Long-Term Strategic Review of the U.S. Strategic Petroleum Reserve

Report to Congress
August 2016

United States Department of Energy
Washington, D.C. 20585

Message from the Secretary

Section 402 of the Bipartisan Budget Act of 2015 (Public Law 114-74), requires the Secretary of Energy to complete a long-term strategic review of the U.S. Strategic Petroleum Reserve and develop and submit to Congress a proposed action plan, including a proposed implementation schedule. The Department of Energy carried out the review required by the Act starting in May 2015 with completion in August 2016.

This report is being provided to the President and the following Members of Congress:

- **The Honorable Joseph R. Biden, Jr.**
  President of the Senate

- **The Honorable Paul D. Ryan**
  Speaker of the House

- **The Honorable Thad Cochran**
  Chairman, Senate Committee on Appropriations

- **The Honorable Barbara A. Mikulski**
  Vice Chairwoman, Senate Committee on Appropriations

- **The Honorable Lamar Alexander**
  Chairman, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations

- **The Honorable Dianne Feinstein**
  Ranking Member, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations

- **The Honorable Michael B. Enzi**
  Chairman, Senate Committee on Budget

- **The Honorable Bernie Sanders**
  Ranking Member, Senate Committee on Budget

- **The Honorable Lisa Murkowski**
  Chairwoman, Senate Committee on Energy and Natural Resources

- **The Honorable Maria Cantwell**
  Ranking Member, Senate Committee on Energy and Natural Resources

- **The Honorable Harold Rogers**
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- **The Honorable Nita M. Lowey**
  Ranking Member, House Committee on Appropriations

- **The Honorable Mike Simpson**
  Chairman, Subcommittee on Energy and Water Development
  House Committee on Appropriations

- **The Honorable Marcy Kaptur**
  Ranking Member, Subcommittee on Energy and Water Development
  House Committee on Appropriations

- **The Honorable Tom Price**
  Chairman, House Committee on the Budget

- **The Honorable Chris Van Hollen**
  Ranking Member, House Committee on the Budget

- **The Honorable Fred Upton**
  Chairman, House Committee on Energy and Commerce

- **The Honorable Frank Pallone, Jr.**
  Ranking Member, House Committee on Energy and Commerce

- **The Honorable Ed Whitfield**
  Chairman, Subcommittee on Energy and Power
  House Committee on Energy and Commerce

- **The Honorable Bobby L. Rush**
  Ranking Member, Subcommittee on Energy and Power
  House Committee on Energy and Commerce

If you have any questions or need additional information, please contact me or Mr. Brad Crowell, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerelv.

Ernest J. Moniz

EXECUTIVE SUMMARY

INTRODUCTION AND SYNOPSIS

The mission of the Strategic Petroleum Reserve (SPR) is to protect the United States (U.S.) from severe petroleum supply interruptions through the acquisition, storage, distribution, and management of emergency petroleum stocks and to carry out U.S. obligations under the International Energy Program. The Long-Term Strategic Review (LTSR) provides an overview of the SPR and addresses key challenges that will impact the SPR's ability to carry out its energy security mission. As expanding North American crude oil production has substantially reduced waterborne imports into the United States and changed the flow of petroleum, numerous questions have arisen about the future of the SPR. While the threat of physical supply disruptions to the United States has diminished, the country remains connected to the global oil market through the price mechanism and its economy remains vulnerable to supply disruption induced oil price shocks.

Major topics examined in this report include the state of the SPR's surface and subsurface infrastructure, bottlenecks in the North American midstream infrastructure that impact the SPR's ability to move oil to the market, a discussion of some of the costs and benefits of SPR options, SPR modernization requirements for infrastructure life extension and the addition of dedicated marine terminals, and issues with the SPR's authorizing legislation, the Energy Policy and Conservation Act (EPCA). These areas are evaluated with consideration given to the Bipartisan Budget Act of 2015 and the Fixing America's Surface Transportation (FAST) Act, which mandate the sale of an estimated 124 million barrels (MMbbl) of the SPR's crude oil inventory and authorize the funding of an SPR modernization program through the sale of up to an additional $2 billion worth of oil.

To address the myriad topics relevant to the SPR strategy, the Department of Energy (DOE) sponsored studies by outside experts in fields including engineering, geology, petroleum logistics, economics, and geopolitics, among others. This review synthesizes these input projects and presents conclusions that will help inform decisions about the SPR going forward.

OUTLINE OF THE REPORT

Chapter 1 provides a review of the SPR (including the Northeast Gasoline Supply Reserve [NGSR] component), which encompasses its history, role, legal framework, infrastructure, organizational structure, and release authorities. It also presents an introduction to the Northeast Home Heating Oil Reserve (NEHHOR).

Chapter 2 provides a more detailed description and analysis of the SPR surface and subsurface infrastructure, and the associated challenges related to the condition of physical assets and operational reliability. A large portion of the SPR's surface infrastructure has exceeded its design life and is in need of life extension. This need for infrastructure life extension, coupled with increasing deferments of major maintenance projects, has resulted in an increasing number of significant equipment failures that have adversely impacted the Reserve's operational readiness capability. The chapter also discusses ongoing subsurface challenges such as cavern creep, ullage requirements, issues with single-cycle drawdown caverns, inventory availability, and storage capacity.

Chapter 3 reviews the overall SPR distribution system, including the physical systems, capabilities, and changes and constraints within the system which, under certain scenarios, impact the ability of the SPR to meet distribution requirements during global oil disruptions. Although the SPR maintains connectivity to major pipelines and terminals, in certain cases the Reserve can no longer bring oil to market without disturbing commercial oil flows. This chapter discusses a DOE-sponsored analysis of the SPR's effective distribution capability (the ability to bring oil to the market without impacting domestic oil flows) and makes clear the need for additional marine distribution capacity.

Chapter 4 discusses some of the costs and benefits of various SPR options. The chapter first addresses the potential impact of projected changes in the world oil market on the SPR. This includes a discussion of the relevant implications of oil market projections in the U.S. Energy Information Administration's (EIA) 2015 *Annual Energy Outlook (AEO)* and a summary of a DOE-sponsored study on world oil market risk. The chapter then reviews the logic, assumptions, and results of a simulation model that quantifies the economic benefits of the SPR in terms of avoided import costs and gross domestic product (GDP) loss. Among other things, the model's results make clear that reducing the SPR's inventory below the levels dictated by the upcoming mandated and authorized sales would reduce the expected economic benefits of the SPR; that rebuilding the SPR's inventory might not be economically justified; and that the economic case for enhancing the SPR's distribution capability is strong. The chapter closes with a discussion of the geostrategic benefits of the SPR.

Chapter 5 reviews the SPR modernization program and the associated legislative authority, funding requirements, and impacts. This includes a discussion of both the SPR's Life Extension II project and the Marine Terminal Distribution Capability Enhancements project, which are authorized to be funded through the sale of SPR crude oil. Along with reviewing the scope and timeline for each project, the chapter discusses the merits for SPR modernization set forth in the Quadrennial Energy Review (QER).

Chapter 6 provides an overview of the legal authorities which provide direction for the operation, maintenance, release, and distribution of SPR crude oil. It also highlights ways in which EPCA could be amended to improve the efficient functioning of the SPR program. Specifically, the chapter highlights revisions to SPR release authorities recommended by the QER that directly impact the ability to respond to an emergency supply interruption in a timely and effective manner.

Chapter 7 summarizes the results from the various studies and offers key findings, discussed below.

KEY FINDINGS

1. *The SPR's aging surface infrastructure will begin to fundamentally compromise the Reserve's capabilities. Investing in a second Life Extension project is essential to ensure the long-term integrity of SPR assets and the ability of the program to carry out its mission.*

2. *Expanding North American oil production and the resulting shifts in U.S. midstream infrastructure have in some cases reduced the SPR's ability to add incremental barrels of oil to the market in the event of an oil supply crisis. The addition of dedicated marine terminals will significantly enhance the Reserve's effective distribution capability.*

3. *The SPR is projected to provide substantial benefits to the national economy over the next 25 years and inventory reductions beyond those mandated in Section 403 of the Bipartisan Budget Act of 2015 and Section 32204 of the FAST Act and those authorized in section 404 of the Bipartisan Budget Act of 2015 will compromise its ability to do so. Determining whether such further reductions are appropriate would require a fuller analysis of costs and benefits.*

4. *The SPR's continually shrinking storage capacity will be able to accommodate the inventory levels mandated and authorized by the upcoming crude oil sales associated with Sections 403 and 404 of the Bipartisan Budget Act of 2015 and Section 32204 of the FAST Act, but significant inventory additions would require the development of new storage.*

5. *Operational requirements dictate that the SPR maintain its current four-site configuration.*

6. *Amending limited, discrete sections of EPCA would result in improvements and efficiencies to management and operating authorities governing the SPR and NEHHOR.*

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INTRODUCTION AND LEGISLATIVE LANGUAGE

Section 402 of the Bipartisan Budget Act of 2015 requires the Secretary of Energy to complete a long-term strategic review of the United States Strategic Petroleum Reserve (SPR) within 180 days after enactment of the Act and develop and submit to Congress a proposed action plan, including a proposed implementation schedule.

Additionally, three provisions of law enacted in November and December 2015 directly impact the SPR over the next decade and beyond:

- **Section 403 of the Bipartisan Budget Act of 2015** requires that the Secretary of Energy (hereinafter "the Secretary") drawdown and sell a total of 58 million barrels (MMbbl) of crude oil from the SPR over eight consecutive years, commencing in Fiscal Year (FY) 2018 and continuing through FY 2025.

  DRAWDOWN AND SALE.—Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), except as provided in subsection (b), the Secretary of Energy shall drawdown and sell—
  5,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2018;
  5,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2019;
  5,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2020;
  5,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2021;
  8,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2022;
  10,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2023;
  10,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2024; and
  10,000,000 barrels of crude oil from the Strategic Petroleum Reserve during fiscal year 2025.
  EMERGENCY PROTECTION.—The Secretary shall not drawdown and sell crude oil under this section in amounts that would limit the authority to sell petroleum products under section 161(h) of the Energy Policy and Conservation Act (42 U.S.C. 6241(h)) in the full amount authorized by that subsection.
  PROCEEDS.—Proceeds from a sale under this section shall be deposited into the general fund of the Treasury during the fiscal year in which the sale occurs.

- **Section 404 of the Bipartisan Budget Act of 2015** authorizes the Secretary to sell up to $2 billion worth of crude oil between FY 2017 and FY 2020 to fund a modernization program for the SPR.

  (a) ESTABLISHMENT.—There is hereby established in the Treasury of the United States a fund to be known as the Energy Security and Infrastructure Modernization Fund (referred to in this section as the ''Fund''), consisting of— (1) collections deposited in the Fund under subsection (c); and (2) amounts otherwise appropriated to the Fund.
  (b) PURPOSE.—The purpose of the Fund is to provide for the construction, maintenance, repair, and replacement of Strategic Petroleum Reserve facilities.
  (c) COLLECTION AND DEPOSIT OF SALE PROCEEDS IN FUND.— (1) DRAWDOWN AND SALE.—Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), to the extent provided in advance in appropriation Acts, the Secretary of Energy shall drawdown and sell crude oil from the Strategic Petroleum Reserve in amounts as authorized under subsection (e), except as provided in paragraph (2). Amounts received for a sale under this paragraph shall be deposited into the Fund during the fiscal year in which the sale occurs. Such amounts shall remain available in

the Fund without fiscal year limitation. (2) EMERGENCY PROTECTION.—The Secretary shall not drawdown and sell crude oil under this subsection in amounts that would limit the authority to sell petroleum products under section 161(h) of the Energy Policy and Conservation Act (42 U.S.C. 6241(h)) in the full amount authorized by that subsection.
(d) AUTHORIZED USES OF FUND.— (1) IN GENERAL.—Amounts in the Fund may be used for, or may be credited as offsetting collections for amounts used for, carrying out the program described in paragraph (2)(B), to the extent provided in advance in appropriation Acts. (2) PROGRAM TO MODERNIZE THE STRATEGIC PETROLEUM RESERVE.— (A) FINDINGS.—Congress finds the following: (i) The Strategic Petroleum Reserve is one of the Nation's most valuable energy security assets. (ii) The age and condition of the Strategic Petroleum Reserve have diminished its value as a Federal energy security asset. (iii) Global oil markets and the location and amount of United States oil production and refining capacity have dramatically changed in the 40 years since the establishment of the Strategic Petroleum Reserve. (iv) Maximizing the energy security value of the Strategic Petroleum Reserve requires a modernized infrastructure that meets the drawdown and distribution needs of changed domestic and international oil and refining market conditions. (B) PROGRAM.—The Secretary of Energy shall establish a Strategic Petroleum Reserve modernization program to protect the United States economy from the impacts of emergency product supply disruptions. The program may include— (i) operational improvements to extend the useful life of surface and subsurface infrastructure; (ii) maintenance of cavern storage integrity; and (iii) addition of infrastructure and facilities to optimize the drawdown and incremental distribution capacity of the Strategic Petroleum Reserve.
(e) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated (and drawdowns and sales under subsection (c) in an equal amount are authorized) for carrying out subsection (d)(2)(B), $2,000,000,000 for the period encompassing fiscal years 2017 through 2020.
(f) TRANSMISSION OF DEPARTMENT BUDGET REQUESTS.—The Secretary of Energy shall prepare and submit in the Department's annual budget request to Congress— (1) an itemization of the amounts of funds necessary to carry out subsection (d); and (2) a designation of any activities thereunder for which a multiyear budget authority would be appropriate.
(g) SUNSET.—The authority of the Secretary to drawdown and sell crude oil from the Strategic Petroleum Reserve under this section shall expire at the end of fiscal year 2020.

- **Section 32204 of the Fixing America's Surface Transportation Act**, also known as the FAST Act (Public Law 114-94), requires the Secretary to drawdown and sell a total of 66 MMbbl of crude oil from the SPR over three consecutive years, commencing in FY 2023 and continuing through FY 2025.

(a) DRAWDOWN AND SALE.— (1) IN GENERAL.—Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), except as provided in subsections (b) and (c), the Secretary of Energy shall drawdown and sell from the Strategic Petroleum Reserve— (A) the quantity of barrels of crude oil that the Secretary of Energy determines to be appropriate to maximize the financial return to United States taxpayers for each of fiscal years 2016 and 2017; (B) 16,000,000 barrels of crude oil during fiscal year 2023; (C) 25,000,000 barrels of crude oil during fiscal year 2024; and (D) 25,000,000 barrels of crude oil during fiscal year 2025. (2) DEPOSIT OF AMOUNTS RECEIVED FROM SALE.—Amounts received from a sale under paragraph (1) shall be deposited in the general fund of the Treasury during the fiscal year in which the sale occurs.

(b) EMERGENCY PROTECTION.—The Secretary shall not drawdown and sell crude oil under this section in quantities that would limit the authority to sell petroleum products under section 161(h) of

the Energy Policy and Conservation Act (42 U.S.C. 6241(h)) in the full quantity authorized by that subsection.

(c) INCREASE; LIMITATION.— (1) INCREASE.—The Secretary of Energy may increase the drawdown and sales under subparagraphs (A) through (I) of subsection (a)(1) as the Secretary of Energy determines to be appropriate to maximize the financial return to United States taxpayers. (2) LIMITATION.—The Secretary of Energy shall not drawdown or conduct sales of crude oil under this section after the date on which a total of $6,200,000,000 has been deposited in the general fund of the Treasury from sales authorized under this section.

