil receipt rates and brine disposal rates – 110,000 barrels per day. Two tanks would be recommended so that planned maintenance can be performed on one tank while keeping the other tank in service. If it is required to keep the existing brine pumps in service, the location of the proposed new tanks would most likely result in a new set of brine booster pumps to replace the current pumps - BCP- 214, 215. New pumps could be sized similar to the existing booster pumps and would supply flow to the existing brine injection / disposal pumps. Conversely, a new tank could be built on one side (north side) of the existing pond and brine disposal operations could continue on the south side of the pond and continue to utilize the existing pumps. Some piping modifications would be required during the interim transition. Siting of any new tank(s) would need to address the cavern 4 potential collapse zone. The volume and dimensions of two new tanks would need to be optimized and consideration should be given to maximizing the open surface area of the top of the tank to allow off-gassing. As in the case of the pond, a tank roof could also be included to prevent entry of rain water. Another consideration is the ability to remove any inadvertent oil that would enter the tanks as a result of an upset event.

Viability: Continue Analysis

D. Identify 3rd Party to Dispose, Sell, or Purchase Brine

This alternative would involve continuing to operate with the existing pond and a contractual relationship to sell brine to or purchase brine from. In either case, brine would be sold if the brine was of adequate salinity for the 3rd party user or purchased from a 3rd party if the brine in the existing pond did not meet the stated

salinity requirements. This alternative would need to provide a dependable brine delivery system as well as an assured brine provider or customer.

Establishing / creating a 3rd party contract to sell brine to or purchase brine from may be feasible; however, determining volumes, delivery rate, logistics and reliance on a 3rd party to support SPR Mission requirements introduces a level of risk that would not be acceptable to the DOE. Brine Disposal capability would be heavily dependent on the ability to purchase brine water to increase the brine in the pond if the brine was not high enough in specific gravity. Additionally, this alternative does not provide the reliability of brine disposal and introduces a concern of lack of competition for someone to provide the service of providing brine or selling brine to.

Viability: No Further Analysis

E. Eliminate Source of Fresh Water Currently Discharged into Pond

This alternative would re-direct any sources of process or storm water discharges into the existing brine pond to another suitable discharge point. Storm water that is currently collected in the Foam Retention pond is discharged into the brine pond via a 4" discharge line. This water would have to be discharged to a different location and be disposed of.

Eliminating sources of fresh water, process water, or rain water from entering the pond is quite feasible and involves re-directing one source of fresh (storm) water from the foam retention pond and one source of process water from the High Pressure pump pad. Currently the rain (storm) water that is collected in the foam retention pond is pumped into the brine disposal pond. Also, process water that results from operational testing requirements of the Raw Water Injection pumps is discharged into the brine pond and would need to be rerouted to a different discharge point. The storm water piping discharge could easily be routed to a different holding area prior to discharge through an existing permitted outfall. Cavern 18 would serve as an excellent location to discharge the water from the foam retention pond. The storm water that falls onto the cavern 18 well-pad flows through an oil/water separator and into a sump where it is pumped to a permitted outfall. The cavern 18 well-pad could serve as a "holding area" for the foam retention pond water. The discharge permit from cavern 18 would need to be analyzed to see if this would be allowable or to determine if a revised permit would be required.

Viability: Continue Analysis

F. Manage or Treat the Fresh Water That Is Introduced into Pond

This alternative would be to install and operate a water treatment system, i.e. a de-salination plant to collect and convert any brine pond surface water (lowest specific gravity water) into fresh water and dispose of in an appropriate manner so that only brine with the required specific gravity would be discharged to the brine disposal wells. The de-salination plant, would need to be sized for the anticipated volume of low specific gravity water and may complement either of other alternatives listed.

A water treatment system to treat fresh or rainwater that is introduced into the pond so that it would meet storm water discharge quality requirements is feasible. The low salinity "fresh water" would be on the surface of the pond and could therefore be collected by a floating skimmer pump or pumps and directed to a treatment facility to be converted to a quality of water for eventual discharge via a permitted outfall. The facility would be similar to a de-salination plant and could be located near the existing brine pond. This would be an intermittent requirement and thus an analysis to determine if a portable / rental unit would be feasible or if a permanent installation is required.

Viability: No Further Analysis

G. Add Filtration Screen to Inlet of 1st Stage Pumps

This alternative would accomplish one of the functional requirements of reducing or eliminating the amount of organic material that could be pumped into the brine disposal wells. A revised inlet to the 1st stage brine disposal pumps could filter or screen out any organic material introduced into the pond.

The addition of a filter screen resulting in a redesign of the inlet to the brine pond pump inlet sump should be installed as part of any design that recommends the continued use of the brine pond. This screen would

prevent the introduction of any organic material (vegetation) form entering the brine pumps and being pumped into the brine disposal wells.

Viability: Continue Analysis

H. Store/Add Salt as Required to Existing Pond

This alternative would include a salt storage container of an appropriate volume located in proximity to the existing pond so that salt could be added to the pond to increase the salinity. A salt unloading facility would also be required in order to fill the salt container. Additionally, this alternative would likely require a means to circulate the content of the pond so that the added salt could be dissolved uniformly into the volume of brine in the pond.

The addition of a dry salt storage container and the ability to add salt to the brine pond to increase the salinity to meet desired levels is feasible if rain water and other sources of water were allowed to continue to be discharged into the pond. The availability, transportation and cost of dry salt would need to be investigated as well as the delivery system to add salt to the pond and the necessary long term maintenance of that system.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, D, and H are eliminated from further consideration. The remaining alternatives, B, E, and G are combined into one alternative and are examined below as alternative A while alternative C is examined below as alternative B.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Continue to Use Existing Brine Pond with Modifications

Combining alternatives B. Cover the Brine Pond, E. Eliminate Sources of Fresh Water Currently Discharged in the Pond, and G. Add Filtration Screen to the Inlet of the 1st Stage Pumps would achieve the projects functional requirements in total and could provide the added benefit of solar power generation. This could also be augmented with an anti-vegetation screen or mat around the outside of the pond dikes to get rid of close proximity vegetation that has to be maintained or mowed. This would prevent organic manner from entering the pond.

Cover Pond: This alternative would consist of a properly designed cover over the entire area of the existing brine pond and would measure approximately 2 acres in area. The roof material would need to be designed for a 25-year life. The main purpose would be to eliminate sources of rain water, approximately 60 inches per year. The supporting structure could also offer to serve as a platform for an array of solar cells for power generation.

Building a roof over the existing brine pond is feasible and would eliminate rainwater from entering the pond. The roof structure would need to be supported along the edges (north and south sides) of the pond and along the center. The sides and ends could be kept open particularly on the east end to accommodate pond cleaning requirements. The roof would be a metal, vented (either ridge vent or powered vent) roof. The sides would not be closed thus allowing the pond to be vented on all four sides. A determination would need to be made if this installation would create a Class 1 Division 2 area if there was an upset event and oil was inadvertently released to the pond.

Eliminate Sources of Fresh Water: This alternative would re-direct any sources of process or storm water discharges into the existing brine pond to another suitable discharge point. Storm water that is currently collected in the Foam Retention pond is discharged into the brine pond via a 4” discharge line. This water would have to be discharged to a different location and be disposed of.

Eliminating sources of fresh water, process water or rain water from entering the pond is quite feasible and involves re-directing one source of fresh (storm) water from the foam retention pond and one source of process water from the High Pressure pump pad. Currently the rain (storm) water that is collected in the foam retention pond is pumped into the brine disposal pond. Also, process water that results from operational testing requirements of the Raw Water Injection pumps is discharged into the brine pond and would need to be rerouted to a different discharge point. The storm water piping discharge could easily be routed to a different holding area prior to discharge through an existing permitted outfall. Cavern 18 would serve as an excellent location to discharge the water from the foam retention pond. The storm water that falls onto the cavern 18 well-pad flows through and oil/water separator and into a sump where it is pumped to a permitted outfall. The cavern 18 well-pad could serve as a “holding area” for the foam retention pond water. The discharge permit from cavern 18 would need to be analyzed to see if this would be allowable or to determine if a revised permit would be required.

Add Filtration Screen: This alternative would accomplish one of the functional requirements of reducing or eliminating the amount of organic material that could be pumped to the brine disposal wells. A revised inlet to the 1st stage brine disposal pumps could filter or screen out any organic material introduced into the pond.

The addition of a filter screen resulting in a redesign of the inlet to the brine pond pump inlet sump should be installed as part of any design that recommends the continued use of the brine pond. This screen would prevent the introduction of any organic material (vegetation) form entering the brine pumps and being pumped to the brine disposal wells.