The volume of crude oil sold under Section 404 will vary based on the market price for crude oil. The volume could be as high as 80 MMbbl with an average crude oil price of $25/barrel (bbl), 50 MMbbl at $40/bbl, 33.3 MMbbl at $60/bbl, or 26.7 MMbbl at $75/bbl.

REPORT CONTEXT

More than a dozen major studies have estimated the optimal size of the SPR since 1974. The most sophisticated studies, the most recent of which was conducted in 2006, attempt to quantify the net economic benefits of strategic oil stockpiles based on probabilistic assessments of averted gross domestic product (GDP) losses stemming from oil market risk.

The outlook for U.S. and world energy markets has changed dramatically since 2006. A confluence of market, geopolitical, and operational issues has significantly altered the parameters that will influence the future performance of the SPR. The significant growth in U.S. oil production due to light tight oil development has increased pipeline and marine vessel utilization in the Gulf Coast region. This limits the ability of the SPR to distribute crude, without disrupting commercial business, and to provide incremental supply into the market in certain crises. Further, the SPR's surface and subsurface infrastructure requires substantial upgrades or replacement to remain effective, and available cavern storage capacity will decrease over time.

The DOE Inspector General's Office, in July 2014, and the Government Accountability Office (GAO), in September 2014, made recommendations that a long-term strategic review of the SPR should be developed looking forward to 2040. In testimony before the Senate Committee on Energy and Natural Resources (October 6, 2015), Secretary of Energy Ernest Moniz emphasized the need for a review of the SPR to address key issues, such as life extension of key infrastructure and modernization of the SPR's distribution capability.

The current Long-Term Strategic Review (LTSR) is broader in scope than the prior studies, and addresses potential investments to extend the SPR's infrastructure design life and ensure that distribution capability exists to meet obligations.

CHAPTER – 1 OVERVIEW

1.1 INTRODUCTION

The mission of the United States (U.S.) Department of Energy's (DOE) Office of Petroleum Reserves (OPR) is to protect the United States from severe petroleum supply interruptions through the acquisition, storage, distribution, and management of emergency petroleum stocks, and to carry out U.S. obligations under the International Energy Program (IEP). In support of this mission, the OPR manages the Strategic Petroleum Reserve (SPR), which consists of 695 million barrels (MMbbl) of crude oil, the 1 MMbbl Northeast Gasoline Supply Reserve (NGSR; a part of the SPR), and the Northeast Home Heating Oil Reserve (NEHHOR), which consists of 1 MMbbl of ultra-low sulfur distillate (ULSD).

This chapter presents an overview of the SPR, including its history, role, organization, international context, legal framework, infrastructure, and operations. It also provides an overview of the NEHHOR and NGSR.

1.2 STRATEGIC PETROLEUM RESERVE

The need for a strategic oil reserve was discussed for decades prior to the establishment of the SPR. The SPR is the largest government-owned oil stockpile in the world. This asset, which anchors the world's collective energy security system, comprises four underground storage sites located along the Gulf Coast in Texas and Louisiana.

History and Role of the SPR

History

From October 1973 to March 1974, the Organization of Arab Petroleum Exporting Countries (OAPEC) imposed an oil embargo due to U.S. support of Israel during the Yom Kippur War of October 1973. In response, the United States Congress passed, and President Gerald R. Ford signed, EPCA in December 1975. Among other initiatives, it authorized the establishment of the SPR and called for a stockpile of petroleum that could mitigate the economic damage of disruptions. It also specified the SPR-related authorities of the Administrator of the Federal Energy Administration (FEA) (transferred in 1977 to the Secretary of Energy), including the details of oil acquisition and certain characteristics of the SPR, as well as U.S. participation in the International Energy Agency (IEA).

At that time, an analysis of the U. S. refining industry indicated there was sufficient domestic capacity to satisfy the majority of U.S. demand for refined petroleum products; however, the nation was dependent on crude oil imports. Crude oil storage also afforded flexibility to meet specific potential refined product emergencies, given the substantial refining capacity located in the Gulf Coast. The FEA, DOE's predecessor agency, conducted studies to determine the optimum crude oil storage level and, based on 1974–1975 import levels, recommended a reserve of 500 MMbbl. Anticipating that consumption and imports of petroleum would increase over time, Congress through EPCA, authorized an SPR size of up to 1 billion barrels (Bbbl), with an initial size target of 500 MMbbl.

EPCA also required the Administration to prepare and submit to Congress a Strategic Petroleum Reserve Plan that would justify major design features. The Plan was submitted to Congress in 1977. The Plan recommended storage sites along the United States Gulf Coast, based on the availability of secure underground salt domes that offered less expensive storage options than the above-ground storage options in other regions, access to major refining centers, and pipelines to Midwest refiners. Storage of the crude oil was envisioned to occur in multiple phases.

For Phase I storage, 150 MMbbl of storage capacity was created through the conversion of existing commercially operated storage caverns used for the storage of non-petroleum products. To accomplish this, the federal government acquired several existing Gulf Coast salt caverns in April 1977 at Bryan Mound, West Hackberry, and Bayou Choctaw to serve as the first storage sites. Construction of facilities began in June 1977. In September 1977, the Weeks Island storage site was acquired. This was followed by the acquisition of land in July 1978 that became the St. James Marine terminal, and the acquisition of the Sulphur Mines storage site in 1979. Phase I storage was completed in September 1980. In order to increase the SPR's storage capacity to 500 MMbbl, Phase II storage, consisting of the creation of 29 new storage caverns at the existing sites, was completed in 1986. This was followed by Phase III storage, which completed current storage development with the completion of the Big Hill storage site in 1991. Both the Sulphur Mines (1992) and Weeks Island (1996) storage sites were subsequently decommissioned.

On July 21, 1977, the first shipment of approximately 412,000 bbl of Saudi Arabian light crude was delivered to the SPR. Over the next 13 years, the crude oil inventory level reached approximately 585 MMbbl (Figure 1) and was maintained around this level through the end of the 1990s. During the George W. Bush Administration, the inventory level was increased by using oil from the royalty-in-kind program, through which oil was acquired by DOE in lieu of cash royalties paid on production from the federal Outer Continental Shelf (OCS).[1] The SPR reached its highest inventory level of 727 MMbbl in 2009.

After Congress passed the Energy Policy Act of 2005 (EPAct) (Public Law 109-58), which directed DOE to expand the SPR to its authorized 1 Bbbl capacity as soon as practicable, DOE developed a plan to increase the storage capacity level and a site selection process was conducted. However, the President's FY 2011 budget request to Congress proposed cancellation of previously appropriated expansion funds. The project was subsequently terminated with no additional expansion. Today, the SPR's crude oil design storage capacity stands at 713.5 MMbbl,[2] with a crude oil inventory level of 695.1 MMbbl.

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[1] The royalty-in-kind program, which was carried out with the U.S. Department of the Interior, applied to oil owed to the U.S. government by producers who operate leases on the federally owned Outer Continental Shelf. The producers were required to provide from 12.5% to 16.7% of the oil they produced to the U.S. government. Under the royalty-in-kind program, the federal government could either acquire the oil itself or receive the equivalent dollar value. See Bamberger, Robert. (August 18, 2009). *The Strategic Petroleum Reserve: History, Perspectives, and Issues*. U.S. Congressional Research Service Report. Congress repealed RIK authority in P.L. 113-67.

[2] Two SPR caverns (Bryan Mound Cavern 2 and West Hackberry Cavern 6) with a combined design storage capacity of 13.5 MMbbl were taken out of service due to operational issues in 2014.

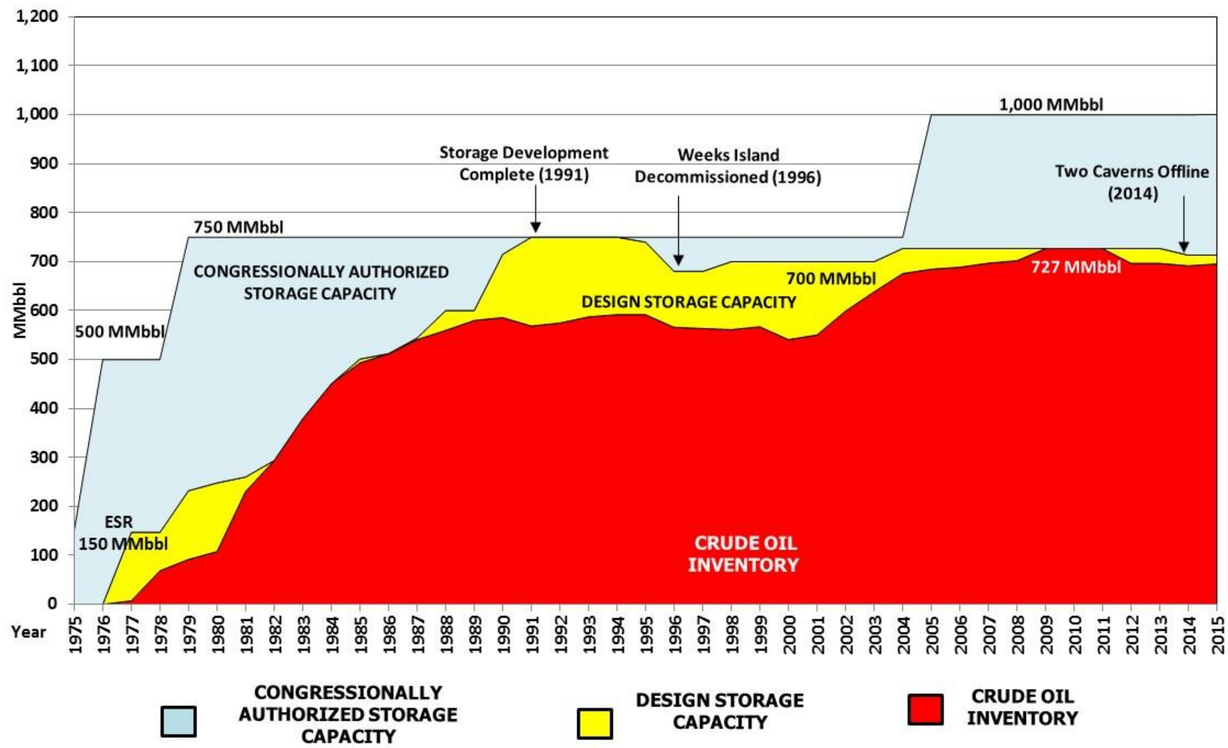

Figure 1: SPR Development and Fill History

SPR Role

The SPR remains the nation's flagship energy security asset, even as the nature of energy security evolves. The United States and global oil markets have changed the environment in which the SPR operates. When the SPR was established, U.S. oil production was in decline and oil price and allocation controls separated the U. S. oil market from the rest of the world. At the time, a truly global commodity market for oil, as we know it today, did not exist. Although U.S. oil production has dramatically increased since the 1970s, the global oil market is the largest and most liquid commodity market in the world, and price controls no longer shield U.S. consumers from fluctuations in the global price.

The original 1970s-era goal of EPCA focused on avoiding "national energy supply shortages." A loss of supply to U.S. refineries is no longer the singular focus of the SPR. Because the United States is linked to the global market, it is exposed to global price spikes. When global oil prices spike, U.S. oil prices spike. Regardless of U.S. oil import levels, a severe global oil supply disruption today would impact domestic petroleum product prices, whether or not U.S. refineries import crude oil from the disrupted countries. These supply linked price shocks, which could significantly affect the American economy, are the focus of the SPR's contemporary mission. In the event of a serious international oil supply disruption, commercial stocks and global spare capacity could provide some relief for lost output, but cannot provide assured additional supply. Offsetting a significant share of lost supplies with SPR oil, in concert with other countries that hold strategic and commercial reserves, can help reduce the sharp increase of international oil prices and the resulting adverse economic impacts that could otherwise occur.

1.2.1 Legal Framework

Domestic

EPCA provides for the creation of a Strategic Petroleum Reserve capable of reducing the impact of severe energy supply interruptions. The legislation lays out the authorities for establishing the SPR and its current configuration and describes the petroleum product to be stored and the conditions and processes for drawdown and sales from the Reserve. Section 167 of EPCA authorizes the original Congressional funding of the SPR and also authorized the establishment of the SPR Petroleum Account, which is funded in part by mandatory budget authority created by SPR emergency sales receipts. In 1990, Congress amended EPCA to provide the President with limited drawdown authority[3] should a circumstance emerge that constitutes, or is likely to become, a domestic *or international* energy supply shortage of significant scope or duration. The amendments were made permanent through additional amendments to EPCA in 2005.[4]

International

One of the SPR's core missions is to carry out U.S. obligations under the IEP, the 1974 treaty that established the IEA. Initially, the intention of the IEP was that members would share oil stocks with one another in the event of a supply crisis. Under the Coordinated Emergency Response Mechanism (CERM), adopted in 1984, selling oil into the market (rather than exchanging the oil withdrawn from stocks among members) became the preferred approach to address supply disruptions. The IEA monitors the world oil market and, in the event of a global oil supply crisis, calls for the release of strategic oil stocks.

As a member of the IEA, the United States has two primary obligations:

1. As a net oil importer, the United States must maintain crude petroleum and petroleum product stock inventories, whether held by industry or government, equal to at least 90 days of net crude petroleum and petroleum product imports. Of the 29 IEA members, 25 other net importers have the same obligation. The remaining three members—Canada, Denmark, and Norway—do not have a stockholding obligation because they are net oil exporters.

2. The United States must be able to contribute to an IEA collective action based on its share of IEA oil consumption. This obligation can be met by any measure a member nation may choose, including release of strategic or commercial stocks or demand restraint. As of October 2015, the United States must be prepared to contribute 43.9% of the barrels released in an IEA coordinated response. The United States government relies on the use of the SPR to meet this requirement.

[3] 1990 Energy Policy and Conservation Act Amendments (Public Law 101-383).
[4] U.S. Library of Congress, Congressional Research Service, *The Strategic Petroleum Reserve: History, Perspectives, and Issues*, by Robert Bamberger, R33341. (2009). http://research.policyarchive.org/2790.pdf.

1.2.3 Organization and Responsibilities

The Office of Petroleum Reserves is part of DOE's Office of Fossil Energy (FE). The organization includes a Program Office located at DOE headquarters in Washington, D.C.; a Project Management Office (PMO) located in New Orleans, LA; and four field storage sites. The Office operates under the direction and leadership of the Deputy Assistant Secretary for Petroleum Reserves. The SPR organization, shown in Figure 2 below, has an authorized staffing level of 126 federal employees, of which 31 are located in the headquarters Program Office and 95 are located at the PMO and field storage sites. Approximately 800 additional staff, consisting of personnel from the SPR Management and Operating (M&O) contractor, support contractors, and subcontractors—including the PMO and field storage site protective force—round out the SPR workforce.

The Program Office has responsibility for program management of the SPR and NEHHOR. In this capacity, the office has executive oversight of all aspects of the program, including major engineering projects; environmental, safety, security, and occupational health issues; oil distribution planning and analysis; budgeting and financial management; and the drawdown and operations of the SPR and NEHHOR. The Program Office also conducts strategic planning, policy analysis, and major program studies, and engages with domestic and international stakeholders.

The PMO is responsible for operating and managing the SPR's field activities. The Office also provides oversight for the SPR's M&O contractor Fluor Federal Petroleum Operations, who conducts the day-to-day operations and maintenance activities of the SPR's storage sites.