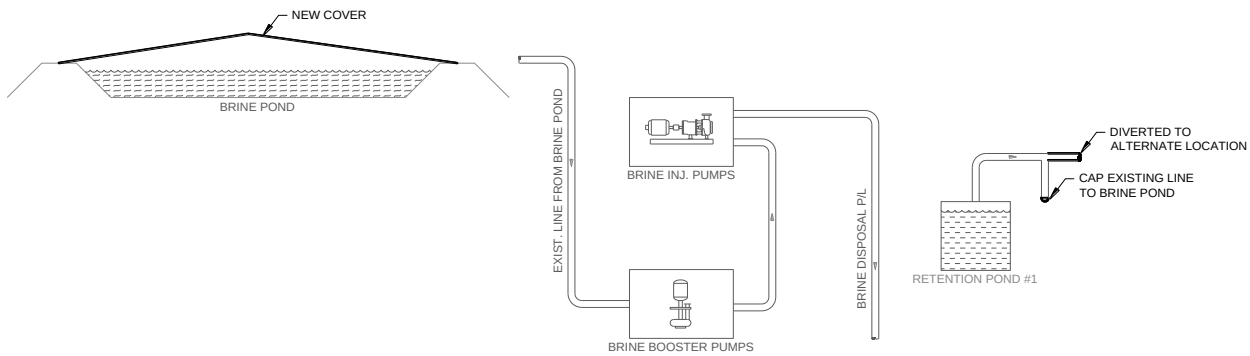

Figure 1 – New Cover Over Brine Pond

Assumptions & Constraints

Assumptions:

- Cavern 4 will remain stable for the foreseeable future and would not compromise the integrity of the pond or containment.
- A low profile roof could be designed and constructed without creating an impact to the existing helicopter landing pad or that a helicopter could safely approach from a different direction (other than southeast).

Constraints:

- The pond may have to be drained of all liquids and may be out of service in order to perform the construction.

Benefits & Effectiveness

The benefit resulting from this alternative is assurance of meeting the project functional requirements and is a simplistic approach. The cover over the pond results in the least of future facilities to be maintained and the inspection / replacement period would be able to be extended with proper material selection. If desired, the roof could offer an opportunity for solar cell installation for power generation. Grass cutting efforts along the slopes of the pond would be eliminated which negates a hazardous activity. From a construction schedule perspective, this alternative would most likely be very favorable.

The benefits of this alternative leverages the continuation with enhancements of a dependable, reliable pond and pumping system and brine disposal mission. The benefits of the higher specific gravity brine will reduce the downstream maintenance costs associated with the brine disposal injection wells and associated maintenance costs. The overall reduction / elimination of fresh water and organic material support the Bayou Choctaw brine disposal mission.

Risk & Mitigation Factors

There is little or no risk of the continued use of pond as a containment area for the brine water as there are no known leaks with the pond. In order to meet the project functional requirements, there would be several modifications to the pond and to existing process systems. The most significant of these modifications is the addition of a roof to cover the entire pond area. Also, the pond is located northeast of an abandoned cavern No. 4. Cavern 4 is known to have a slight risk of collapsing and a sophisticated monitoring system is installed on the cavern 4 well head and sub-surface casing to detect any ground movement or shift. If cavern 4 were to catastrophically fail, the existing brine pond would be in the failure zone and could be impacted. There has been little if any movement detected by the cavern 4 monitoring system over the past 25 years and the cavern is believed to be stable.

All of the risks associated with the suggested alternative modifications to the existing pond would result in little to any interruption of the use of the ponds.

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Continue to Use Existing Brine Pond with Modifications

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
The brine pond is located northeast of abandoned cavern No. 4. Cavern 4 is known to have a slight risk of collapsing and a sophisticated monitoring system is installed on the cavern 4 well head and sub-surface casing to detect for any ground movement or shift. If cavern 4 were to catastrophically fail, the existing brine pond would be in the failure zone and could be impacted.	The existing monitoring system provides an alarm to the site central control room if any movement is detected. The functionality of the alarm is assured through periodic testing and maintenance. There has been very little if any detectable movement detected by the cavern 4 monitoring system over the past 25 years and the cavern is believed to be stable.	Low – High	Low Risk Hazard
Cover Over the Entire Pond: Design, height and materials of construction would need to meet SPR Design Criteria and be suitable for use in this type of atmosphere. The installation of the structural foundations and structural steel would most likely require the existing pond to be emptied and taken out of service for a period of time.	**Cover Over the Entire Pond:** Structural Design and coatings (galvanizing) would provide corrosion resistance and meet wind load criteria. Site operations would need to appropriately manage brine operations requirements to allow for the brine pond to be taken out of service to support construction and installation.	Low – Low	Low Risk Hazard
Continued reliance on a 30 + year pond. The integrity of the existing pond is accomplished with a single liner and grandfathered registration for brine containment.	Continued monitoring via the existing monitoring wells will provide indication of integrity of the existing pond and liner.	Low- Medium	Low Risk Hazard
A helicopter landing pad is located northwest of the existing pond and a cover may impact the approach angle of a helicopter to the landing pad.	A low profile cover could be designed to not adversely impact the helicopter approach angle or the helicopter landing pad could be relocated.	Low – Low	Low Risk Hazard
Cover Over the Entire Pond: Addition of a cover may result in the area under the roof being classified.	**Cover Over the Entire Pond:** Appropriate ventilation would need to be assured to reduce the area classification. The addition of a fixed installation of toxic gas detection meters would provide alarms if toxic gases were detected.	Medium – Medium	Medium Risk Hazard
Elimination of fresh water: The redirecting of fresh water to other locations (Cavern 18 well pad) may impact or violate existing storm water discharge permits.	**Elimination of fresh water:** Monitoring / sampling of water from the foam retention pond could take place in the foam pond prior to being released to cavern 18 or after release from cavern 18. The volume of process water generated from pump exercise operations could be discharged into the foam retention pond.	Low – High	Low Risk Hazard
Addition of filter screens to sump pump inlet: This minor modification to the existing system would not add any appreciable risk to the current system. The filter screens would need to be accessible for periodic inspection and cleaning.	**Addition of filter screens to sump pump inlet:** An access platform may need to be provided to safely get to the screens for inspection and cleaning.	High – Low	Low Risk Hazard
The placement of mats around the outside of the pond dike does not result in the reduction of hand tool, grass cutting maintenance and associated risks on the slopes of the pond dikes.	Anti-vegetation mats or concrete would need to be installed on the outside of the pond dike.	Low – Low	Low Risk Hazard

B. Construct New Brine Tanks

This alternative would be to construct two new atmospheric pressure brine tanks of an appropriate volume to hold brine in prior to being pumped to the brine disposal wells. The tanks could be open top or covered. The tanks would not address the functional requirement of a large surface area to allow for off-gassing of any vapors unless the tanks were very large in area. This alternative would either result in taking the existing pond out of service for an extended period of time or would require selecting a suitable location for constructing two new tanks. If two new tanks were selected, a determination would need to be made to determine if the existing brine booster pumps could be re-used or if the installation of two new pumps is required in order to have brine disposal capability during construction of the new tanks.

The new brine tanks would have to be sized to support oil receipt rates and brine disposal rates – 110,000 barrels per day. Two tanks would be recommended so that planned maintenance can be performed on one tank while keeping the other tank in service. The tanks would be a nominal 50,000-barrel shell capacity (40,000 usable volume). If it is required to keep the existing brine pond and pumps in service, the location of the proposed new tanks would most likely result in a new set of brine booster pumps to replace the current pumps - BCP- 214, 215. New pumps could be sized similar to the existing booster pumps and would supply flow to the existing brine injection / disposal pumps. Conversely, a new tank could be built on one side (north side) of the existing pond and brine disposal operations could continue on the south side of the pond and continue to utilize the existing pumps. Some piping modifications would be required during the interim transition. Citing of any new tank(s) would need to address the cavern 4 potential collapse zone. The volume and dimensions of two new tanks would need to be optimized and consideration should be given to maximizing the open surface area of the top of the tank to allow off-gassing. As in the case of the pond, a tank roof would also be included to prevent entry of rain water. Another consideration is the ability to remove any inadvertent oil that would enter the tanks as a result of an upset event.