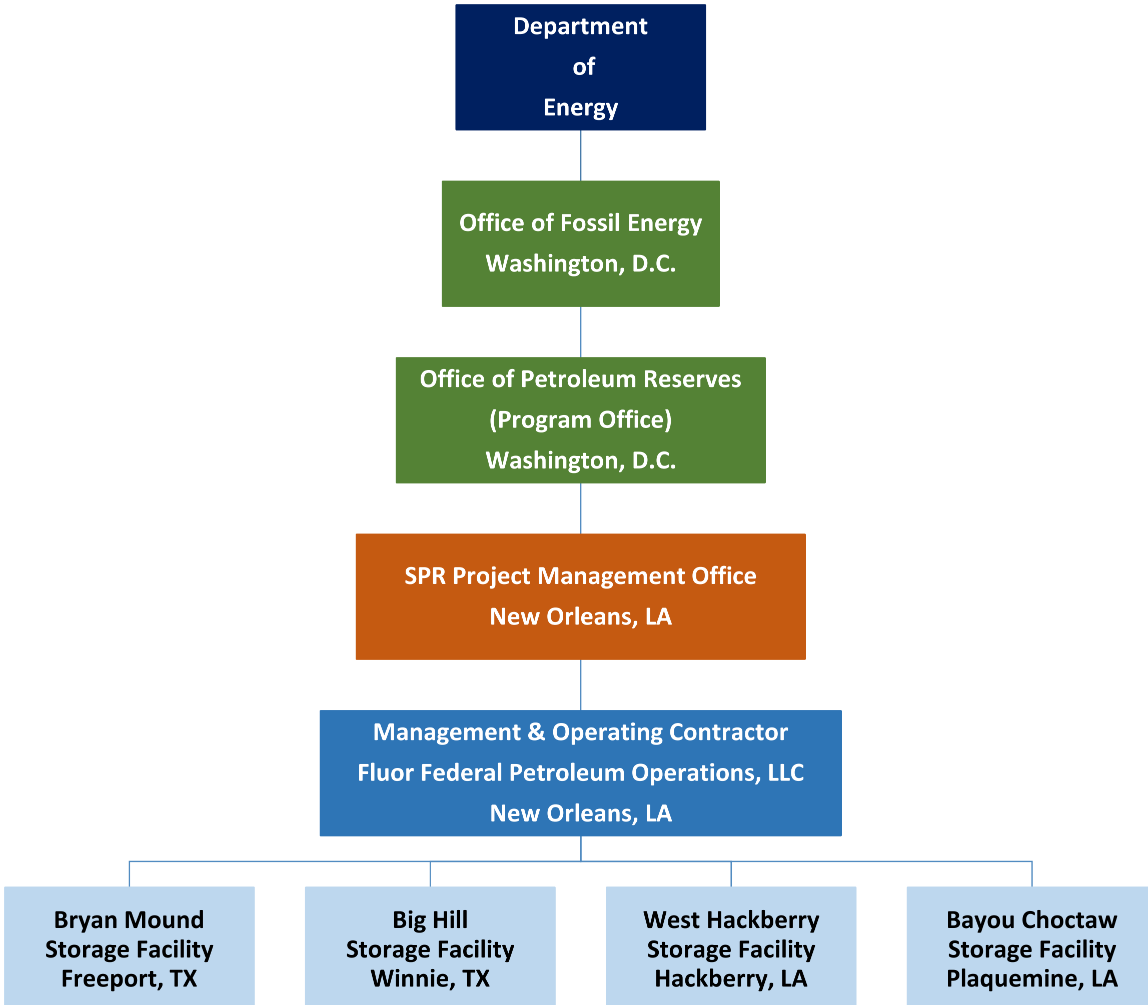

Figure 2: The SPR Organization

1.2.4 Field Locations and Key Site Parameters

In addition to the PMO, DOE operates and maintains four major oil storage sites in the Gulf Coast region: the Bryan Mound and Big Hill sites in Texas and the West Hackberry and Bayou Choctaw sites in Louisiana (Figures 3 and 4). These sites are located in close proximity to Gulf Coast refineries and midstream infrastructure.

Figure 3: Locations of SPR Storage Sites

Figure 4: Aerial Views of SPR Storage Sites

The SPR's crude oil inventory is stored in 60 underground caverns spread across these sites. The sites vary in size and design drawdown rate, as illustrated in Table 1.

SPR Site	Location	Operational Caverns (Number)	Design Storage Capacity (MMbbl)	Current Inventory (MMbbl)	Design Drawdown Rate (MMbbl per day (/d))
Bryan Mound	Freeport, TX	19	247.1	245.0	1.500
Big Hill	Winnie, TX	14	170.0	162.7	1.100
West Hackberry	Hackberry, LA	21	220.4	213.8	1.300
Bayou Choctaw	Plaquemine, LA	6	76.0	73.6	0.515
Total		**60**	**713.5**	**695.1**	**4.415**

Table 1: Key Site Operational Parameters

1.2.5 Technical Performance Criteria and System Requirements

DOE established technical performance criteria related to the design, construction, and operation of the SPR. These criteria provide guidance for configuration of the Reserve as well as benchmarks for the type of oil stored, how SPR facilities are developed and operated, and all aspects of system assurance and readiness. These guidelines are divided into Level I criteria[5] that broadly define the program and Level II criteria[6] that deal with the specifics of system functionality. Major categories included in the criteria are:

- **Storage Quantities and Quality**. The SPR shall provide storage as prescribed by law and approved for implementation by the Secretary. Crude oil must meet specifications in the areas of American Petroleum Institute (API) gravity, sulfur content, pour point, salt content, viscosity, Reid vapor pressure (RVP), total acid number, water and sediment, and hydrocarbon yields. Storage capacities are specified by site and total 439 MMbbl for sour crude and 274.5 MMbbl for sweet crude, for a total storage capacity of 713.5 MMbbl.

- **Drawdown**. The SPR system is to provide the capability to draw down and deliver crude oil from the storage sites to designated distribution terminals with additional access to commercial pipeline networks and marine docks. Each site shall be capable of drawing down and delivering crude oil to the designated distribution terminals and pipelines for custody transfer at the specified rates until 90% of its inventory is depleted.

- **Distribution**. The SPR's physical distribution system is required to make use of the commercial petroleum distribution infrastructure to the maximum extent feasible. SPR terminal facilities, both DOE-owned and commercial, shall be capable of meeting the specified distribution rates and shall be able to drawdown oils of different specifications on a differentiated basis. Each SPR distribution system will have a distribution capability equal to 120% of the combined site

[5] U.S. DOE. (October 2004). *Strategic Petroleum Reserve Technical and Performance Criteria – Level I*.
[6] U.S. DOE. (August 2008). *Strategic Petroleum Reserve Project Performance Criteria – Level II*.

drawdown rates to provide sufficient allowance for terminal and marine vessel operational delays and commercial refinery demand variances.

- **Fill**. The design fill rate for each SPR storage site is specified as 225 thousand barrels per day (Mbbl/d) for all sites, except Bayou Choctaw, which has a design fill rate of 110 Mbbl/d.

- **Operational Readiness**. The SPR is required to maintain operational readiness at all times. After a Presidential Finding of a severe energy supply interruption, or to meet U.S. obligations under the IEP in the event of an IEA collective action, the SPR must be able to meet the schedule shown in Table 2.

Days After Notification	Activity
Within first 11 days	Commence awarding contracts.
Within first 13 days	Begin the flow of oil.
Within first 15 days	Achieve maximum drawdown rate, if required.

Table 2: SPR Drawdown Timetable

1.2.6 Infrastructure and Operations

Crude Oil and Storage

Crude oil is stored in large underground caverns that have been created in salt dome formations. Salt dome storage technology provides maximum security and safety for the crude oil and is the lowest cost technology for large-scale storage projects. These storage sites provide a flexible means for connecting to the nation's commercial oil transport network. Each SPR cavern contains either sweet or sour crude; there is no comingling of the two streams within individual storage caverns. As of May 2016, the SPR's crude oil inventory level was 695.1 MMbbl, consisting of 266.1 MMbbl of sweet crude and 429 MMbbl of sour crude. The SPR's sweet crude inventory has a maximum of 0.5% total sulfur content. SPR sour crude has approximately 1.4% total sulfur content, depending on the site. SPR crude oil is primarily light API gravity oil (>31.1°API), with the remainder consisting of medium gravity oil (between 22.3° and 31.1°).

The SPR does not contain heavy crude oil,[7] even though this represents a considerable share of U.S. oil imports. DOE has analyzed heavy oil storage and found that the costs outweigh the benefits and storing heavy oil would present considerable operational difficulties. U.S. refiners could run SPR crudes in a supply crisis without significantly curtailing the production of transportation fuels.[8] The current inventory mix provides DOE with fungible crudes that maximize the flexibility of the Reserve in a crisis.

[7] Heavy oil is generally considered to be crudes below 22.3° API.

[8] U.S. DOE. (April 2010). Strategic Petroleum Reserve Updated Crude Compatibility Study.

Drawdown and Fill

Drawing down and filling the SPR is a complex process. The design drawdown rate at an SPR site is the rate at which oil can be displaced by raw water pumped into the caverns. Various factors can affect a site's actual drawdown rate, including cavern wells or other equipment that are temporarily out of service due to maintenance, repair, or replacement. Figure 5 is a simplified general purpose diagram of the overall SPR storage, injection (fill), and withdrawal (drawdown) systems.

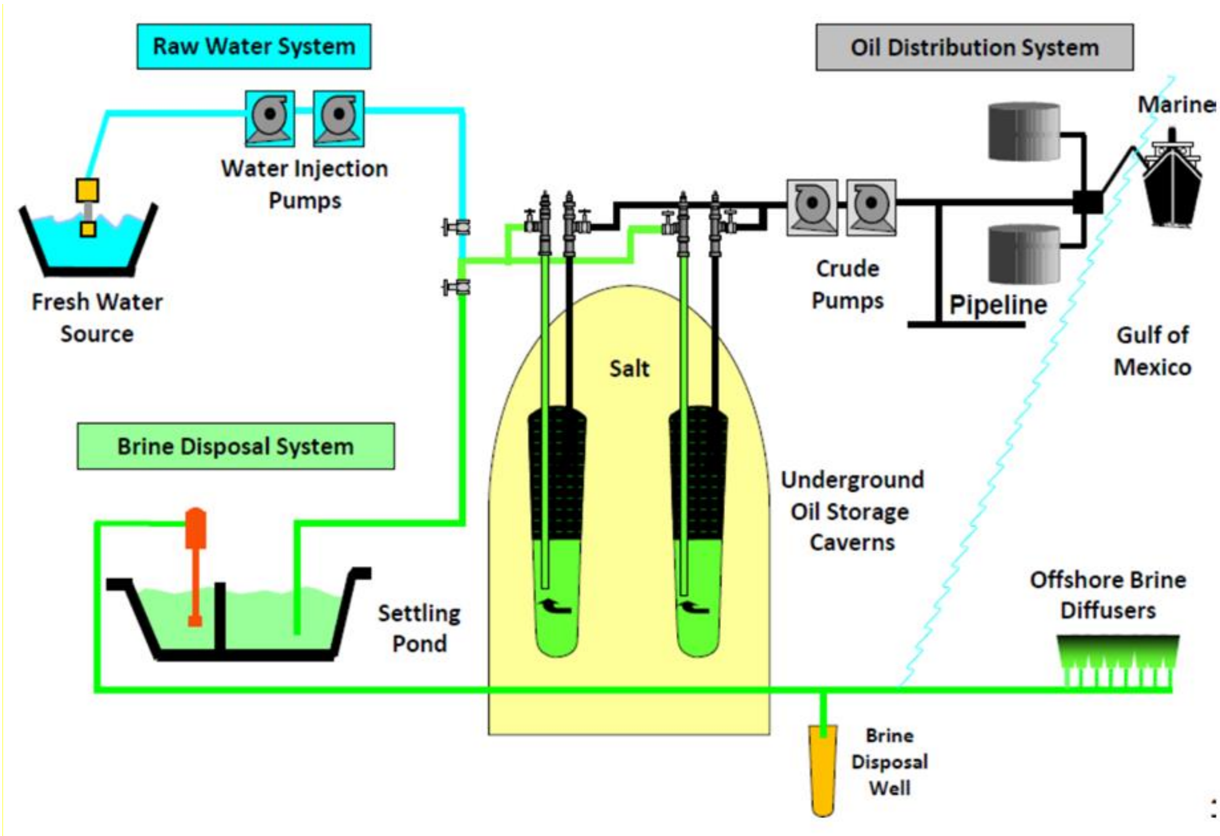

Figure 5: Schematic of Major SPR Systems

Salt caverns are created in underground salt domes by a process called "solution mining." The process involves drilling a well into the salt formation, then injecting raw water to dissolve the salt to create a storage cavern. The dissolved salt is removed as brine and disposed. A second well system is then added to accommodate the flow of crude oil. During fill operations, crude oil is pumped into the top of a cavern where it displaces brine. The crude oil then sits on top of the remaining brine in the cavern. The displaced brine is initially transported to a settling pond, and then subsequently transported to either brine disposal wells for injection into salt water aquifers, or by pipeline to offshore diffusers in the Gulf of Mexico for disposal in accordance with permitted standards. During drawdown operations, raw water is injected through the brine well into the cavern below the oil/brine interface level, displacing the crude oil and forcing the oil up the crude oil well to the wellhead at the surface. From there, crude oil pumps (if needed) can be used to increase the crude oil's pressure to an off-site pipeline, where the crude oil is then transported by pipeline for disposition in the midstream pipeline network or sent to a marine terminal for further transport.

Sales Process

SPR oil is sold in a competitive auction to the highest bidder. The first step in the SPR's competitive sales process is the issuance of a Notice of Sale, which lists the volume, characteristics, and location of the petroleum for sale; delivery dates and procedures for submitting offers; and measures for ensuring performance and financial responsibility.

Over the course of a drawdown, several Notices of Sale may be issued, each covering a sales period of one to two months. Offerors may have only five days from the date a Notice of Sale is issued until offers are due, with delivery of oil commencing no later than 30 days after a Presidential Finding to drawdown the SPR. DOE coordinates Notice of Sale issuance with standard industry delivery periods and maintains a registry of prospective offerors to facilitate communication in an emergency.

When prospective purchasers submit offers, they must unconditionally accept all terms and conditions in the Notice of Sale, and submit an offer guarantee based on potential contract value. After DOE evaluates the offers, "apparently successful offerors" are selected. Winning bidders determine their method of delivery and make specific delivery arrangements that are negotiated later in the process. All apparently successful offerors must provide a letter of credit within five business days of being notified to guarantee payment of the amounts due under the contract. Once the letter is received, DOE issues the Notices of Award. Deliveries then commence to the purchasers, who are invoiced following crude oil deliveries.

Distribution

Purchasers of SPR crude oil are responsible for making their own transportation arrangements via pipeline or marine vessel. The oil from the SPR is distributed via three major pipeline and refinery distribution systems: Seaway, Texoma, and Capline, shown in Figure 6. The Seaway system connects to the Bryan Mound SPR site and includes refinery centers in Houston and Texas City. The Texoma system connects to the Big Hill and West Hackberry SPR sites and includes refineries at Beaumont, Port Arthur, and Lake Charles. The Capline system connects to the Bayou Choctaw SPR site and includes refineries in Southeast Louisiana.

Connections to marine loading facilities are in place for each system. The Seaway system includes ship loading docks at Freeport (400 Mbbl/d) and Texas City (300 Mbbl/d). The Texoma system includes Sunoco Logistics Nederland (1.19 MMbbl/d) and Phillips 66 Beaumont (200 Mbbl/d) marine loading facilities. The Capline system connects to the St. James terminal marine loading facilities (400 Mbbl/d).