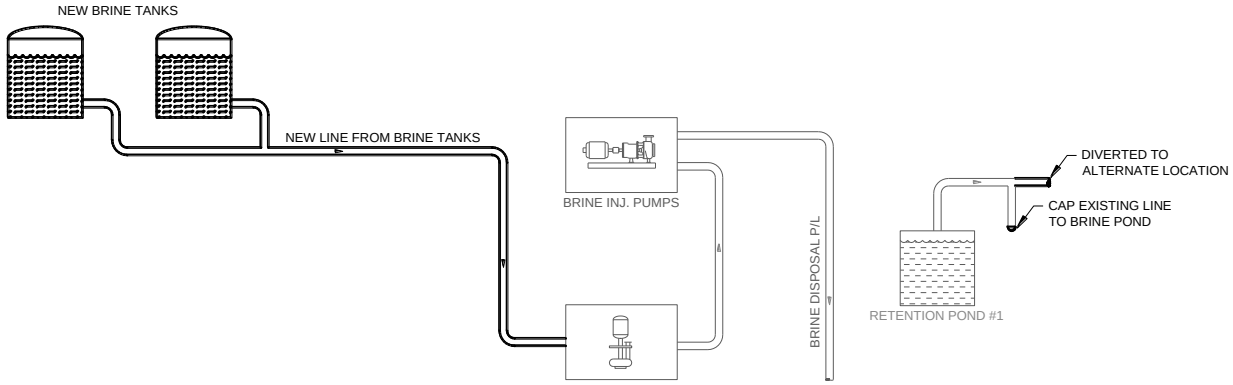

Figure 2 – New Brine Tanks

Assumptions & Constraints

An assumption for this approach is that a suitable location can be found to construct two new tanks with minimal or no impact to the ongoing capability to dispose of brine with the existing pond and pumps. It is assumed that the existing pond and brine site piping could be reconfigured to receive brine from the caverns and flow to the brine booster pumps while constructing the first of two or both new brine tanks. Due to limited space on which to construct two new tanks of the appropriate volume, the location of the existing pond would most likely be the only available place to build two new tanks. Other potential locations on the DOE Property site would involve the use of areas currently classified as wetlands. Wetland remediation would most likely be required if this was determined as the only suitable location. It is further assumed that there would <u>not</u> be an on-going mission to receive oil into the Bayou Choctaw site thus creating the need to dispose of brine. Normal brine production that results from stand-by cavern operations would be manageable.

Benefits & Effectiveness

The benefit resulting from this alternative is new, properly constructed steel tanks and containment berm surrounding the tanks. The new facility would be located outside of the “collapse zone” of cavern 4. The project functional requirements would be met; however, the location selection for the new tanks may result in new pumps needing to be installed if the existing vertical pumps could not be re-used or relocated.

The benefits of this alternative are less than that of the previous alternative. With two new tanks, some of the existing infrastructure (pumps, motors, piping, and valves) may need to be replaced. This would assure that new equipment could be specified and installed for a 25-year service life

Risk & Mitigation Factors

The sequence of construction would necessitate one tank being built at a time (if new tanks were built in the same location as the existing pond) or both tanks could be built concurrently if a new separate location were selected.

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Construction New Brine Tanks

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
The location would need to be suitable to support the ability to use the existing pumps or new pumps would need to be constructed.	It may be possible to construct the new tanks (one at a time) inside of the existing pond area. Wetlands remediation may be required if the pond is not a suitable location.	High – High	High Risk Hazard
The addition of new, above ground, painted steel tanks would result in future, additional tank inspection, maintenance and confined space entry requirements.	The ability to clean, drain and inspect the inside of the tank safely needs to be addressed. Current SPR practice would be applicable to these tanks resulting in a confined space entry and appropriate measures	High – High	High Risk Hazard
The selected location is not beyond the “collapse zone” of cavern 4, and if there were a catastrophic failure of cavern 4.	The collapse zone would need to be properly identified and new tanks placed outside of that zone.	Low – High	Low Risk Hazard
If the tanks are cited in or near the existing pond, the pond may be unable to be drained and reconfigured to maintain on-going brine disposal capability.	Operational coordination would be paramount to manage the construction effort.	High – High	High Risk Hazard
Secondary containment would need to be provided beyond the tank itself.	Appropriately designed berms, liners, and monitoring around the new tanks would need to be installed to provide assurance of secondary containment.	High – High	High Risk Hazard
Hydrocarbons (oil) may be introduced into the tanks as a result of an upset event.	The tanks would need to be configured in a way to remove any entrained hydrocarbons that may be introduced into the pond as a result of an upset event.	High – High	High Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Continue to Use Existing Brine Pond with Modifications

Description of Alternative Combining alternatives A. Cover the Brine Pond, D. Eliminate Sources of Fresh Water Currently Discharged in the Pond, and F. Add Filtration Screen to the Inlet of the 1st Stage Pumps would achieve the projects functional requirements in total. Additionally, the roof could offer an opportunity for solar cell installation for power generation. This could also be augmented with an anti-vegetation screen or mat around the outside of the pond dikes to get rid of close proximity vegetation that has to be maintained or mowed. This would prevent organic matter from entering the pond.

B. Construct New Brine Tanks

This alternative would be to construct two new brine tanks of an appropriate volume to hold brine in prior to being pumped to the brine disposal wells. The tanks could be open top or covered. The tanks would not address the functional requirement of a large surface area to allow for off-gassing of any vapors unless the tanks were very large in area. This alternative would either result in taking the existing pond out of service for an extended period of time or would require selecting a suitable location for constructing two new tanks and evaluating whether the existing brine booster pumps could be re-used or installation of two new pumps in order to have brine disposal capability during construction of the new tanks.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Important*	*Important*
Alternative A	*Good*	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Good*	*Excellent*	*Good*
Alternative B	*Excellent*	*Marginal*	*Good*	*Adequate*	*Adequate*	*Excellent*
	Marginal	*Marginal*	*Good*	*Adequate*	*Marginal*	*Excellent*
	Good	*Good*	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$16,990,060**	**$17,244,950**
Alternative B	**$13,407,380**	**$13,654,269**

Recommended Alternative

A. Continue to Use Existing Brine Pond with Modifications

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated overall higher on the evaluation criteria. The initial cost and life cycle cost of Alternative B were both lowest of the alternatives. The technical evaluation ratings in multiple categories were far superior for Alternative A, including all of the most important criteria. Therefore, Alternative A is the recommended preferred alternative based on the technical merits outweighing the increased initial and life cycle costs.

BC-MM-770

Upgrade & Automate Brine Disposal Well Valves & Flow Meters

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Install New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves at Each of the Brine Disposal Flow Lines to Each Well and Install a New Brine Pipeline Motor Operated Isolation Valve

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Level I Criteria for the Bayou Choctaw SPR Site is to be capable of disposing 110,000 Barrels per day of brine. The brine disposal occurs via injection into existing brine disposal wells. A total of 12 injection wells exist at 3 separate locations approximately 2 miles from the main site.

Each of the 3 brine disposal well pads consist of piping, valves, filters and associated instrumentation to meter the rate and quantity of brine disposed.

Functional Requirements

The functional requirement for this project is to provide a dependable, standardized, maintainable system to isolate, control, and meter the instantaneous and sustained rate of brine being disposed in the brine disposal pipeline. Additionally, each brine disposal well shall be configured with the capability to isolate, control, and meter the instantaneous and sustained rate and total quantity of brine being disposed. Additionally, each brine disposal well shall be provided with a motor operated isolation valve (MOV), motor operated flow control valve (MOC), and a flow meter. The MOV and MOC shall be capable of being operated from the Central Control Room (CCR) and the flow meter results be displayed in the CCR. Also, each well shall be equipped with a reverse flow prevention device.

This Project is one component of a series of Projects to upgrade the Brine Disposal System at Bayou Choctaw in accordance with SPR Level I Criteria. Other projects that are part of the completed Brine Disposal System that are affected by this BC-MM-770 project are: BC-MM-769, 824, BC-MM-771, BC-MM-775 and BC-MM-1344. Lighting requirements for the Brine Disposal Facilities are identified in Project BC-MM-308.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Manager
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Damon Bruno	DOE, Site General Engineer
Laren Tushim	VCI, Mechanical Engineer
John Walker	VCI, Mechanical Engineer
Janet Robert	FFPO, Director, Facilities Design and Integrity
Marc Gross	FFPO, Manager Design Engineering
Russ Romero	FFPO, Director of Site
Samuel Gauthe	FFPO, Manager Site Operations
Marc Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance
Stacie Hess	FFPO, Principal Operational Systems Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would be to continue to maintain the existing valves and meters and replace only upon failure. The existing system does not have flow control capability, nor is it able to be monitored from the Central Control room. Due to the variety of flow meters, flow measurement is less accurate than reporting requirements dictate. The existing system does not meet the mission need and functional requirements.

Viability: No Further Analysis

B. Replace Existing Meters and Valves with Same Type of Meters and Valves

This alternative will replace existing orifice meters with new orifice meters and magnetic flow meters with new magnetic flow meters. Additionally, isolation and flow control valves will be replaced in like kind as existing.

This alternative replaces all of the existing equipment in like kind but does not achieve standardization and does not provide the level of control for each of the 12 brine disposal wells and level of automation for the Brie Disposal Well (BDW) flowlines. Additionally, this alternative does not meet the project specific requirements.

Viability: No Further Analysis

C. Install New Flow Meters

This alternative will replace all existing flow meters with new, magnetic flow meters on all 12 brine disposal wells.

This alternative includes only the replacement of all in line flow meters (orifice plate and magnetic) with new current technology flowmeters on each flow line to each well head.

Viability: No Further analysis

D. Seek Reporting Exemption from LADNR

This alternative would seek an exemption from the Louisiana Department of Resources to continue to report the quantity of brine disposed.

The state of Louisiana requires all disposal well operators to provide information as to the total quantity of material being disposed via Underground Injection Well. This requirement has been complied with for many years and the expectation is for this reporting to continue.

Viability: No Further Analysis

E. Upgrade All Valves and Meters with New Motor Operated Isolation Valves, Motor Operated Control Valves, and New Current Technology Flow Meters and Install New Well Head Check Valves to Prevent Reverse Flow

This alternative would replace and standardize all 12 Brine Disposal Well isolation valves, flow control valves, and flow meters. Additionally, a new check valve would be included in the piping near the brine disposal wellhead to prevent reverse flow. Also included in this alternative is the installation of a new brine pipeline motor operated isolation valve.

This alternative would meet the project specific requirements and would provide flow control and isolation for each of the 12 BDWs to the Control Room operator. This approach would provide a standardized piping arrangement for operations and maintenance purposes. This alternative would also include the reverse flow prevention check valves. Additionally, any new Brine Disposal Wells that are drilled and completed would have this same valve / meter arrangement.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, B, C, and D are eliminated from further consideration. The remaining alternative, E is examined below as alternative A.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Install New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves at Each of the Brine Disposal Flow Lines to Each Well and Install a New Brine Pipeline Motor Operated Isolation Valve

This alternative would replace and standardize all 12 Existing Brine Disposal Well Isolation valves, flow control valves, and flow meters and would be the standard arrangement for any new Brine Disposal Wells. Additionally, a new check valve would be included in the piping near the brine disposal wellhead to prevent reverse flow. Also included in this alternative is the installation of a new brine pipeline motor operated isolation valve.

This alternative would meet the project specific requirements and would provide flow control and isolation for each of the 12 BDWs to the Control Room operator. This approach would provide a standardized piping arrangement as for operations and maintenance purposes. This alternative would also include the reverse flow prevention check valves.

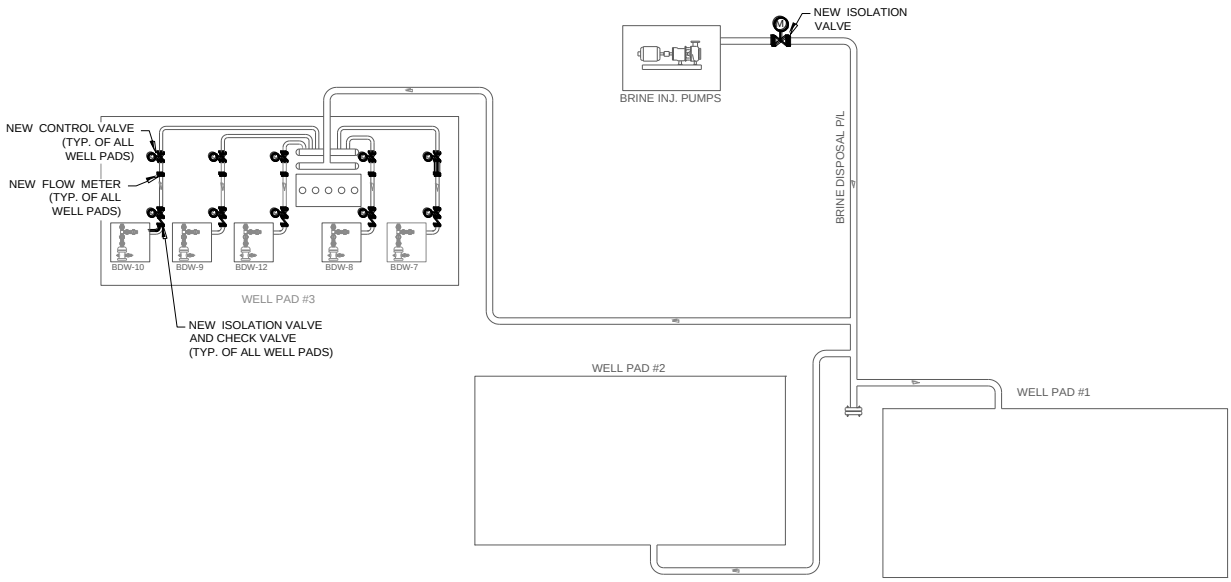

Figure 1 – Install New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves; Install New Brine Pipeline Motor Operated Isolation Valve

Assumptions & Constraints

Assumptions:

- A separate project to provide upgraded electric power at each of the three well pads (BC-MM-771) is implemented in conjunction with this project.
- The engineering specifications for the new valves, valve operators, and meters is such that the equipment is commercially available and that it is normal process plant equipment.

Benefits & Effectiveness

This alternative provides benefit in that the equipment is standardized thus allowing for reductions of sparing requirements and inventory. The valves and meters could be monitored and controlled from the main site control room thus reducing operator presence at the disposal wells during brine disposal operations. Technician training for maintaining the provided equipment would be minimal and meets the mission need and project specific requirements.

The implementation of this alternative assures the ability to operate, in a safe, effective, and efficient manner, the disposal well operations from the main control room.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves at Each of the Brine Disposal Flow Lines to Each Well and Install a New Brine Pipeline Motor Operated Isolation Valve			
Risks	**Mitigation Strategy**	**Likelihood – Impact**	**Risk Code**
Addition of Motor Operated Control Valves and Isolation Valves at each well pad may exceed current capacity of Motor Control Center (MCC) electric capability.	This project requires coordination with BC-MM-771 to upgrade the electric service requirements to all 3 brine disposal well pads.	High – High	High Risk Hazard
Technician lack of familiarity with the type of motor operated valve	Operator training may be required although there is a very knowledgeable and capable work force to maintain motor operated valves in this service.	Low - Low	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Install New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves at Each of the Brine Disposal Flow Lines to Each Well and Install a New Brine Pipeline Motor Operated Isolation Valve

This alternative would replace and standardize all 12 Brine Disposal Well Isolation valves, flow control valves and flow meters. Additionally, a new check valve would be included in the piping near the brine disposal wellhead to prevent reverse flow. Also included in this alternative is the installation of a new brine pipeline motor operated isolation valve.

This alternative would meet the project specific requirements and would provide flow control and isolation for each of the 12 BDWs to the Control Room Operator. This approach would provide a standardized piping arrangement for operations and maintenance purposes. This alternative would also include the reverse flow prevention check valves.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Important*	*Less Important*	*Less Important*
Alternative A	*Excellent*	*Good*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Good*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$2,261,469**	**$2,503,720**

Recommended Alternative

A. Install New Motor Operated Control Valves, Motor Operated Isolation Valves and Check Valves at Each of the Brine Disposal Flow Lines to Each Well and Install a New Brine Pipeline Motor Operated Isolation Valve

Based on the screening process led by the Core Team Members that reviewed five possible alternatives, Alternative A was the only viable alternative selected to be studied that would meet the mission need and functional requirements. Therefore, Alternative A is the recommended preferred alternative.

BC-MM-771

Upgrade Brine Disposal Well MCCs and MCC Electrical Service

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Electrical Switch Racks to Replace the Existing MCCs

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The current mission requirement for Bayou Choctaw is to meet the SPR Level I Brine Disposal rate of 110,000 barrels per day (110MBD).

Functional Requirements

The existing electrical system at each of the three brine disposal well areas consists of an incoming (commercial) power feed cable, a 480V Motor Control Center (MCC), conduit, and cable providing the electrical power for each end device. The end devices include such things as lighting, pumps, motor operated valves (MOVs), and some instrumentation.

The functional requirement for this project is to assure that safe, dependable, reliable electric power is provided at each Bayou Choctaw Brine Disposal well pad (3 each) in order to conduct brine disposal operations. Additional electric load and devices (motor operated valves and control valves) are anticipated from two separate projects (BC-MM-770 and BC-MM-1334) and the current system is not capable of providing power to the new devices. Any proposed equipment should contain the capability to provide electrical power to future, additional loads.