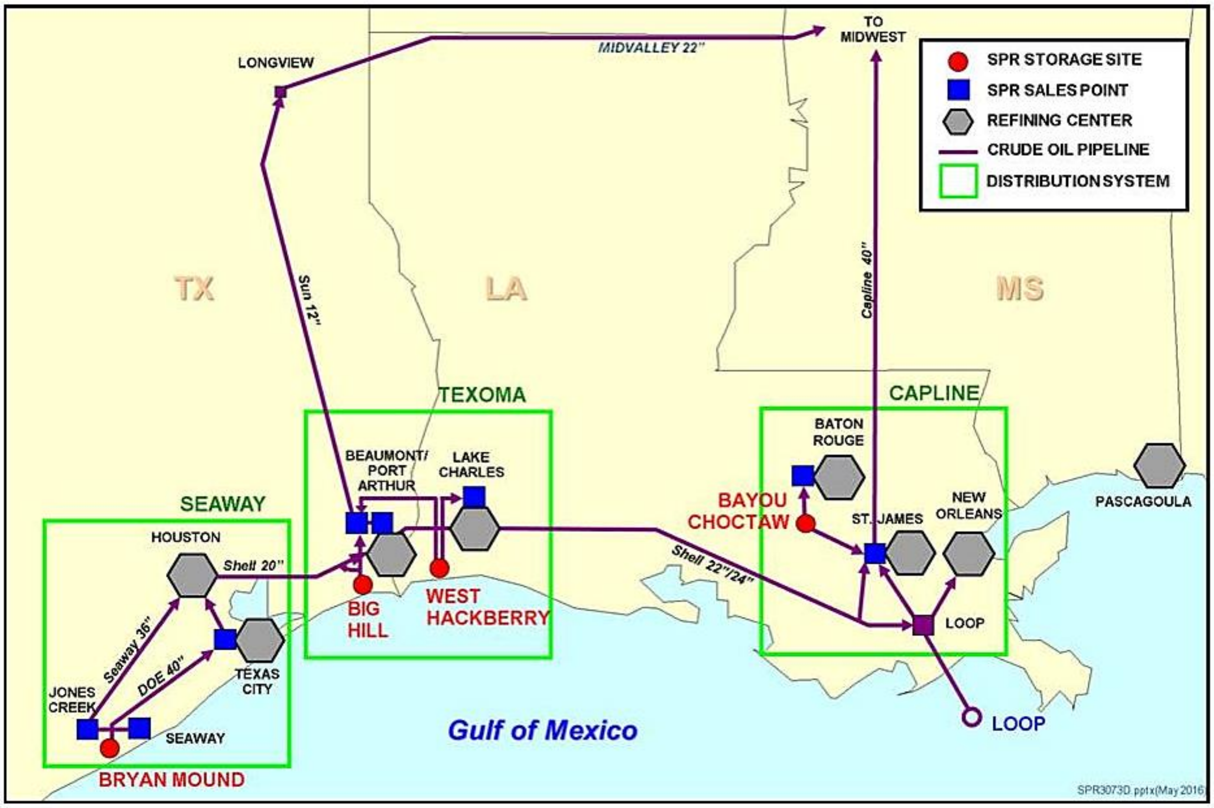

Figure 6: Map Showing SPR Crude Storage Sites and Connections in Texas and Louisiana

1.2.7 Release Authorities and History

EPCA identifies the conditions under which SPR oil can be released. A full or limited drawdown must be authorized by the President through a Presidential Finding. The Secretary also has the authority to release SPR petroleum products for the purpose of conducting test sales and exchanges. SPR release authorities include the following:

- EPCA Section 161(d) provides the President with Full Drawdown Authority to respond to a "severe energy supply interruption" or to meet U.S. obligations under the IEP.
- EPCA Section 161(h) provides the President with Limited Drawdown Authority to prevent or address lesser supply shortages. This authority is limited to a release of no more than 30 MMbbl for no more than 60 days and is subject to a requirement of retaining at least 500 MMbbl in the Reserve.
- EPCA Section 161(g) provides authority to the Secretary to conduct a test drawdown and sale or exchange as part of the continuing evaluations of drawdown and sales procedures. This authority is limited to a release of no more than 5 MMbbl.
- EPCA Section 159(f) provides authority to the Secretary to acquire petroleum products through exchanges.

In addition to the SPR release authorities contained in EPCA, Section 32204(a)(1)(A) of the FAST Act provides authority to the Secretary to drawdown and sell crude oil from the SPR in a quantity the Secretary determines to be appropriate to maximize the financial return to U.S. taxpayers for each of FYs 2016 and 2017.

Release History

The United States has participated with other IEA members to release strategic petroleum stocks as part of an IEA collective action under the IEP on three occasions. The first, in 1991, with the commencement of Operation Desert Storm, resulted in a release of 17.3 MMbbl of oil from the SPR. The second release came after Hurricane Katrina, in 2005, and resulted in a release of 11 MMbbl of SPR oil. The third, a release of 30.6 MMbbl, occurred in June 2011, in response to oil supply disruptions driven by hostilities in Libya.

EPCA requires the Secretary to conduct a continuing evaluation of the SPR’s drawdown and sales procedures. In the conduct of this evaluation, the Secretary is authorized to conduct a test sale to ensure that the SPR is ready to respond, both for emergencies and for other purposes. This has occurred three times since the establishment of the SPR. The first test sale of approximately 1 MMbbl of oil occurred in 1985. The second sale of 3.9 MMbbl of oil occurred between Iraq's invasion of Kuwait in August 1990 and the beginning of Operation Desert Storm in January 1991. The third test sale of 5 MMbbl of oil, the statutory maximum under EPCA, took place in May 2014.

In addition to the aforementioned operational and test sales, SPR crude oil has been released and acquired through a mechanism known as an exchange. In an exchange, an entity (usually an oil refiner) borrows SPR crude oil for a short time period due to exigent circumstances and later replaces it in full, along with a premium of an additional quantity of oil. This concept is similar to a financial loan, where the original volume of SPR crude oil that is repaid is considered the “principal” and the additional premium barrels returned by the borrower (the oil acquisition part of the transaction) are considered the “interest.” SPR crude oil has been released through exchange agreements 11 times, with all but one of the requests originating from a private company (see Table 3). These exchanges occurred during severe weather events, such as Hurricanes Lili (2002), Ivan (2004), Katrina (2005), Gustav and Ike (2008), and Isaac (2012). Other exchanges occurred in response to temporary disruptions, such as pipeline blockages and ship channel closures, and during the creation of the NEHHOR in 2000.

SPR oil has also been sold to meet SPR-specific and general government fiscal purposes. To help defray the cost of decommissioning the Weeks Island SPR storage site, 5.1 MMbbl of oil from the site were sold in January 1996. Between May and August 1996, 12.8 MMbbl of Weeks Island oil were sold which yielded $227 million that was used to reduce the FY 1996 federal budget deficit. In FY 1997, 10.2 MMbbl of SPR oil was also sold for deficit reduction purposes, yielding $220 million to the federal treasury.

The historical release activity of crude oil from the SPR is shown below in Table 3. Activity is grouped into five category types: operational sales, test sales, decommissioning sales, budget deficit reduction sales, and exchanges.

Date	Purpose	Category Type	Release Volume (MMbbl)
1985 – November	**Test Sale**: After extending the EPCA in June 1985, Congress authorized DOE to conduct test sales of up to 5 MMbbl to involve the private sector in the competitive sales process.	Test Sale	0.967
1990 – September	**Desert Shield**: President George H. W. Bush ordered a 5 MMbbl test sale to "demonstrate the readiness of the [Reserve] system under real life conditions." Only 3.9 MMbbl were sold because of the lack of bids for one of the six types of crude oil advertised.	Test Sale	3.900
1991 – January	**Desert Storm**: President George H. W. Bush authorized a 33.75 MMbbl drawdown over a 45-day period under a coordinated emergency response plan drawn up by the IEA. DOE accepted bids from 13 companies that bid on only 17.3 MMbbl of Reserve oil. Industry offers for the higher-sulfur "sour" crude oil were substantially lower than bids for the lower-sulfur "sweet" crude.	Operational Sale	17.300
1996 – January	**Weeks Island Sale**: After becoming geologically unstable, DOE decided to decommission the Weeks Island SPR site, and offered 5.1 MMbbl for sale to offset the decommissioning costs.	Decommissioning Sale	5.100
1996 – April	**Omnibus Consolidated Rescissions and Appropriations Act of 1996**, Public Law 104-134.	Budget Deficit Reduction Sale	12.800
1996 – May	**Pipeline Blockage, Seaway Pipeline System**: During a pipeline blockage to Cushing, OK, DOE provided .901MMbbl with ARCO, which replaced the oil with an equivalent grade of crude within six months under an emergency crude oil lease exchange agreement.	Exchange	0.901
1996 – October	**Omnibus Consolidated Appropriations Act of 1997**, Public Law 104-208.	Budget Deficit Reduction Sale	10.200
1999 – September	**Maya Exchange**: DOE exchanged 11 MMbbl of Maya crude for 8.5 MMbbl of other higher value crude oil to improve the SPR's operational efficiency.	Exchange	11.000
2000 – June	**Calcasieu Ship Channel Closure**: DOE exchanged 500 Mbbl each with CITGO and Conoco, due to blockage of the ship channel that provided access of incoming crude oil shipments to those refineries. Action taken in order to avert temporary shutdown of both refineries.	Exchange	1.000
2000 – September	**Establish NEHHOR**: DOE exchanged 2.8 MMbbl of crude oil to pay for the first year of tank-storage and stocks for establishing a 2 MMbbl NEHHOR.	Exchange	2.840
2000 – October	**Exchange 2000**: DOE exchanged 30 MMbbl in response to concern over low distillate levels in the Northeast.	Exchange	30.000
2002 – October	**Hurricane Lili**: DOE exchanged 98 Mbbl with Shell Pipeline Company to secure Capline storage tanks in advance of Hurricane Lili.	Exchange	0.980
2004 – September	**Hurricane Ivan**: DOE exchanged 5.4 MMbbl of sweet crude due to disruptions in the Gulf of Mexico caused by Hurricane Ivan.	Exchange	5.400
2005 – September	**Hurricane Katrina**: DOE approved six requests for emergency loans of crude oil to address supply shortages caused by oil production and distribution facilities being shut ahead of Hurricane Katrina's landfall.	Exchange	9.800

Date	Purpose	Category Type	Release Volume (MMbbl)
2005 – September	**Hurricane Katrina**: President George W. Bush issued a Finding of a Severe Energy Supply Interruption and authorized the sale of 30 MMbbl as part of an IEA collective action. 10.8 MMbbl of sweet crude and 200 Mbbl of sour crude were sold.	Operational Sale	11.000
2006 – January	**Barge Accident, Sabine Neches Ship Channel**: DOE exchanged 767 Mbbl of sour crude with Total Petrochemicals USA due to closure of the Sabine Neches ship channel to deep-draft vessels after a barge accident in the channel. Action was taken to avert temporary shutdown of the refinery.	Exchange	0.767
2006 – June	**Calcasieu Ship Channel Closure**: DOE exchanged 750 Mbbl of sour crude with ConocoPhillips and Citgo due to the closure for several days of the Calcasieu Ship Channel to maritime traffic. The closure resulted from the release of a mixture of storm water and oil. Action was taken to avert a temporary shutdown of both refineries.	Exchange	0.750
2008 – September	**Hurricanes Gustav and Ike**: Following Hurricanes Gustav and Ike, DOE loaned nearly 5.4 MMbbl to Marathon, Placid, ConocoPhillips, Citgo, and Alon USA after their supplies had been cut off due to shutdown of the petroleum industry in the Gulf region. The companies repaid the loans with a premium of 93.35 Mbbl.	Exchange	5.389
2011 – June	**Libya Collective Action**: President Barack Obama issued a Finding of a Severe Energy Supply Interruption and directed DOE to offer 30 MMbbl of sweet crude to offset Libya's production curtailment as part of an IEA collective action.	Operational Sale	30.640
2012 – September	**Hurricane Isaac**: In late August 2012, Tropical Storm Isaac entered the Gulf of Mexico. Marathon Petroleum Company requested an emergency loan of 1 MMbbl to supplement Marathon's supplies to ensure that their refining operations had sufficient supplies to continue operations.	Exchange	1.000
2014 – March	On March 12, 2014, the Secretary authorized a test sale under Section 161(g) of EPCA in order to evaluate the SPR drawdown and distribution mechanisms. A portion of the revenues from this sale was used to fund the NGSR.	Test Sale	5.000

Table 3: Strategic Petroleum Reserve Historical Summary

1.3 NORTHEAST HOME HEATING OIL RESERVE AND NORTHEAST GASOLINE SUPPLY RESERVE

The role of these reserves is to provide modest volumes of petroleum distillate and gasoline, respectively, to regional markets in the event of severe product shortages. Both reserves are intended to provide a short-term buffer until commercial inventories become available. As shown in Figure 7, the NEHHOR and NGSR sites are strategically placed throughout the Northeast to support consumers.

Figure 7: NEHHOR and NGSR Storage Locations

1.3.1 Northeast Home Heating Oil Reserve

History and Purpose

In July 2000, President William J. Clinton directed DOE to establish a 2 MMbbl reserve in the Northeast that would provide consumers with supplemental sources of home heating oil in the event of supply shortages due to severe winter weather. The intent was to create a buffer large enough to allow commercial companies to compensate for interruptions in supply during severe winter weather, but not so large as to dissuade the companies from maintaining stock levels sufficient to respond to routine weather events or to recognize that increasing prices are an indicator that more supply is needed. The NEHHOR was established to hold approximately 10 days of inventory, the time required for ships to carry additional heating oil from the Gulf of Mexico to New York Harbor.

In response to the President's Directive, DOE, acting through the United States Department of Defense (DoD) Energy Support Center, issued a solicitation to exchange a quantity of crude oil from the SPR for 2 MMbbl of distillate heating oil stocks to be placed in leased commercial storage facilities in the Northeast. An exchange using SPR crude oil was chosen because no appropriated funding was available to create the heating oil reserve. In November 2000, Congress amended EPCA providing clear authority for the NEHHOR under Title 1, Part D, Section 181. This authorization, codified as Title 42 U.S. Code 6250, states that "Notwithstanding any other provision of this Act, the Secretary may establish, maintain, and operate in the Northeast[9] a Northeast Home Heating Oil Reserve. A Reserve established under this part is not a component of the Strategic Petroleum Reserve established under part B of this title."

On March 6, 2001, then-Energy Secretary Spencer Abraham formally notified Congress that the Bush Administration would establish the NEHHOR as a permanent part of America's energy readiness effort, separate from the SPR. In May 2001, President George W. Bush issued his National Energy Policy, which endorsed the NEHHOR as a way to help ensure adequate supplies of heating oil in the event of colder-than-normal winters.

In 2011, DOE converted the NEHHOR inventory to cleaner burning ULSD to accommodate more stringent state fuel standards that required replacement of high sulfur heating oil with cleaner burning distillate, and the size of the NEHHOR was reduced to 1 MMbbl.