This Project is one component of a series of Projects to upgrade the Brine Disposal System at Bayou Choctaw in accordance with SPR Level I Criteria. Other projects that are part of the completed Brine Disposal System that are affected by this BC-MM-771 project are: BC-MM-769, 824, BC-MM-770, BC-MM-775; and BC-MM-1344. Lighting requirements for the Brine Disposal Facilities are identified in Project BC-MM-308.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Damon Bruno	DOE, Site General Engineer
Sam Washington	DOE, Lead General Engineer
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Russ Romero	FFPO, Director of Site
Samuel Gauthe	FFPO, Manager Site Operations
Marc Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance
Stacie Hess	FFPO, Principal Operational Systems Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would continue to maintain the existing electrical service as it currently is and repair or replace only upon failure. The existing equipment does not have any expansion capability and would not be able to meet the power demands of new equipment being proposed as defined in Project BC-MM-770.

Viability: No Further Analysis

B. Replace Existing MCC

This alternative would replace the existing MCCs in like kind with new current technology Motor Control Centers and associated electrical service. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the drilling and operation of additional wells as defined in Projects BC-MM-770 and BC-MM-1344. New power cables from the utility provided to each of the three MCCs would be required as a result of new, additional loads.

This alternative meets the project functional requirements and assures that reliable power isolation for all current power needs. MCCs are usually specified for known, expected loads and can generally be sized for future additional loads without significant modification.

Viability: Continue Analysis

C. Electrical Switch Racks to Replace Existing MCCs

This alternative would replace the three existing MCCs with three new, fabricated steel switch racks with the appropriate electric breakers, switches, and necessary services and the associated electrical wiring from the switch rack to the new or existing end device. New power cables from the utility provided to each of the three switch racks would be required as a result of new, additional loads. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the drilling and operation of additional wells as defined in Projects BC-MM-770 and BC-MM-1344.

Switch Racks generally provide the same function as a MCC and can be designed for all known or planned electric service needs and can be sized for future electric service. The switch rack usually contains a series of individual enclosures each of which is designed for exposure to the elements. Switch racks are usually easy to operate and maintain and are generally suitable for this installation.

Viability: Continue Analysis

D. Single Switch Rack to Replace All Three MCCs

This alternative would be to have a single switch rack in one location to provide electric power isolation to all brine disposal well devices. New power cables from the utility provided to a new switch rack would be required as a result of new, additional loads. As with Alternative C above (Electrical Switch Racks to Replace Existing MCCs)**,** the electrical service requirements are anticipated to change as a result of a separate project to install new motor operated isolation and control valves and new flow meters at each brine disposal well as defined in Projects BC-MM-770 and BC-MM-1344. The suggested location would be somewhere in the middle of the three well pads, at or near disposal well pad two and nearly equal distance to well pads 1 and 3.

This alternative would consolidate the electric service needs for all three brine disposal well pads in one location. Because of the distance between each of the well pads and the numbers and size of each cable to each of the various loads would render this approach as economically not desirable.

Viability: No Further Analysis

E. Solar Power Panel / Array for Power Generation / Augmentation

This option could be incorporated in conjunction with one of the above mentioned alternatives and would install solar power panels to produce electrical power sufficient to power up all devices or augment the utility company provided electric power. The solar power panel would be located near the switch rack or MCC (whichever alternative is selected). Each of the three brine disposal well pads have a large unobstructed area so that direct sun light is available nearly all day, year round.

This alternative does not address the project specific requirements, but could reduce the use of electric power to be purchased from the commercial utility provider.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and D are eliminated from further consideration. The remaining alternatives, B and E and C and E, are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Existing MCC

This alternative would replace the existing MCCs in like kind with new current technology Motor Control Centers and associated electrical service. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the drilling and operation of additional wells. New power cables from the utility provided to each of the three MCCs would most likely be required as a result of new, additional loads.

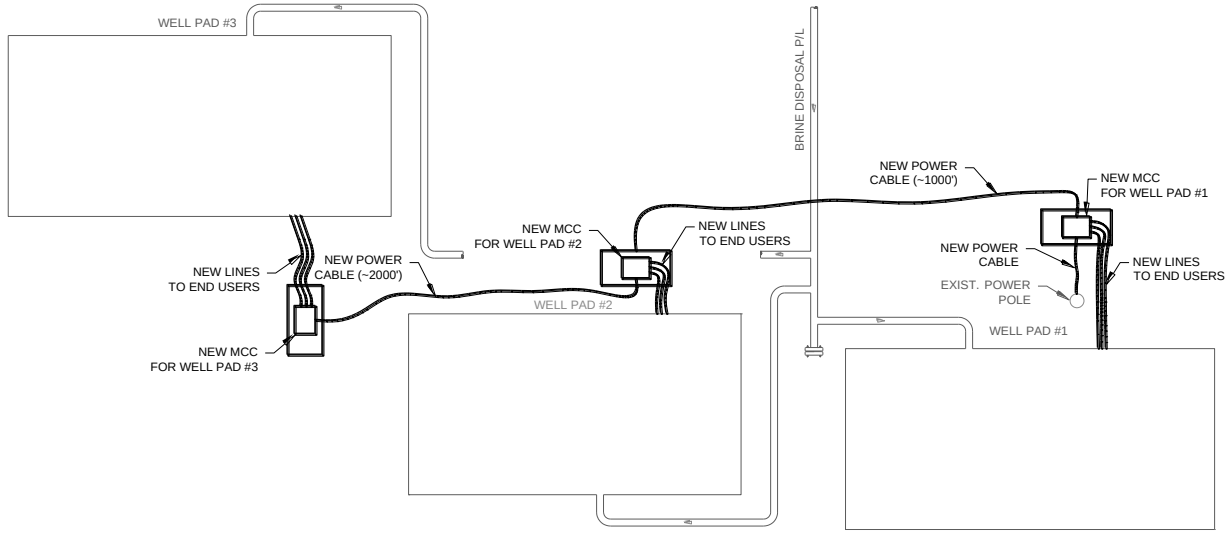

Figure 1 – Replace Existing MCCs

Assumptions & Constraints

An assumption for this project is that a Motor Control Center can be manufactured meeting the size (electric load requirements) and with the proper materials of construction to meet the outdoor installation requirements at this particular location. Additionally, this project must be coordinated with the design of Project BC-MM-770 and BC-MM-1334 to determine exactly what the electric load requirements are going to be.

Benefits & Effectiveness

This alternative would effectively support the project's functional requirements and is a technically sound method of providing the required electric power to each load device. MCCs can be manufactured / fabricated for outdoor service at this particular location. New power feeder cables are required to be installed from the utility provider to each MCC.

Reliable, dependable, electric power is required at the three Brine Disposal Well Pads in order to support the DOE oil fill / brine disposal mission. The installation of this alternative will support the brine disposal mission.

As an enhancement to this alternative, an evaluation could be conducted during detail engineering design to install solar power panels to produce electrical power to augment the utility company provided electric power. The solar power panel would be located near the MCC at each well-pad. Each of the three brine disposal well pads have a large unobstructed area so that direct sun light is available nearly all day, year round.

Detailed engineering of a new electrical power distribution scheme that takes into account the existing as well as anticipated, future loads would determine the viability of this option.

Benefits & Effectiveness

This option meets sustainability project objectives and could result in lower power costs for the operation of the brine disposal wells. The installation of this option will support the brine disposal mission

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Existing MCC

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
The selected MCC will not accommodate the known and anticipated power requirements and end devices.	This project needs to be coordinated with BC-MM-770 and BC-MM-1334 projects to determine the required number of end devices, i.e. motor operated valves, meters, pumps, lighting, rectifiers etc. for appropriate MCC size requirements.	Low – High	Low Risk Hazard
The selected MCC is unable to be placed on the existing concrete slab as the length or depth may vary from the current MCC foundation.	A new concrete or structural steel foundation may be required with new underground duct bank to get to the new MCC location.	Medium – High	Medium Risk Hazard

B. Electrical Switch Racks to Replace the Existing MCCs

This alternative would replace the three existing MCCs with three new, fabricated steel switch racks with the appropriate electric breakers, switches, and necessary services along with the associated electrical wiring from the switch rack to the new or existing end device. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the addition of new brine disposal wells. New power cables from the utility provider to each of the three switch racks would be required as a result of new, additional loads.

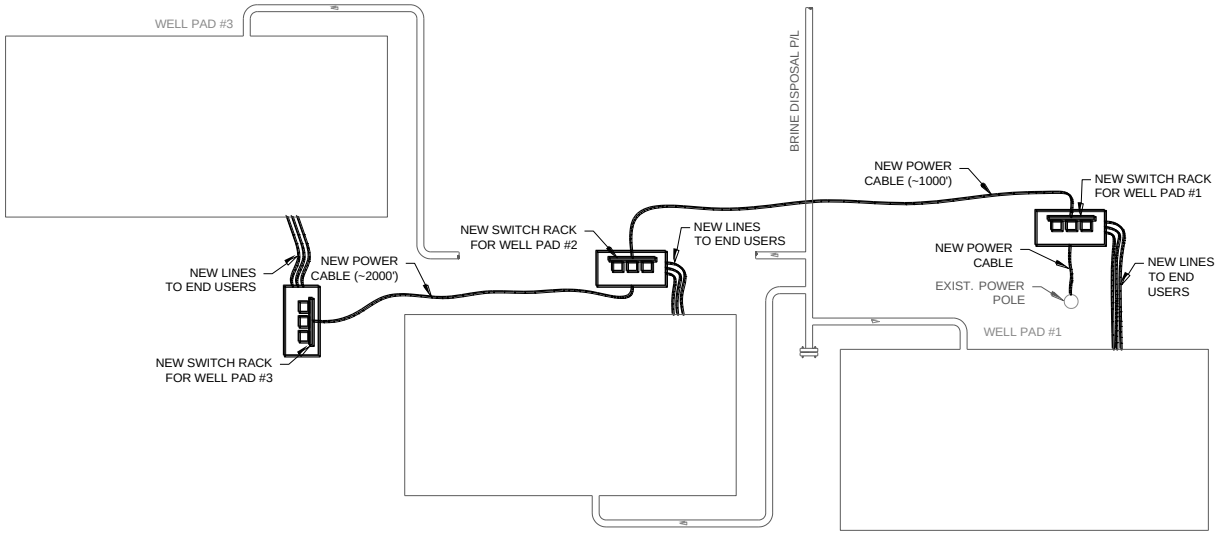

Figure 2 – Replace Existing MCCs with Switch Racks

Assumptions & Constraints

This project must be coordinated with the design of Projects BC-MM-770 and BC-MM-1334 to determine exactly what the electric load requirements are going to be.

Benefits & Effectiveness

This alternative would effectively support the project's functional requirements and is a technically sound method of providing the required electric power to each load device. Switch-racks can be manufactured / fabricated for outdoor service at this particular location. New power feeder cables are required to be installed from the utility provider to each switch-rack.

Reliable, dependable, electric power is required at the three Brine Disposal Well pads in order to support the DOE oil fill / brine disposal mission. The installation of this alternative will support the brine disposal mission.

As an enhancement to this alternative, an evaluation could be conducted during detail engineering design to install solar power panels to produce electrical power to augment the utility company provided electric power. The solar power panels would be located near the Switch Rack at each well-pad. Each of the three brine disposal well pads have a large unobstructed area so that direct sun light is available nearly all day, year round.

Detailed engineering of a new electrical power distribution scheme that takes into account the existing as well as anticipated, future loads would determine the viability of this enhancement.

Benefits & Effectiveness

This option meets sustainability project objectives and could result in lower power costs for the operation of the brine disposal wells. The installation of this option will support the brine disposal mission

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing Switch Racks to Replace Existing MCCs

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
The selected switch-rack will not accommodate the known and anticipated power requirements and end devices.	This project needs to be coordinated with the BC-MM-770 and BC-MM-1334 projects to determine the required number of end devices, i.e. motor operated valves, meters, pumps, lighting, rectifiers etc. for appropriate switch-rack size requirements.	Low – High	Low Risk Hazard
The selected switch-rack design is unable to fit on the existing concrete / structural steel pedestal as the current MCC.	A new concrete or structural steel foundation may be required with new underground duct bank to get to the new switch-rack location.	Medium – High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Existing MCC

This alternative would replace the existing MCCs in like kind with new current technology Motor Control Centers and associated electrical service. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the drilling and operation of additional wells. New power cables from the utility provided to each of the three MCCs would most likely be required as a result of new, additional loads.

B. Electrical Switch Racks to Replace the Existing MCCs

This alternative would replace the three existing MCCs with three new, fabricated steel switch racks with the appropriate electric breakers, switches, and necessary services along with the associated electrical wiring from the switch rack to the new or existing end device. The electrical service requirements are anticipated to increase as a result of two separate projects to install new motor operated isolation and control valves and new flow meters at each brine disposal well and the addition of new brine disposal wells. New power cables from the utility provider to each of the three switch racks would be required as a result of new, additional loads.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Important*	*Less Important*	*Less Important*
Alternative A	*Good*	*Adequate*	*Good*	*Adequate*	*Excellent*	*Excellent*
	Good	*Adequate*	*Good*	*Adequate*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Good*
Alternative B	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Good	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$2,321,095**	**$2,327,613**
Alternative B	**$2,422,401**	**$2,424,574**

Recommended Alternative

B. Electrical Switch Racks to Replace the Existing MCCs

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated overall higher on the evaluation criteria. Alternative A had a slightly lower initial cost and life cycle cost. Alternative B is the recommended preferred alternative based on the higher technical merits in sustainability, safety and maintenance that outweigh the slightly higher initial and life cycle costs.

BC-MM-775

Replace/Line Brine Disposal Well Branch Piping to Pads 2 & 3

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Install New Piping on Above Ground Supports

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Level I Criteria for the Bayou Choctaw SPR Site is to be capable of disposing 110,000 Barrels per day of brine. The brine disposal occurs via injection into existing brine disposal wells. A total of 12 brine disposal injection wells exist at 3 separate locations approximately 2 miles from the main site.

Brine is pumped from the main Bayou Choctaw Site through a 24-inch, HDPE lined, steel pipeline. The 24-inch line is connected to three smaller diameter, bare steel pipelines to distribute brine to 3 separate locations for injection into deep underground aquifers.

Functional Requirements

The requirement for this project is to assure that dependable, reliable, piping is in place for the capability to transfer brine to Brine Disposal well-pads 1, 2, and 3. The piping should be capable of meeting the flow and pressure requirements to support brine disposal and should be lined or coated with a non-corrosive material such that rust scale is not generated prior to entry into the disposal well. All piping in the brine disposal system between the brine ponds and brine disposal wells should be internally lined to prevent internal pipe corrosion.

This Project is one component of a series of Projects to upgrade the Brine Disposal System at Bayou Choctaw in accordance with SPR Level I Criteria. Other projects that are part of the completed Brine Disposal System that are affected by this BC-MM-775 project are: BC-MM-769, 824, BC-MM-770, BC-MM-771, and BC-MM-1344. Lighting requirements for the Brine Disposal Facilities are identified in Project BC-MM-308.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

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Russ Romero	FFPO, Site Director
Samuel Gauthe	FFPO, Manager Site Operations
Marc Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance
Chris Vedros	FFPO, Manager, Pipeline and Equipment Integrity
Kevin Williams	FFPO, Senior Site Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo alternative is to continue to operate and maintain the existing piping in a manner similar to current practice. Recent pipe integrity assessments have indicated extensive internal corrosion to the point that the pressure rating of the pipe is compromised. Continuation of this operation and maintenance approach will likely result in unexpected failures or leaks of the current piping system.

Viability: No Further Analysis

B. Replace Existing Piping

This alternative would replace the existing piping with new, lined metallic, or non-metallic piping meeting process requirements. The new piping would be designed to be corrosion resistant and would negate maintenance cost for repairs of leaks for at least 25 years. This alternative should address the piping to each of the three well pads from the end of the existing 24-inch, carbon steel, HDPE lined brine disposal pipeline and the piping between the brine pond and the brine disposal pipeline.

This alternative would result in the elimination of any rust scale that is generated on the inside of the existing uncoated piping to well pads 1, 2, and 3. In this arrangement nearly all of the piping from the pumps to the disposal wells would be lined and therefore rust scale would not be generated. This could result in being able to bypass the filters at the disposal well pads prior to injection into the brine disposal wells.

Viability: Continue Analysis

C. Install New Piping On Above Ground Supports

This alternative would be to install new piping on above ground supports. The existing piping to pad 3 and the majority of the pipe to pad 2 is above ground; however, the pipe to pad 1 is buried. In the case of pads 2 and 3, the existing supports would need to be evaluated and repaired / replaced as required. New pipe supports would be required for the piping to pad 1. The new pipe supports could be used as cable / conduit supports for electric power service to pad 1.

Any process piping that is installed on above ground supports offers the advantage of making the pipe very accessible for inspection and maintenance. Maintenance requirements would include periodic painting for external corrosion protection. Above-ground piping negates the need for reliance on a cathodic protection system to preserve the steel pipe exterior surface.

Viability: Continue Analysis

D. Install New Piping Below Ground

This alternative would be to install new piping below ground. The existing piping to pad 3 and the majority of the pipe to pad 2 is above ground; however, the pipe to pad 1 is buried. A new pipe route would need to be selected to all three well pads so that the existing pipe could remain in service while the new pipe is being installed.

Piping that is installed below ground is less accessible for inspection and maintenance; however, the need for pipe supports is negated and it is completely “out of the way”. To preserve exterior steel of the pipe, cathodic protection is required and must continue to be in place.