Under DOE's storage contract, terminal operators are required to guarantee the quality of the product, provide full availability of all federal government-owned stocks in the event of a release, and provide the capability to deliver the government's product within 10 days of notification. To facilitate distribution during an emergency, each terminal is also required to have the capability to deliver product by both marine and truck modes. When ULSD is sold from the Reserve as heating oil, red dye is added to distinguish the product from taxable diesel fuel. It is then referred to as ultra-low sulfur heating oil (ULSHO). In November 2012, there was a Presidential finding of a severe energy supply interruption as a result of Superstorm Sandy that directed a transfer of ULSD from the NEHHOR to the DoD to support response efforts. As a result, approximately 120 Mbbl of ULSD were transferred to DoD, which was returned to the NEHHOR in December 2012.

NEHHOR Locations and Configuration

One MMbbl of government-owned ULSD is stored in three commercial terminals under commercial storage service contracts. The terminals are located in Groton, CT; Revere, MA; and Port Reading, NJ. Key parameters of the NEHHOR terminals are shown below in Table 4.

Terminal Operator	Terminal	Location	Product	Volume (Mbbl)
Buckeye Partners, LP	Buckeye Port Reading Terminal	Port Reading, NJ	ULSD	300
Buckeye Partners, LP	Buckeye Groton Terminal	Groton, CT	ULSD	300
Global Companies, LLC	Global Revere Terminal	Revere, MA	ULSD	400
Total				**1,000**

Source: Northeast Home Heating Oil Reserve Distribution Plan. (April 2016).

Table 4: NEHHOR Terminals and Key Parameters

[9] EPCA, Title 1, Part D, Section 181(b)(1) defines the term "Northeast" to mean the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, and New Jersey.

1.3.2 Northeast Gasoline Supply Reserve

History and Purpose

In 2012, Superstorm Sandy made landfall in the northeastern United States. The storm caused heavy damage to two New York Harbor area refineries and left more than 40 terminals in New York Harbor closed. Some New York gas stations were without fuel for as long as 30 days. In response to the supply shortages caused by the storm, DOE administratively established the 1 MMbbl NGSR in 2014. This reserve is designed to provide Northeast consumers with supplemental supplies of gasoline for a limited period in the event of a natural disaster or other disruption, until existing distribution infrastructure can return to operation. The NGSR was established through the authority contained in EPCA Title 1, Part C, Section 171, and currently operates as part of the SPR. Both the acquisition of the government-owned gasoline and award of the commercial storage service contracts to store the gasoline in commercial storage terminals were funded out of the SPR Petroleum Account from budget balances created by the 2014 Test Sale. The commercial storage service contracts were awarded in late summer 2014, and the gasoline was acquired and delivered to the storage terminals soon thereafter.

Under DOE's storage service contracts, terminal operators are required to rotate the product, guarantee the quality of the product, provide full availability of all federal government-owned stocks in the event of a release, and provide the capability to deliver the government's product within 10 days notification. To facilitate distribution during an emergency, each terminal is required to operate and release the gasoline under conditions without commercial power. Collectively, the terminals have multiple options to move fuel in the event of a disruption, including truck and marine vessel loading facilities. Several terminals also have pipeline connectivity to move fuel. There have been no releases from the NGSR since its establishment in 2014.

NGSR Locations and Configuration

One MMbbl of government-owned gasoline blendstock is stored in four commercial terminals under four commercial storage service contracts. Two terminals with a cumulative volume of 700 Mbbl are located in the New York Harbor geographical area; one terminal containing 200 Mbbl is located in the greater Boston, MA geographical area; and one terminal with a volume of 100 Mbbl is located in northern New England in the greater Portland, ME geographical area. Key parameters of the NGSR terminals are shown below in Table 5.

Operator	Terminal	Location	Product	Volume (Mbbl)
BP Products NA, Inc.	KMI – Carteret Terminal	Carteret, NJ	RBOB	200
Buckeye Terminals, LLC	Raritan Bay Terminal	Perth Amboy, NJ	RBOB	500
Global Companies, LLC	Global Revere Terminal	Revere, MA	RBOB	200
Buckeye Terminals, LLC	South Portland Terminal	South Portland, ME	RBOB	100
Total				**1,000**

Notes: RBOB = Reformulated Gasoline Blendstock for Oxygenate Blending

Source: Northeast Gasoline Supply Reserve Distribution Plan. (February 24, 2015).

Table 5: NGSR Terminals – Key Storage Parameters

CHAPTER 2 – SPR INFRASTRUCTURE

This chapter discusses the SPR's infrastructure. It includes information on key operating parameters of the four SPR storage sites, as well as a description of the major surface and subsurface systems and equipment that impact site operations. It closes with a discussion of the challenges facing the SPR infrastructure and the impacts these will have on the program's capabilities going forward.

2.1 SPR OVERVIEW

Infrastructure provides the structural foundation that is fundamental for the ability of the SPR to maintain operational readiness and meet mission requirements. At a current replacement value of more than $6.7 billion,[10] the SPR infrastructure is composed of complex surface and subsurface assets that are grouped into major systems. Each system is unique, has a specific purpose and function, and consists of equipment specifically designed to optimize system performance. Although each system is unique, there is a dependent relationship among the systems. The ability to successfully carry out SPR operations—drawdowns, filling, intra- and inter-site fluid movements—requires major components of each system to operate within specifications.

The sections in this chapter provide greater detail on the systems and equipment within the SPR infrastructure.

2.2 SPR STORAGE SITES – KEY OPERATING PARAMETERS

Table 6 provides a list of the key operating parameters for the four SPR storage sites.

[10] DOE Facilities Information Management System (FIMS) database. (May 2016).

Site and Location	Key Operating Parameters	Sweet	Sour	Total
Bayou Choctaw Plaquemine, LA	Current crude oil inventory (MMbbl)[11]	21.8	51.8	73.6
	Design storage capacity (MMbbl)	24.0	52.0	76.0
	Number of operational storage caverns	2	4	6
	Number of operational wells	4	8	12
	Site design drawdown rate (MMbbl/d)	0.300	0.515	0.515
	Site design fill rate (Mbbl/d)			110.0
	Distribution system group: Capline			
	Crude oil distribution sales points: 3 • St. James terminal docks • St. James terminal pipeline • Baton Rouge pipeline			
West Hackberry Hackberry, LA	Current crude oil inventory (MMbbl)	106.2	105.9	212.1
	Design storage capacity (MMbbl)	107.8	112.6	220.4
	Number of operational storage caverns	10	11	21
	Number of operational wells	11	17	28
	Site design drawdown rate (MMbbl/d)	1.3	1.3	1.3
	Site design fill rate (Mbbl/d)			225.0
	Distribution system group: Texoma			
	Crude oil distribution sales points: 4 • Sun Nederland terminal ship docks • Sun Nederland terminal barge docks • Sun Nederland terminal pipeline • Lake Charles Metering Station pipeline			
Big Hill Winnie, TX	Current crude oil inventory (MMbbl)	68.8	94.6	163.4
	Design storage capacity (MMbbl)	72.0	98.0	170.0
	Number of operational storage caverns	6	8	14
	Number of operational wells	12	16	28
	Site design drawdown rate (MMbbl/d)	1.0	1.1	1.1
	Site design fill rate (Mbbl/d)			225.0
	Distribution system group: Texoma			
	Crude oil distribution sales points: 6 • Sun Nederland terminal ship docks • Sun Nederland terminal barge docks • Sun Nederland terminal pipeline • Phillips 66 Beaumont terminal ship dock • Phillips 66 Beaumont terminal pipeline • Shell Houston-Houma pipeline			
Bryan Mound Clute, TX	Current crude oil inventory (MMbbl)	68.6	176.4	245.0
	Design storage capacity (MMbbl)	70.7	176.4	247.1
	Number of operational storage caverns	6	13	19
	Number of operational wells	14	31	45
	Site design drawdown rate (MMbbl/d)	1.0	1.5	1.5
	Site design fill rate (Mbbl/d)			225.0
	Distribution system group: Seaway			
	Crude oil distribution sales points: 4 • Freeport terminal ship docks • Jones Creek pipeline • Texas City terminal ship docks • Texas City terminal pipeline			

Table 6: SPR Storage Sites – Key Operating Parameters

[11] The total crude oil inventory in storage at the four sites is 694.1 MMbbl. An additional 1 MMbbl of inventory is in use for pipeline fill.

2.3 SURFACE INFRASTRUCTURE SYSTEMS

This section identifies each major SPR infrastructure system, describes its major equipment, and explains its purpose.

2.3.1 Crude Oil Transfer System

The *crude oil transfer system* consists of all surface equipment used for the transfer, storage, and recovery of crude oil, including on-site piping, valve manifolds and accessories, crude oil injection/transfer pumps, meter stations, equipment used to recover oil from surges and local operations, and associated instrumentation. This system is used during drawdown, fill, and degassing operations; intra- and inter-site crude oil transfers; and operational testing of equipment.

Crude oil injection/transfer pumps provide pressure to inject crude oil into the caverns during filling operations, and to deliver crude oil to the receiving terminal during drawdown operations (for Bayou Choctaw and Big Hill sites only). During fill, the pumps draw crude oil from the pipeline metering system or storage tanks and discharge it into a manifold connected to the cavern wells. During withdrawal, the injection pumps (under conditions requiring their use for off-site distribution) draw oil from the manifold and pump it into the distribution pipeline system.

Crude oil storage tanks are utilized only at the Bryan Mound site. The storage tanks are used as intermediate storage for crude oil received during filling or delivered during drawdown from/to SPR-contracted marine terminals, as well as for providing temporary storage during an intra-site transfer.

Each site has a *crude oil metering and proving station* that is a complete, independent, skid-mounted, totally integrated, and functionally tested metering facility used for volumetric flow measurement during both drawdown and filling operations.

Crude oil coolers, consisting of water-cooled shell and tube heat exchangers, are used to cool the temperature of the crude oil delivered from the storage caverns to prevent excessive vapor emissions when the oil is delivered to receiving terminals to ensure compliance with environmental and safety regulations.

A *crude surge system* is in place to protect the terminal delivery pipelines from high pressure and transient surges. The system consists of pressure relief valves, crude oil surge tanks, and pumps. Any crude oil released through the relief valves collects in the crude oil surge tank and is injected back into a storage cavern by the crude oil surge pump.

An *oil recovery system* collects oil from the brine ponds and tanks, and from collection drains or sumps. The system consists of one or more slop oil tanks, slop oil pumps, and oil recovery and drainage systems. Recovered oil is examined for quality and, if acceptable for further use, is reinjected into the storage caverns.

2.3.2 Raw Water System

The *raw water system* consists of all equipment used for the screening, pumping, conveyance, and cavern injection of raw water. It includes piping, valves and accessories, a raw water intake structure and intake pumps, raw water injection pumps, and associated instrumentation. This system is used during drawdown operations, during operational testing of equipment, and for the backflush of piping and well casings to remove precipitated salt that accumulates on the inner surfaces and restricts flow.

The *raw water intake structure* is a land-based structure[12] that is the first point in the raw water system connecting a surface water source to an SPR storage site. The raw water intake structure houses the raw water intake pumps, and contains screens located on the intake pump manifolds that prevent large debris and marine life from damaging the raw water intake pumps.

Raw water intake pumps transfer raw water from the raw water intake structure to the site's raw water injection pumps through the raw water intake pipelines.

Raw water intake pipelines are used to convey the raw water supplied at the raw water intake structure to the site's raw water injection pumps. The pipelines range from 26–48 inches in diameter, and can be more than five miles in length, depending on the particular site.

The *raw water injection pumps* are used to inject raw water at high pressure into the caverns during drawdown operations.

2.3.3 Brine Disposal System

The *brine disposal system* consists of all equipment used for the transfer, treatment, and disposal of brine. System equipment includes piping, valves, and accessories, pumps, settling ponds, oil recovery ponds (Bayou Choctaw and Big Hill sites), brine retention tanks (West Hackberry and Bryan Mound sites), brine disposal pumps, either brine disposal wells or an offshore brine diffuser, and all associated instrumentation. This system is used during crude oil fill operations, intra-site crude oil transfers, and cavern leaching operations. During crude oil fill operations, crude oil injected into a storage cavern displaces an equivalent volume of brine to the surface through a brine well. The displaced brine is transported to a settling pond, and subsequently to either deep brine disposal wells at the Bayou Choctaw and West Hackberry sites, or to offshore diffusers in the Gulf of Mexico at the Big Hill and Bryan Mound sites. Small quantities of brine are also generated during cavern pressure maintenance or cavern depressurization as brine is bled off to compensate for natural cavern creep.

A *brine settling pond or tank* allows insoluble mineral particles to settle out of the brine stream by gravity. An *oil recovery pond or tank* allows any oil that was removed coincidentally with the brine from a storage cavern to separate and float to the surface where it is recovered.

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[12] The Bayou Choctaw raw water intake structure is located on-site. The raw water intake structures for West Hackberry, Big Hill, and Bryan Mound are located off-site on DOE-owned land.

Brine disposal pumps draw brine from the pond or tank and discharge it through a brine disposal pipeline to either brine disposal wells or an offshore diffuser.

Brine disposal pipelines convey the disposed brine from the disposal pumps to either disposal wells or an offshore diffuser.

The brine system also includes a *brine re-pressurization pump* to restore the static operating pressure of a cavern after a drawdown or filling operation, or for maintenance activity.

2.3.4 Instrumentation and Distributed Control System

The *instrumentation and distributed control system* is used to monitor and control site operations. *Site instrumentation* includes various pressure, temperature, flow, vibration, and electrical sensors, transmitters, receivers, detectors, alarms, and interlocks, and provides inputs to the *distributed control system (DCS)*, which controls site operations. The DCS includes the control network, process controllers, input/output (I/O), an advanced alarm management system, external interfaces, application and diagnostic workstations, and three control room operator interface workstations used for operator monitoring and control of site operations.

2.3.5 Power Distribution System

DOE owns and operates the *electrical substations* at three SPR storage sites (Big Hill, Bryan Mound, and West Hackberry).[13] The substations step down the incoming voltage to 4.16 kilovolts (kV) for large equipment such as pump motors. *Transformers* are then used to further step down the voltage to 480 volts (V) for smaller equipment such as small pumps and valve actuators, and to 120/208 V three-phase or 120/240 V single-phase power for lighting, appliances, and various control systems. Separate 120 V single-phase systems supplied by uninterruptible power supply (UPS) systems (complete with backup batteries) serve critical loads such as the DCS in the control room, as well as the physical security system.

A *power monitoring and control communications system* in the central control room at each site monitors the electrical power system to protect and/or monitor loads and to facilitate power system fault diagnostics.

2.3.6 Physical Protection System

The SPR is a national critical infrastructure asset, and the *physical protection system* serves as the foundation of the SPR Safeguards and Security Program, which employs a graded and layered approach to the security mission. This system is designed to provide immediate intrusion detection at the site perimeter that, when coupled with simultaneous camera assessment and tactical delay, enables a timely protective force response for effective threat interdiction and neutralization.

[13] The electrical substation at Bayou Choctaw is utility owned and operated.

Both the *perimeter intrusion detection system* and the *drawdown critical area intrusion detection system* incorporate multiple types of detectors, including a Fiber Optic Intelligence and Detection System (FOIDS), Intelli-Flex, ported coax, Intrusion Prevention and Intrusion Detection System (IPIDS), building management systems (BMS), fixed cameras, taut-wire, and lighting systems.

The *interior intrusion detection system* includes motion detectors, infrared detectors, BMS, Pan-Tilt-Zoom (PTZ) cameras, and thermal cameras. The intrusion detection systems for the special designated security areas (Site Security Specialist office and the control room) include BMS, motion detectors, and Site-Wide Card Access (SWCA) devices.

2.3.7 Firefighting System

The *firewater distribution system* at each site is an underground, pressurized, closed system (a crossover valve provides access to the raw water system in an emergency situation). The system delivers a continuous supply of water to *hydrants, monitors, sprinkler systems, deluge systems,* and *foam systems* located throughout the facility. *Water sources* include a lake at the Bayou Choctaw site and storage tanks at the other sites (the Bryan Mound site, in addition to storage tanks, also has access to river water). Each location also has an *aqueous film-forming foam (AFFF) firefighting system* that protects the crude oil injection pumps, the brine injection pumps, crude oil meter/prover skids, and the crude oil pig launchers/receivers. The systems are actuated by combination *ultraviolet/infrared fire detection systems*, or can be manually operated. Foam deluge can quickly suppress, extinguish, and blanket a pooled ground fire associated with a crude oil release.

Each of the well pads is protected with a combination of *monitor nozzles* and *fire hydrants*. Fire extinguishers are also provided. Each system of nozzles surrounding the well pads is supplied by a water main that loops the pad.

In addition to the fire apparatus, the sites are provided with two-2,000 gallons per minute (gpm), trailer-mounted water and foam monitor nozzles, and a number of trailers containing support equipment.

2.3.8 Auxiliary Systems

Potable Water System

Potable water is supplied by the municipal water district near each site. The *potable water system* supplies water for washroom and lavatory service, drinking water, and hose bib water for housekeeping and the degassing facility.

Sewage Treatment System

An *above-ground mechanical sewage treatment plant* at each SPR site treats the domestic sanitary wastewater from the control center, administration, warehouse and maintenance, vehicle maintenance, and security operations center buildings, as well as from any on-site trailers.

2.3.9 Summary of the SPR's Surface Infrastructure Major Systems and Equipment

Table 7 provides a summary of the SPR's surface infrastructure major systems and equipment.

System/Key Equipment	Bayou Choctaw	Big Hill	Bryan Mound	West Hackberry	SPR Overall
Crude Oil Transfer System					
Crude Oil Injection/ Transfer Pumps	3 at 1,600 horsepower (HP) each	6 at 2,000 HP each	2 at 1,500 HP each 5 at 1,000 HP each 2 at 600 HP each	1 at 3,000 HP each 2 at 1,750 HP each 2 at 500 HP each	23
Storage Tanks	None	1 at 20 Mbbl	3 at 200 Mbbl each	None	4
Slop Oil Tanks	1 at 10,500 gallons (gal) 1 at 20,000 gal	2 at 10,000 gal each	2 at 10,000 gal each	4 at 20,000 gal each	10
Crude Oil Meter Proving Stations	1 station w/3 meters at a flow capacity of 12 Mbbl/h each	1 station (on-site) w/3 meters at a flow capacity of 12 Mbbl/h each 1 station (offsite) w/3 meters at a flow capacity of 17.1 Mbbl/h each	1 station w/7 meters at a flow capacity of 12 Mbbl/h each	1 station (on-site) w/6 meters at a flow capacity of 10.5 Mbbl/h each 1 station (offsite) w/6 meters at a flow capacity of 7.42 Mbbl/h each	6 stations 28 meters
Heat Exchangers (HEX)	2 at 252.6 Mbbl/d each	5 at 232 Mbbl/d each	5 trains of 4 exchangers per train at 263.2 Mbbl/d each	6 at 219 Mbbl/d each	33
Raw Water System					
Raw Water Source	Onsite lake	Intracoastal waterway	Brazos River	Intracoastal waterway	
Raw Water Injection System Pipeline	26 inch diameter (on-site connection)	48 inch diameter, 5.2 miles	36 inch diameter, 0.6 miles	48 inch diameter, 4.2 miles	3 pipelines 10 pipeline miles
Raw Water Intake Pumps	3 at 600 HP each	4 at 2,500 HP each	4 at 1,500 HP each	4 at 1,500 HP each	15
Raw Water Injection Pumps	7 at 1,500 HP each	7 at 2,000 HP each	8 at 3,500 HP each	7 at 3,500 HP each	29
Brine Disposal System					
Brine Oil Recovery Ponds/Tanks	1 pond at 92 Mbbl	2 ponds at 100 Mbbl each	1 tank at 150 Mbbl	2 tanks at 50 Mbbl each	3 ponds 3 tanks
Brine Disposal Pumps	2 primary at 1,500 HP each 2 boosters at 250 HP each	2 primary at 500 HP each	2 primary at 1,500 HP each	2 primary at 1,000 HP each 2 service at 60 HP each	8 primary 2 booster 2 service
Brine Disposal Wells	12	None	None	9	21
Brine Disposal Offshore Diffuser	N/A	5 miles offshore	4 miles offshore	N/A	2 diffusers
Brine Disposal Pipeline	2.3 miles, 24 inch diameter	14.1 miles, 48 inch diameter	6 miles, 24 inch diameter	3.6 miles, 24 inch diameter	4 pipelines 26 pipeline miles

System/Key Equipment	Bayou Choctaw	Big Hill	Bryan Mound	West Hackberry	SPR Overall
Power Distribution System					
Substations	1 utility-owned 69/4 kV	1 DOE-owned 138/34 kV	1 DOE-owned 69/4 kV	2 DOE-owned 69/4 kV	4 substations (3 DOE-owned)
Major Transformers	None	8 above 34 kV and 5 megavolt-amperes (MVA)	3 above 34 KV and 5 MVA	4 above 34 KV and 5 MVA	15 transformers
Power Distribution Transformers	10 above 4 kV and 150 kilovolt-amperes (kVA)	21 above 4 kV and 150 kVA	23 above 4 kV and 150 KVA	19 above 4 kV and 150 KVA	73 transformers
Generators (Capacity)	1 at 700 kilowatts (kW) and 480V	1 at 900 kW and 4 kV	1 at 1,000 kW and 4 kV	1 at 1,000 kW and 4 kV	4 generators
Physical Security System					
Perimeter Detection System	Fence sensors, infrared, taut-wire, and more	Fence sensors, infrared, taut-wire, and more	Fence sensors, infrared, taut-wire, and more	Fence sensors, infrared, taut-wire, and more	
Perimeter Cameras	65	51	48	85	249 cameras
Monitoring Capability	6 monitors for cameras and alarms	6 monitors for cameras and alarms	6 monitors for cameras and alarms	6 monitors for cameras and alarms	24 monitors
Firefighting System					
Water Pumping Capacity	4,000 gpm 2 pumps at 530 total HP	5,000 gpm 2 pumps at 590 total HP	11,000 gpm 5 pumps at 1,656 total HP	4,000 gpm 2 pumps at 590 total HP	11 pumps
Water Source	Onsite lake (unlimited)	840,000-gallon tank	500,000-gallon tank River (unlimited)	920,000-gallon tank	
Other Infrastructure					
Crude Oil Laboratory	1 laboratory	1 laboratory	1 laboratory	1 laboratory	4 laboratories
Valves	765	1,266	1,831	1,573	5,435 valves

Table 7: SPR Surface Infrastructure

2.4 SUBSURFACE INFRASTRUCTURE SYSTEMS

The SPR's subsurface infrastructure is composed of the storage caverns, storage cavern wells, and brine disposal system wells. The following subsections provide a description of each of these assets.

2.4.1 Storage Caverns

The SPR's crude oil inventory is stored in a total of 60 *subsurface salt caverns* distributed among the four storage sites, as described in Section 1.2.6. The salt caverns were created in naturally occurring underground salt domes through a process called "solution mining." The process involves drilling a well into the salt formation, then injecting fresh water to dissolve the salt and create a cavern. It takes seven barrels of raw water to dissolve enough salt to create one 1 bbl of storage space.

There are two basic types of storage caverns in use. Phase I, or early storage reserve (ESR) caverns, were created prior to the establishment of the SPR (some are more than 60 years old) for commercial mining of brine. These pre-existing caverns provided storage capacity to quickly establish the SPR, but were not designed for the purpose of storing petroleum products. The irregular cavern shapes, shallow depths, and spacing between caverns have resulted in geo-mechanical and structural challenges that make them unsuitable for conducting multiple drawdowns. Most of these caverns are commonly referred to as "single-cycle drawdown" caverns, meaning that they are available for use for only a single drawdown. Storage volumes in ESR caverns range in size from 8 to 37 MMbbl. Figure 8 is a depiction of an ESR cavern (West Hackberry 9) that was developed through sonar data.

Phase II and Phase III caverns have been specifically designed for long-term crude oil storage. The standard DOE-designed cavern is cylindrically shaped, tapering slightly from the top to the bottom of the cavern. These caverns are about 200 feet in diameter and 2,500 feet in vertical height, with the bottom of the cavern at typically 4,000–5,000 feet below the earth's surface, and have been designed for five drawdown cycles. Typical storage volumes in these caverns range in size between 10 and 12 MMbbl. Cavern pressures vary by individual cavern and SPR site, with standard operating cavern pressures between 600 and 1,030 pounds per square inch (psi). Figure 9 is a depiction of an SPR cavern (Big Hill 101) that was developed through sonar data.

Figure 8: Depiction of ESR Cavern West Hackberry

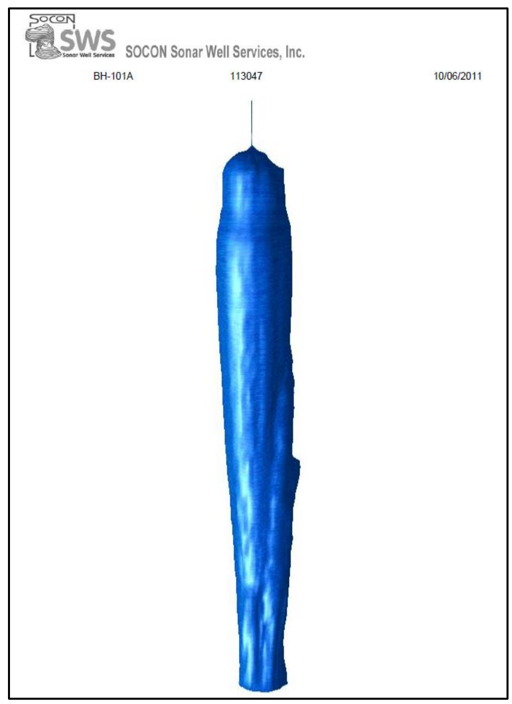

Figure 9: Depiction of SPR Cavern Big Hill

2.4.2 Storage Cavern Wells

Each storage cavern is accessed via three types of *cavern wells*, which allow for the flow of oil, brine, and raw water into and out of the caverns. Dedicated oil wells have a single open pipe for the flow of oil.

Dedicated brine wells consist of lengths of piping sections that are suspended to near the bottom of the caverns, and are designed to transport raw water or brine into or out of the cavern. Combined wells are found in single well caverns only, and consist of a brine pipe suspended within an oil well; brine and raw water flow through the brine pipe and oil flows through the annular space between the brine pipe and the cemented well casing. The number of wells per cavern varies throughout the SPR.

Table 8 describes the key parameters of the SPR's operational storage caverns and wells.

Cavern Number	Cavern Type	Crude Stream	Design Storage Capacity (MMbbl)	Total Number of Wells	Number of Oil Wells	Number of Brine Wells	Number of Combined Wells	Remaining Drawdowns
Bayou Choctaw								
BC 15	ESR	Sour	16.1	2	1	1	0	1
BC 17	ESR	Sour	11.6	2	1	1	0	1
BC 18	ESR	Sweet	15.0	2	1	1	0	1
BC 19	ESR	Sour	11.9	2	1	1	0	1
BC 101	SPR	Sour	12.4	2	1	1	0	1
BC 102	SPR	Sweet	9.0	2	1	1	0	5
West Hackberry								
WH 7	ESR	Sweet	12.6	2	1	1	0	5
WH 8	ESR	Sour	9.763	2	1	1	0	2
WH 9	ESR	Sour	8.86	3	2	1	0	1
WH 11	ESR	Sour	8.035	3	2	1	0	5
WH 101	SPR	Sweet	10.4	1	0	0	1	5
WH 102	SPR	Sweet	10.3	1	0	0	1	5
WH 103	SPR	Sweet	9.6	1	0	0	1	5
WH 104	SPR	Sweet	10.5	1	0	0	1	5
WH 105	SPR	Sour	11.225	1	0	0	1	5
WH 106	SPR	Sour	10.575	1	0	0	1	5
WH 107	SPR	Sweet	10.8	1	0	0	1	5
WH 108	SPR	Sweet	10.7	1	0	0	1	5
WH 109	SPR	Sour	11.222	1	0	0	1	5
WH 110	SPR	Sweet	11.0	1	0	0	1	5
WH 111	SPR	Sour	9.33	1	0	0	1	5
WH 112	SPR	Sour	10.59	1	0	0	1	5
WH 113	SPR	Sweet	10.975	1	0	0	1	5
WH 114	SPR	Sour	10.73	1	0	0	1	5
WH 115	SPR	Sour	10.57	1	0	0	1	5
WH 116	SPR	Sweet	10.9	1	0	0	1	5
WH 117	SPR	Sour	11.7	2	1	1	0	5

Cavern Number	Cavern Type	Crude Stream	Design Storage Capacity (MMbbl)	Total Number of Wells	Number of Oil Wells	Number of Brine Wells	Number of Combined Wells	Remaining Drawdowns
Big Hill								
BH 101	SPR	Sweet	11.6	2	1	1	0	3
BH 102	SPR	Sweet	11.75	2	1	1	0	4
BH 103	SPR	Sweet	11.8	2	1	1	0	4
BH 104	SPR	Sweet	12.3	2	1	1	0	3
BH 105	SPR	Sweet	12.25	2	1	1	0	4
BH 106	SPR	Sour	12.6	2	1	1	0	4
BH 107	SPR	Sour	11.8	2	1	1	0	4
BH 108	SPR	Sour	11.05	2	1	1	0	5
BH 109	SPR	Sour	12.55	2	1	1	0	5
BH 110	SPR	Sour	12.15	2	1	1	0	5
BH 111	SPR	Sour	13.05	2	1	1	0	4
BH 112	SPR	Sour	12.7	2	1	1	0	3
BH 113	SPR	Sour	12.1	2	1	1	0	3
BH 114	SPR	Sweet	12.3	2	1	1	0	5
Bryan Mound								
BM 1	ESR	Sour	7.2	1	0	0	1	1
BM 4	ESR	Sweet	21.6	3	1	2	0	1
BM 5	ESR	Sour	37.439	3	1	2	0	1
BM 101	SPR	Sour	13.124	2	1	1	0	5
BM 102	SPR	Sour	11.422	2	1	1	0	5
BM 103	SPR	Sour	11.718	2	1	1	0	5
BM 104	SPR	Sour	11.411	3	2	1	0	5
BM 105	SPR	Sour	11.229	2	1	1	0	5
BM 106	SPR	Sweet	13.173	3	1	2	0	5
BM 107	SPR	Sour	12.319	3	2	1	0	5
BM 108	SPR	Sour	12.017	3	2	1	0	5
BM 109	SPR	Sour	12.729	3	2	1	0	5
BM 110	SPR	Sour	11.5	3	2	1	0	5
BM 111	SPR	Sour	12.205	2	1	1	0	5
BM 112	SPR	Sour	12.1	2	1	1	0	5
BM 113	SPR	Sweet	6.65	2	1	1	0	5
BM 114	SPR	Sweet	8.596	2	1	1	0	5
BM 115	SPR	Sweet	9.977	2	1	1	0	5
BM 116	SPR	Sweet	10.732	2	1	1	0	5

Table 8: Key Parameters of the SPR's Operational Storage Caverns and Wells

2.4.3 Brine Disposal Wells

The brine disposal system discussed in Section 2.3.3 also includes *brine disposal wells* at both the Bayou Choctaw and West Hackberry sites. Brine is physically disposed of by injection into 12 individual brine disposal wells at the Bayou Choctaw site and nine individual disposal wells at the West Hackberry site. Brine is pumped through a disposal pipeline to the well site, where it is injected to the underground wells. The brine disposal rate is the controlling factor for the rate of oil injection during oil filling operations; therefore, any decreases in disposal capacity will decrease the rate of fill. The salinity of the brine must also be kept at 95% saturation or higher. The higher brine saturation keeps the water from swelling the clays in the underground disposal beds, which would result in reduced disposal rates. As the wells are used, they require specialized maintenance through processes of recompleting the wells at different injection zones, as well as cleaning and flushing.