Viability: No Further Analysis

E. Drain, Clean, Inspect, and Repair Existing Piping

This alternative would drain, clean, and inspect the existing piping to determine the extent of condition and performs repairs / replacement as necessary. Inspection could be performed by robotic, crawler pigs with high resolution inspection results or the pipe could be subjected to a hydrostatic test to determine if the pipe would meet pressure rating requirements. As required, the defective section(s) could be repaired or replaced. In order to achieve the desired quality of inspection results, the pipe would have to be significantly clean to facilitate inspection. With the pipe in a clean, dry condition, HDPE liner could be installed in the pipe thus reducing or eliminating any source of rust scale into the brine stream upstream of the disposal well filtration system. This could result in the removal of the filtration system and all of the supporting tanks and pumps at each brine disposal well-pad.

This approach involves the need to thoroughly inspect and determine the full extent of condition via robotic inspection (non-destructive method), or conducting a hydrostatic pressure test determine if the pipe would maintain integrity at a desired or defined pressure rating. Robotic inspection pigs are very effective in this piping arrangement and this system could be taken out of service for an amount of time required to perform the cleaning, inspection, and repairs, if necessary. A hydrostatic test (in lieu of robotic inspection pigs may result in a failure of the piping and immediate pipe replacement. The section to pad 1 is buried and repairs of a failure would be costlier than repairs to either of pad 2 or 3.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, D, and E are eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Existing Piping

This alternative would replace the existing piping with new, lined metallic, or non-metallic piping meeting process requirements. The new piping would be designed to be corrosion resistant and would negate maintenance cost for repairs of leaks for at least 25 years. This alternative should address the piping to each of the three well pads from the end of the existing 24-inch, carbon steel, HDPE lined brine disposal pipeline.

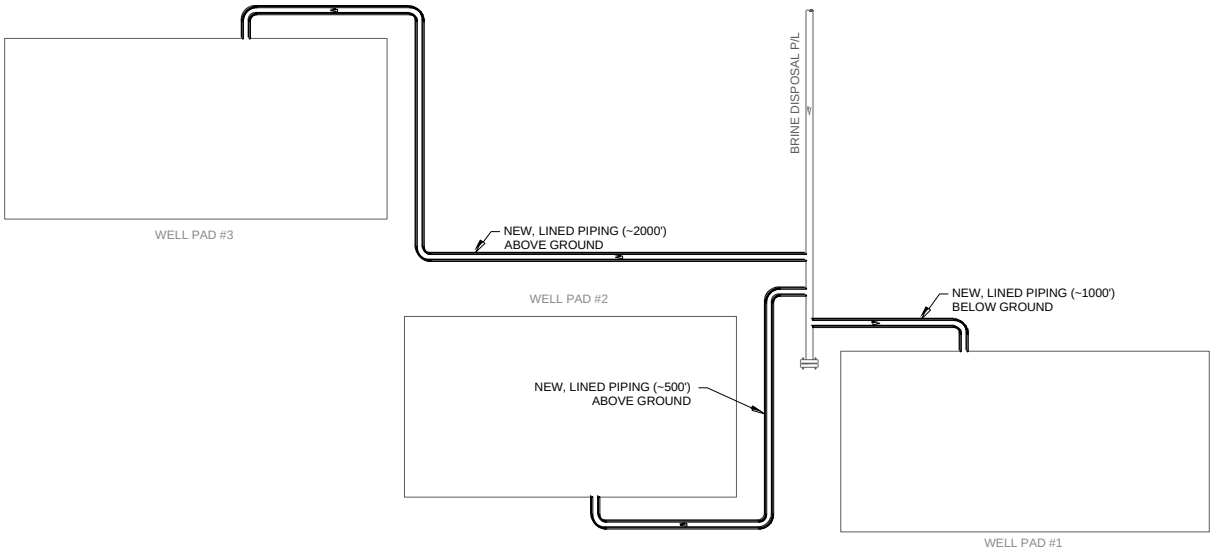

Figure 1 – Replace Exiting Piping

Assumptions & Constraints

One key assumption for this project is that the 24-inch brine disposal pipeline can be safely and effectively evacuated to allow tie-ins to be made at the end of the pipeline to replace the sections of piping going to well pads 1, 2, and 3. Evacuation of the line has successfully been performed in the past and should be able to be safely performed again. An additional assumption is that the brine disposal operations can be adequately coordinated to take the pipeline out of service for the required length of time to make the tie-ins at the end of the pipeline. Additionally, a separate project BC-MM-1297 (Replace Timber Supports) could be coordinated and implemented concurrently with the above ground pipe replacement to brine disposal well pads 2 and 3.

A potential constraint for this project, although not anticipated, is that there may be an on-going requirement to dispose of brine during the installation process.

Benefits & Effectiveness

This alternative will result in long life, dependable, brine service piping from the brine disposal pumps to the brine disposal pipeline and from the pipeline to each of the brine disposal wells 1 through 12 and would provide rust scale free brine for disposal into the disposal wells. The rust free brine stream is extremely advantageous and would be very key to maintaining unrestricted brine flow into the sub-surface brine casing and sub-surface brine aquifer.

The clean, rust scale free brine stream assures (at a minimum) that plugging or restricting of the sub-surface, perforated brine casing would be largely eliminated or at the very least, greatly reduced.

Risk & Mitigation Factors

The installation of new pipe to all three well pads would involve purchasing, fabricating, and installing new, lined, steel pipe or specifying a non-metallic pipe material meeting the engineering requirements. The tie-in to the existing pipeline would involve excavation to the existing piping and assurance of not damaging the existing pipe. Standard practice is for machine excavation where the extent of underground features are well defined and documented and for hand excavation where there is a low confidence of the presence of underground obstructions. The existing pipe would need to be drained and possibly flushed prior to disposing. If flushing would be required, there would be approximately 65,000 gallons of waste water to be dealt with.

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Existing Piping

Risks	Mitigation Strategy	Likelihood-Impact	Risk Code
Injury or damage while performing excavation to the existing brine disposal pipeline.	Machine excavation where underground features are well defined and documented. Hand excavation where there is low confidence of presence of underground obstructions.	Low – High	Low Risk Hazard
Waste water created if existing pipe needs to be drained and flushed.	Containment, collection and transporting would be required in order to properly manage the fluid in the existing piping.	High – Low	Low Risk Hazard

B. Install New Piping On Above Ground Supports

This alternative would be to install new piping on above ground supports. The existing piping to pad 3 and the majority of the pipe to pad 2 is above ground; however, the pipe to pad 1 is buried. In the case of pads 2 and 3, the existing supports would need to be evaluated and repaired / replaced as required. New pipe supports would be required for the piping to pad 1. The new pipe supports could be used as cable / conduit supports for electric power service to pad 1.

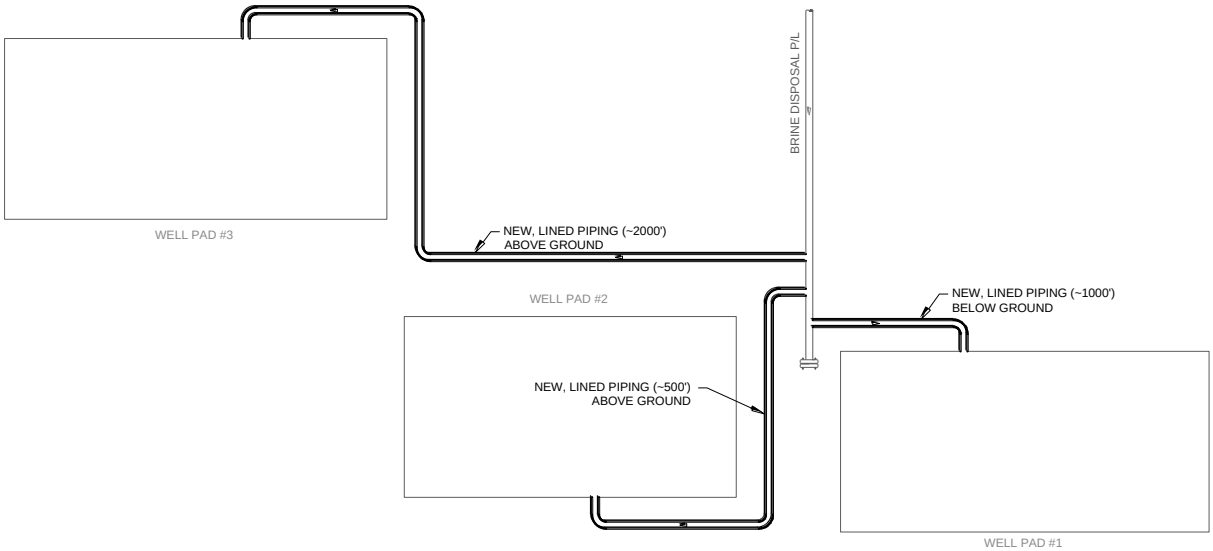

Figure 2 – Replace Exiting Piping All Above Ground

Assumptions & Constraints

One key assumption for this project is that the 24-inch brine disposal pipeline can be safely and effectively evacuated to allow tie-ins to be made at the end of the pipeline to replace the sections of piping going to well pads 1, 2, and 3. Evacuation of the line has successfully been performed in the past and should be able to be safely performed again. An additional assumption is that the brine disposal operations can be adequately coordinated to take the pipeline out of service for the required length of time to make the tie-ins at the end of the pipeline. Additionally, a separate project BC-MM-1297 (Replace Timber Supports) could be coordinated and implemented concurrently with the above ground pipe replacement to brine disposal well pads 2 and 3.