Table 9 provides a summary of the brine disposal wells located at the Bayou Choctaw and West Hackberry SPR sites.

Bayou Choctaw Brine Disposal Well Summary				West Hackberry Brine Disposal Well Summary		
Well	**Depth**	**Design Disposal Rate (Mbbl/d)**		**Well**	**Depth**	**Design Disposal Rate (Mbbl/d)**
1	4,452	18		1A	4,722	44
2	4,527	18		1B	4,537	40
3	4,332	4		1C	5,513	45
4	4,808	4		2	3,626	23
5	4,512	15		2A	6,302	42
6	3,986	7		2B	3,404	30
7	4,550	12		2C	5,372	18
8	4,366	18		2D	1,702	37
9	4,053	12		2E	5,304	43
10	3,712	30				
11	3,991	38				
12	6,461	30				
Disposal Rate Capability: 206 Mbbl/d				**Disposal Rate Capability: 322 Mbbl/d**		

Table 9: West Hackberry and Bayou Choctaw Brine Disposal Well Summaries

2.5 SPECIALIZED INFRASTRUCTURE

In addition to surface and subsurface infrastructure, the SPR has additional infrastructure assets that can be considered as specialized infrastructure. A description of this infrastructure follows.

2.5.1 Crude Oil Processing (Degasification) Plant

Long-term storage of crude oil in deep salt caverns subjects the oil to geothermal heating and gas intrusion from the surrounding salt, which increases the crude oil's vapor pressure. During a drawdown, oil that is delivered to storage tanks at receiving terminals has the potential to release toxic and flammable vapors at levels that can present environmental and health risks to terminal personnel as these vapors come out of solution with the oil. To ensure compliance with applicable regulatory requirements, the SPR mitigates the risks posed by these gases through the use of a customized, transportable *crude oil degasification plant*, shown in Figure 10. The degasification plant processes the crude oil stored in the SPR's storage caverns to reduce the oil's vapor pressure, ensuring that the crude oil can be delivered safely. Depending on the specific SPR site and the volume of crude oil required to be processed, the degasification plant typically takes two to four years to process the crude oil at one of the sites. Once processing at a site is completed, the plant is moved to the next SPR site scheduled for crude oil processing. Each site requires crude oil processing approximately every 15–20 years.

Figure 10: SPR Crude Oil Degasification Plant

2.5.2 Crude Oil Laboratories

Each SPR site has a *crude oil laboratory* equipped to perform the basic analyses required for crude oil storage, as well as for conducting environmental testing. The labs perform various analyses of crude oil samples to ensure that the quality of the crude oil is within the specified limits. Testing includes analyses for sulfur content, density, sediment content, water content, and background radiation. The labs also conduct environmental tests on both potable water and process water streams.

2.5.3 Recovery Program Equipment

The SPR Recovery Program is a comprehensive plan meant to address a range of potential critical equipment outages at SPR storage sites and command locations. This program is designed to provide a level of redundancy for SPR operational readiness in the event of a loss of operations at one or more SPR storage sites from natural disasters (such as hurricanes) or other incident-specific events impacting the SPR's drawdown capabilities. An inter-agency agreement is in effect with the United States Army Corps of Engineers for the use of barge-mounted pumps and electrical generators to replace a site's raw water intake structure pumping capability. Transportable *SPR-owned drawdown-critical recovery program equipment* consisting of skid-mounted diesel pumps, piping, valves, and electrical transformers is stored at a leased offsite warehouse. The equipment can be transported to any of the sites, where it can be connected to existing site infrastructure for use in a drawdown. While this equipment does provide a level of operational redundancy, site drawdown capability is limited to 85% of the maximum site drawdown rate for a single site or 65% of the maximum combined drawdown rate for two sites.

2.5.4 St. James Terminal

DOE owns the St. James marine terminal (105 acres at the main terminal and approximately 48 acres adjacent to the Mississippi River), which is currently under a 20-year long-term lease to a private sector company (the current lease expires December 31, 2017). The St. James marine terminal facility consists of six crude oil storage tanks with a total storage capacity of 2 MMbbl (four 400 Mbbl tanks and two 200 Mbbl tanks), two marine docks, two pump stations, two metering stations, and a crude oil laboratory.

The terminal has pipeline distribution connections to the nearby Capline, LOCAP, and Plains terminals, as well as the midstream pipeline networks connected to these terminals, and supports the Bayou Choctaw site during drawdown and fill operations through a 37.2-mile, 36-inch pipeline connection to the site. Additional discussion of the St. James terminal is included in the following section of this report.

2.5.5 DOE-Owned Off-site Pipelines

DOE-owned off-site crude oil pipelines connect the SPR's storage sites and sales delivery points. There are 172.5 miles of off-site pipelines, ranging in size from 30–42 inches in diameter. These pipelines are maintained in accordance with the requirements of the United States Department of Transportation's pipeline integrity management program. For DOE-owned and operated off-site pipelines, a leak detection system continuously monitors pipeline pressure and flow data to identify any leaks. Each pipeline is equipped with remotely operated emergency shutdown valves between the sites and sales delivery points in order to isolate sections of the pipelines in the event of a pipeline failure.

2.6 INFRASTRUCTURE CHALLENGES

The SPR's energy security capabilities depend on the reliability of the SPR's infrastructure. The SPR faces a growing number of challenges with regard to both surface and subsurface infrastructure, and these challenges are magnified by the passage of both the Bipartisan Budget Act of 2015 and the FAST Act, which require SPR infrastructure to withstand the rigors of nine consecutive years of upcoming high-volume drawdown operations.

In 2014, DOE conducted an internal review of the SPR capabilities and infrastructure. The review objectives included: (1) comparing the SPR's current operational capability to performance criteria, (2) identifying gaps within its storage infrastructure and distribution system, and (3) identifying the requirements needed to address gaps in the storage infrastructure for both surface and subsurface assets. The review concluded that significant investment in infrastructure and equipment is required to ensure that the SPR can fulfill its mission.

A separate audit report by DOE's Office of the Inspector General[14] found that although DOE generally maintained the SPR to ensure operational readiness, the SPR did not meet all of its Level I technical performance criteria. The audit reported that due to the suspension and deferral of various maintenance and remediation activities, the SPR was unable to achieve the drawdown rate specified in its performance criteria, that it could not store oil at its full capacity, and that it had not ensured that its full inventory was available for drawdown.

This section summarizes the significant challenges facing the SPR's surface and subsurface infrastructure, as well as current and potential future impacts.

2.6.1 Surface Infrastructure Challenges

Aging Infrastructure

Most of the SPR's current equipment was initially installed between the SPR's establishment in 1975 and the completion of the Big Hill storage site in 1991, with a design life of 25 years. Between 1993 and 2000, under the Life Extension Master Plan, the SPR undertook an equipment upgrade program called the Life Extension Program (LEP).[15] Prior to 1993, the systems at the SPR storage sites had become overly complex, poorly integrated, extremely costly to maintain, and had unacceptably low reliability.

The objective of the LEP was assurance in being able to achieve the SPR's maximum rate for drawdown capability. This was ultimately accomplished by considering four areas: equipment availability, system simplification, maintainability, and operability. While simultaneously accommodating drawdown rate enhancements, the LEP simplified operations by streamlining the equipment configuration at the cavern sites, reduced the possibility of operator error, and facilitated control of site operations from centralized control rooms.

LEP I was successful in accomplishing its objective; however, it did not address the need for replacement or upgrade of a significant amount of equipment across multiple systems. Consequently, this equipment today is near, at, or beyond the end of its design life. In addition to this equipment, other equipment that was replaced during LEP I is also approaching its 25-year design life, with more than 70% of the SPR's equipment and infrastructure needed for SPR crude oil operations exceeding its serviceable life.[16]

[14] DOE/IG-0916. (July 2014).

[15] With the advent of proposals for a second Life Extension Program (LEP II), the earlier LEP is now commonly referred to as LEP I.

[16] U.S. DOE. (May 2015a). *Strategic Petroleum Reserve, Life Extension Phase II, Mission Need Statement, CD-0 for a Major Acquisition Project*. Office of Petroleum Reserves.

Deferred Major Maintenance

The SPR's major maintenance program focuses on maintaining, upgrading, and prolonging the life of the Reserve's physical assets. A major maintenance project is defined as a single undertaking involving design, procurement, construction, fabrication, installation, and testing, or some combination thereof, which has a total estimated cost of $100,000 or greater.

This program is the primary vehicle used for any significant repair and replacement of the SPR's systems and equipment. With a significant amount of equipment near, at, or beyond the end of its design life, the level of major maintenance project activity required to keep pace with equipment repair and replacement has substantially increased over the past five years. However, a challenging budget environment, an increase in the number and severity of equipment failures, and escalating costs associated with equipment repair and replacement have caused more projects to be deferred beyond their scheduled timeframe, resulting in an extensive major maintenance backlog. Between the end of FY 2013 and the end of FY 2015, this backlog increased from approximately $53.5 million to $79.8 million. This has contributed to several equipment failures that have impacted the SPR's operational readiness capability until repairs could be made.[17]

2.6.2 Subsurface Infrastructure Challenges

Cavern Storage Capacity

Cavern Decommissioning: When the structural integrity of a cavern is in doubt, when the condition of the wells threatens a cavern's reliability, or when the condition of a cavern or well poses a threat to the environment, it must be decommissioned. Two SPR caverns were decommissioned in 2015, which resulted in the loss of 13.5 MMbbl of design storage capacity. While there are currently no indications that additional caverns will need to be decommissioned in the immediate future, further cavern decommissioning could reduce the SPR's design storage capacity to a level that is problematic for storage of the SPR's existing inventory.

Capacity Maintenance: In 2011, the SPR established a capacity maintenance program with the objective of incrementally expanding the SPR's storage capacity. To accomplish this, cavern leaching using raw water dissolved existing cavern salt at a small group of caverns with sufficient salt content that were known to be geo-mechanically stable to increase storage capacity at all SPR sites with the exception of Bayou Choctaw. Simultaneously, Sandia National Laboratories[18] was tasked with analyzing and evaluating the feasibility of applying cavern leaching throughout the SPR's storage cavern system to determine potential capacity expansion based on geo-mechanical properties of the individual caverns. Although this analysis determined limited additional capacity expansion was possible beyond the approximately 9.1 MMbbl of additional storage capacity initially created, there were unintended consequences associated with this program. The leaching operations resulted in considerable equipment wear and fatigue of drawdown-critical equipment, significantly increased equipment

[17] In one instance, an equipment failure of an above-ground storage tank at Bryan Mound will continue to impact the site's actual drawdown rate until repairs can be effected.
[18] Sandia National Laboratories provides geo-technical support services to the SPR.

maintenance requirements and associated costs, and substantially increased the cost of electrical power contracts. It was also determined that additional high cost surface and subsurface infrastructure modifications would be required for the program to continue. Due to the need to address higher priority issues within existing program funding constraints, as well as the potential longer-term impact on drawdown-critical equipment, the program was terminated in 2013.

Cavern Creep: One of the challenges associated with accommodating the SPR's crude oil inventory is the loss of storage capacity due to cavern creep. This phenomenon, in which the SPR's physical cavern storage capacity shrinks each year, consists of both natural creep caused by pressure on the salt structure and induced creep, which occurs whenever a cavern must be de-pressurized to work on a cavern well. Historical data indicates that the SPR loses approximately 20 Mbbl/year/cavern of storage on average, or approximately 1.2 MMbbl/year across the SPR, due to natural creep. The SPR also loses approximately 100 Mbbl per cavern per workover of a well, which equates to approximately 1 MMbbl of storage capacity loss across the SPR per year, based on an average of 10 well workovers per year. This amounts to a total average capacity loss of approximately 2.2 MMbbl/year across the SPR. Over 25 years, this will result in the loss of approximately 55 MMbbl of cavern storage capacity.

Required Cavern Ullage: Cavern ullage is the difference between the amount of actual storage capacity available and the amount of crude oil inventory in the SPR's storage caverns. Based on the SPR's current crude oil inventory level of 695.1 MMbbl and a current design storage capacity of 713.5 MMbbl, the total cavern ullage is approximately 18.4 MMbbl, or approximately 2.6% of current inventory. The ullage should be a minimum of 10% of the crude oil inventory level to ensure that sufficient storage capacity is available to address exigent circumstances, such as the unanticipated need to decommission a cavern, or the acquisition of additional inventory. This operating requirement must be taken into account when determining the future storage capacity and configuration of the SPR.

ESR Caverns: There are 11 operational ESR caverns with a total design storage capacity of a little more than 160 MMbbl. A November 2015 assessment of these ESR caverns indicated that 8 of the 11 caverns, representing approximately 129.9 MMbbl of design storage capacity, have one remaining drawdown left. With the upcoming SPR crude oil sales, a decision will have to be made about whether to drawdown crude oil stored in ESR caverns as part of these sales, as this would have both an immediate and long-term impact on the SPR's overall design storage capacity. Taking creep loss and required cavern ullage into account and assuming that no additional caverns are decommissioned, a drawdown of 25% of single-cycle drawdown ESR cavern capacity (32.5 MMbbl) is feasible if the inventory level after the sales is no more than 569 MMbbl and the inventory level will not be rebuilt. A drawdown of 50% of single-cycle drawdown ESR cavern capacity (65 MMbbl) is feasible only if the inventory level after the sales is no more than 542 MMbbl and the inventory level will not be rebuilt. Therefore, the decision to drawdown any single-cycle drawdown ESR caverns should be informed by SPR size policy and storage capacity requirements.

New Storage Caverns: Table 10 is a summary of requirements for new storage caverns for three example cases of inventory levels of 610, 630, or 695 MMbbl. The number of new storage caverns required to accommodate these inventory levels are two (each 10 MMbbl capacity), four (each 10 MMbbl capacity), and 10 (4−10 MMbbl capacity and 6–12 MMbbl capacity) caverns, respectively.

New Storage Capacity – Planning Factors	MMbbl Requiring 2 New Caverns	MMbbl Requiring 4 New Caverns	MMbbl Requiring 10 New Caverns
Inventory Level	610	630	695
10% Ullage Level	61	63	69.5
Natural Creep Loss	30.6	31.2	33
Induced Creep Loss	26.5	26.5	28
New Storage Capacity Required	728.1	750.7	825.5
Current Design Storage Capacity	713.5	713.5	713.5
Additional Storage Capacity Required	14.6	37.2	112.0

Table 10: New Storage Cavern Requirements[19]

The cost to develop and construct a new storage cavern is approximately $10 million/MMbbl of storage capacity, plus an additional $20 million/cavern for two wells and associated equipment. Based on this cost, new storage capacity requirements to meet example inventory levels of 610, 630, or 695 MMbbl would cost $240 million, $480 million, and $1.32 billion, respectively, at the approximated cost level.