A potential constraint for this project, although not anticipated, is that there may be an on-going requirement to dispose of brine during the installation process.

Benefits & Effectiveness

This alternative will result in long life, dependable, brine service piping from the brine disposal pipeline to each of brine disposal well pads 1, 2, and 3 and would provide rust scale free brine for disposal into the disposal wells. The rust free brine stream is extremely advantageous and would be very key to maintaining unrestricted brine flow into the sub-surface brine casing and sub-surface brine aquifer.

The clean, rust scale free brine stream assures (at a minimum) that plugging or restricting of the sub-surface, perforated brine casing would be largely eliminated or at the very least, greatly reduced.

Risk & Mitigation Factors

Of the several thousand feet of pipe to be replaced, approximately 70% of the existing pipe is currently above ground and there would be no excavation required for the replacement. The remaining pipe is buried and would be abandoned in place if new pipe supports were built. The new pipe supports would involve clearing of an approximate 1,500-foot-long right of way and crossing of another pipeline operator right of way. The design and installation of the portion of the new piping to brine disposal well pad 1 would need to be coordinated with a 3rd party pipeline operator. This portion may indeed be underground. The existing and any new above ground pipe supports would also provide a route for new, replacement electric power cable service as part of the BC-MM-771 project. Additionally, this project should be worked in conjunction with Project BC-MM-770 which replaces the valves and meters to each brine disposal well head and could include the installation of lined piping to each brine disposal well head.

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing New Piping On Above Ground Supports

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Injury or damage while performing excavation to the existing brine disposal pipeline.	Machine excavation where underground features are well defined and documented. Hand excavation where there is low confidence of presence of underground obstructions.	Low – High	Low Risk Hazard
Waste water created if existing pipe needs to be drained and flushed.	Containment, collection and transporting would be required in order to properly manage the fluid in the existing piping.	High – Low	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Existing Piping

This alternative would replace the existing piping with new, lined, metallic or non-metallic piping meeting process requirements. The new piping would be designed to be corrosion resistant and would negate maintenance cost for repairs of leaks for at least 20 years. This alternative should address the piping to each of the three well pads from the end of the existing 24-inch, carbon steel, HDPE lined brine disposal pipeline.

B. Install New Piping on Above Ground Supports

This alternative would be to install new piping on above ground supports. The existing piping to pad 3 and the majority of the pipe to pad 2 is above ground; however, the pipe to pad 1 is buried. In the case of pads 2 and 3, the existing supports would need to be evaluated and repaired / replaced as required. New pipe supports would be required for the piping to pad 1. The new pipe supports could be used as cable / conduit supports for electric power service to pad 1.

Comparison of Alternatives

Core Team Member Ratings:

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Good*	*Good*	*Good*	*Good*	*Excellent*	*Excellent*
	Good	*Good*	*Good*	*Good*	*Excellent*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Good*	*Good*
Alternative B	*Good*	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$6,541,331**	**$6,781,036**
Alternative B	**$7,470,383**	**$7,834,535**

Recommended Alternative

B. Install New Piping on Above Ground Supports

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated overall higher on the evaluation criteria. The initial cost and life cycle cost of Alternatives A was lower than Alternative B. Alternative B is the recommended preferred alternative based on technical evaluation merits that outweigh the initial and life cycle cost increase over Alternative A.

BC-MM-810

Replace Site Emergency Generator

VCI Project Engineer: Brian Tuminello

Recommended Go Project:

Conduct a Thorough Load Analysis of Site Critical Loads and Install a New Generator to Meet the Critical Load Requirements

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Bayou Choctaw Site is designed to be powered by electric power from the local, commercial utility service provider. In the event of loss of commercial power, the Bayou Choctaw site (as well as all SPR Sites) is provided with an emergency generator that will start upon loss of commercial power and provide electric power to all site buildings and pre-identified critical areas / equipment.

Functional Requirements

The functional requirement for this project is to provide a dependable, reliable, appropriately sized emergency generator to provide electric power to all buildings and critical equipment and areas in the event of loss of commercial power. The current generator is fueled by diesel fuel and since there is no existing proximity to an alternate fuel source (i.e. natural gas or propane) any new, future generators will continue to be fueled by diesel.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for Go/No Go Projects has been standardized for all Go/No Go AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Damon Bruno	DOE, Site General Engineer
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Marc Gross	FFPO, Manager Design Engineering
Russ Romero	FFPO, Site Director
Samuel Gauthe	FFPO, Manager Site Operations
Marc Blouin	FFPO, Manager Site Construction
Larry Martinez	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

Formal selection criteria will not be applicable in a Go/No Go Project.

IV. ALTERNATIVES IDENTIFICATION

Alternatives Identification is not applicable in a Go/No-Go Project. However, in order to ensure there were no additional alternatives worth further study, the team briefly considered the below alternatives.

A. Status Quo

The current approach is to conduct periodic testing on the generator and identify and make necessary repairs as required.

This alternative does not address the age and condition and only addresses identified or discovered repair requirements.

Viability: No Further Analysis

B. Replace Existing Generator In Kind, Continue to Provide Generator Power to Existing Electric Load and Re-Use Existing Fuel Source

This alternative would replace the existing 480V, 3 phase, 750 KVA, diesel fueled generator in kind and power up the existing electrical load. If required, a new Automatic Transfer Switch would become part of the installation; however, this is not anticipated. The generator could be installed in the same location as the current generator and connected to the existing fuel source.

This approach would not address the revalidation of the current / required loads and would result in the purchase and installation of perhaps an improperly sized piece of equipment.

Viability: No Further Analysis

C. Conduct a Thorough Load Analysis of Site Critical Loads and Install a New Generator to Meet the Critical Load Requirements

This alternative would be to coordinate with the site operator and conduct a table top review to determine if the existing load on the generator is appropriate or if electrical load needs to be added or deleted. The load determination would provide the generator specification to determine the proper rating and voltage. It is assumed that the existing generator concrete foundation is adequate for the new generator and that the fuel source (diesel) is adequately sized to support the new generator. This includes the size of the fuel tank and the pipe size that delivers fuel to the tank.

This alternative employs a “needs based” approach to assure the equipment to be purchased and installed will perform the mission as it is intended to do.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and B are eliminated from further consideration. The remaining alternative, C is examined below as alternative A.

The below analysis provides the research and technical information gathered by the AoA Team. This analysis is not evaluative or comparative.

A. Conduct a Thorough Load Analysis of Site Critical Loads and Install a New Generator to Meet the Critical Load Requirements

This alternative would be to coordinate with the site operator and conduct a table top review to determine if the existing electrical loads on the generator meet requirements or if electrical loads need to be added or deleted. An increase in load is not anticipated; however, a thorough load analysis will allow for proper sizing and selection of a new generator. (If the load analysis indicates that a larger generator is required resulting in increased air emissions, the BC air permit will need to be revised.) It is assumed that the existing generator concrete foundation is adequate for the new generator and that the fuel source (diesel) is adequately sized to support the new generator. This includes the size of the fuel tank and the pipe size that delivers fuel to the tank. For estimating purposes, it is assumed that the new generator will not exceed 750 kVA.

VI. ALTERNATIVE SELECTION

Recommended Go Project

A. Conduct a Thorough Load Analysis of Site Critical Loads and Install a New Generator to Meet the Critical Load Requirements

This alternative would be to coordinate with the site operator and conduct a table top review to determine if the existing electrical loads on the generator meet requirements or if electrical loads need to be added or deleted. An increase in load is not anticipated; however, a thorough load analysis will allow for proper sizing and selection of a new generator. It is assumed that the existing generator concrete foundation is adequate for the new generator and that the fuel source (diesel) is adequately sized to support the new generator. This includes the size of the fuel tank and the pipe size that delivers fuel to the tank. For estimating purposes, it is assumed that the new generator will not exceed 750 kVA

Cost

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$1,070,929**	**$1,098,089**