Additional costs associated with land acquisition could be required, depending on the cavern location. While the West Hackberry and Big Hill sites have sufficient land available on the existing salt dome for cavern expansion activities, additional land is not available on the Bryan Mound and Bayou Choctaw sites. It would take approximately 5–8 years from commencement of planning activities until a cavern is operationally available.

An inventory level of 598 MMbbl is the maximum size at which no new additional storage capacity would be required. This assumes the natural creep rate and the number of annual well workovers remain constant over time, and the 60 existing storage caverns currently in operational service remain available to meet future storage requirements. However, this would preclude the use of any single-cycle drawdown ESR cavern during the upcoming mandated sales.

Storage Capacity Relationship to Future SPR Site Configuration: Storage capacity issues must inform any decision regarding future SPR site configuration. The SPR's crude oil inventory level after

[19] Assumptions: All 60 existing storage caverns remain operational for 25 years, and new additional caverns are available in 10 years. Natural creep loss is calculated at 20 Mbbl/year per cavern based on 25 years for the 60 existing caverns (total of 30 MMbbl) and 20 Mbbl/year per cavern based on 15 years for an additional two, four, or 10 caverns (total of 0.6, 1.2, and 3.0 MMbbl, respectively) for a total natural creep loss of 30.6 MMbbl, 31.2 MMbbl, and 33 MMbbl for either 62, 64, or 70 caverns, respectively. Induced creep loss is calculated at 100 Mbbl per workover at 10 workovers per year for 10 years for 60 caverns, plus either 100 Mbbl per workover at 11 workovers per year for 15 years for either 62 or 64 caverns (an increase of 1 workover/year from the current average for an additional two or four caverns) or 100 Mbbl per workover at 12 workovers per year for 15 years for 70 caverns (an increase of two workovers per year from the current average for an additional 10 caverns). This results in an induced creep loss of 26.5 MMbbl for either 62 or 64 caverns, and an induced creep loss of 28 MMbbl for 70 caverns, over 25 years.

completion of the upcoming mandated and authorized sales is anticipated to be 536–574 MMbbl,[20] depending on how much oil is sold for SPR modernization. An issue for consideration is whether the SPR's crude oil inventory level after sales makes the closure of one of the existing sites feasible. One aspect of addressing this issue is through an analysis of storage capacity. Table 11 shows the impact on the SPR's design storage capacity of closing each one of the SPR's four storage sites, and how this compares with the minimum storage capacity required to support various inventory levels after sales, taking into account the need to maintain a ullage level of 10% of total inventory and to account for creep losses over a 25-year period.[21]

SPR Storage Site Status	Total Available SPR Storage Capacity (MMbbl)	Required Storage Capacity			
		536 MMbbl Inventory + 10% Ullage + Creep Loss	549 MMbbl Inventory + 10% Ullage + Creep Loss	571 MMbbl Inventory + 10% Ullage + Creep Loss	574 MMbbl Inventory + 10% Ullage + Creep Loss
All sites open	713.5	644.6	658.9	683.1	686.4
Bayou Choctaw closed	637.5	629.9	654.1	678.3	681.6
West Hackberry closed	493.1	635.3	649.6	673.8	677.1
Big Hill closed	543.5	637.1	651.4	675.6	678.9
Bryan Mound closed	466.4	635.9	650.2	674.4	677.7

Table 11: Impact of SPR Site Closure on Required Storage Capacity

The results contained in Table 11 indicate that over the range of anticipated SPR crude oil inventory levels remaining after the upcoming mandated and authorized sales, the required storage capacity would exceed the total available storage capacity of the SPR under all conditions, with the exception of a site closure of Bayou Choctaw and an SPR inventory level of 536 MMbbl.

Drawdown Rate Impacts: While several factors can affect the SPR's drawdown rate, the primary driver is the number of operational storage caverns and their fill level. Figure 11 shows the drawdown profile for the current SPR configuration of 60 operational caverns with a crude oil inventory level of 695.1 MMbbl.

[20] This inventory level range is based on outcomes of the economic modeling discussed in more detail in Chapter 4.
[21] The 25-year creep losses will vary based on site closure. Calculations assume that all caverns at a closed site are decommissioned in 2026, resulting in 10 years of natural creep losses for a closed site versus 25 years. Calculations also assume a reduction in the number of cavern workovers across the SPR from 10 to 8 per year after a site closure due to a reduced number of caverns.

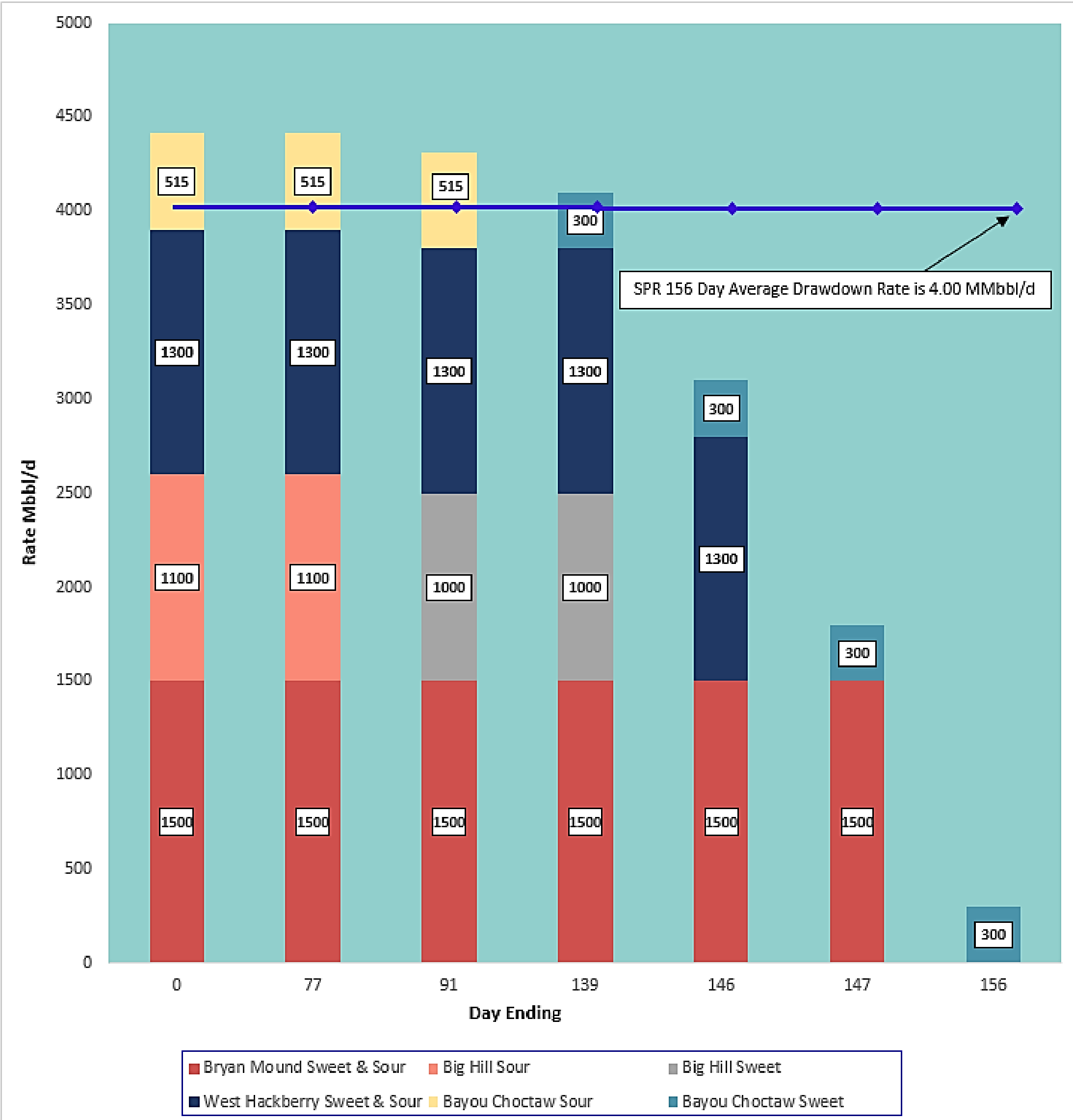

Figure 11: SPR Drawdown Capability for a 695.1 MMbbl Inventory

DOE can model the impact on the SPR's drawdown rate for varying inventory sizes and site configurations, which calculates the maximum days of availability for each SPR stream for a maximum drawdown rate.[22] Table 12 provides a comparison of the drawdown profile for various SPR crude oil inventory levels. As indicated in the table, the SPR can sustain a maximum drawdown rate of 4.1–4.3 MMbbl/d for 90 days. For all starting inventory levels except 430 MMbbl, as the number of caverns with stored oil decreases, the length of time for which a maximum drawdown rate can be sustained decreases. It would take 156 days to deplete a starting inventory of 695 MMbbl to a 10% inventory level, but only 90 days to deplete a starting inventory of 430 MMbbl to a 10% inventory level.

[22] The model assumes that 10% of the crude oil inventory remains in the caverns, all caverns are available for drawdown, and the drawdown is proportional across streams.

SPR Drawdown Rates (MMbbl/d)							
Starting Inventory	At 60 Days	At 90 Days	At 105 Days	At 110 Days	At 120 Days	At 125 Days	At 156 Days
695	4.4	4.3	4.1	4.1	4.1	4.1	Inventory Depleted to 10% Level
630	4.4	4.1	4.1	4.1	4.1	3.1	Inventory Depleted to 10% Level
570	4.4	4.1	4.1	4.1	0.3	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level
544	4.3	4.1	3.1	3.1	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level
530	4.3	4.1	3.1	0.3	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level
430	4.1	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level	Inventory Depleted to 10% Level

Table 12: SPR Maximum Drawdown Rates at Various Inventory Sizes

Cavern Wells

Well Integrity and Remediation: There are a total of 113 operational wells in the 60 operational storage caverns throughout the four SPR storage sites. In order to ensure well safety and flow integrity, as well as to maintain compliance with state laws and regulations governing underground storage, the SPR established a casing inspection and cavern remediation program in 2010. As part of this program, each well undergoes a periodic diagnostic workover using a multi-arm caliper survey to determine the condition of the well. This is important because wells can be compromised over time due to changing geological conditions within a salt dome, falling salt within a cavern that damages well piping, or failure of equipment seals or the cement in well casings. Additionally, state regulations require that a mechanical integrity test be conducted on each well every five years to ensure the integrity of the well. If a problem with the well is discovered, the well must undergo a remediation workover, at an average cost of $2 million, to correct the problem.

Concurrent with the establishment of the program, the SPR developed a well condition assessment database for use in tracking the condition of all SPR wells. It also assists with the development of annual program funding requirements, as well as workover schedule planning and execution. As of May 2016, slightly more than 27% of all SPR wells (31 of 113) have either been remediated (24) or require a remediation (7). An additional 35% of the wells require enhanced monitoring due to anomalies observed during previous multi-arm caliper surveys.

Crude Oil Inventory Availability: Over the past year, as much as 22% (or approximately 153 MMbbl) of the SPR's total crude oil inventory has been unavailable to be used in the event of a drawdown at any given time because of well remediation and diagnostic workovers, cavern integrity issues, state-mandated mechanical integrity tests on caverns, or unanticipated well failures. A weekly cavern inventory status report produced by the SPR's PMO since summer 2013 tracks key parameters of all SPR caverns, including the amount of crude oil unavailable for drawdown. Since the initiation of this report, the amount of unavailable crude oil, on average, has been approximately 90–95 MMbbl during any given month, with a current unavailability level (as of mid-May 2016) of 81.1 MMbbl. Also, approximately 12 MMbbl of additional crude oil inventory is considered "roof" oil (oil that is required to remain in caverns in order to prevent damage to cavern roofs during full cavern drawdowns) and is also considered to be unavailable for drawdown. Issues associated with wells will result in the continued unavailability of a percentage of the SPR's inventory at any given time. This should inform any decision regarding future SPR inventory levels, as well as the potential impacts on operational readiness capabilities.

CHAPTER 3 – SPR DISTRIBUTION

In order for the SPR to fulfill its mission, it must have the ability to drawdown crude oil and distribute that oil to refineries. This chapter describes the connections to markets from the SPR sites and their drawdown and distribution capabilities. Section 3.2 reviews distribution contracts held by the SPR. Sections 3.3 and 3.4 discuss how the changing U.S. crude oil supply patterns and infrastructure may limit distribution capability.

The ability to move SPR oil to market is assessed using three criteria:

1. **Design Drawdown Rate:** the maximum drawdown rate that crude oil can be pumped out of SPR storage caverns if the entire system is activated and fully functional.

2. **Physical Distribution Capability:** the actual physical connectivity that the SPR maintains to physical distribution assets, such as pipelines, refineries, and terminals.

3. **Effective Distribution Capability:** the distribution rate at which SPR crude oil can be *incrementally* added to the oil market in the event of a supply disruption without displacing domestic production or Canadian imports.

These concepts will be discussed in greater detail later in this chapter.

3.1 DISTRIBUTION SYSTEMS

Table 13 presents the storage capacity and design drawdown rate of each SPR site and identifies connected refinery hubs, major pipelines, and marine terminal facilities. The SPR sites are connected to midstream assets within three distribution systems: Seaway, Texoma, and Capline.

System	Site	Design Storage Capacity (MMbbl)	Design Drawdown Rate (MMbbl/d)	Connected Refinery Hubs	Connected Major Pipelines	Connected Marine Facilities
Seaway	Bryan Mound	247.1	1.5	Houston/ Texas City/ Freeport	Seaway to Houston	Seaway Freeport, Seaway Texas City
Texoma	Big Hill	170.0	1.1	Beaumont/ Port Arthur	Shell to Clovelly, Sunoco Logistics to Mid-Valley to Midwest	Sunoco Logistics Nederland, Phillips 66 Beaumont
	West Hackberry	220.4	1.3	Beaumont/ Port Arthur/ Lake Charles	Shell to Clovelly, Sunoco Logistics to Mid-Valley to Midwest	Sunoco Logistics Nederland
Capline	Bayou Choctaw	76.0	0.515	Mississippi River Area, Baton Rouge Area	Capline to Midwest	Shell St. James
SPR Total		**713.5**	**4.415**			

Table 13: Summary of Design Systems, Drawdown Capacities, and Connections

Figures 12 through 14 diagram the facilities associated with the Seaway, Texoma, and Capline systems. SPR facilities are shown as red circles, pipelines are in red, terminals are shown as blue squares, and refineries are grey hexagons.[23] Terminals with marine facilities are indicated with ship icons.

3.1.1 Seaway System

The Seaway System (Figure 12) includes the Bryan Mound SPR site. Bryan Mound has a design drawdown rate of 1.5 MMbbl/d and is connected to three terminals via DOE-owned pipelines (DE): Seaway Jones Creek (DE 30”), Seaway Freeport (DE 30”), and Seaway Texas City (DE 40”). From the Seaway Freeport terminal, Bryan Mound SPR crude can be loaded onto marine vessels at the terminal’s dock, delivered by pipeline to the Seaway Jones Creek terminal, or delivered by pipeline to the nearby Phillips Freeport Facility (not shown in Figure 12) where the crude can be further shipped to the Phillips 66 Sweeny refinery. From Seaway Texas City, SPR crude can be moved to refineries in the Texas City area or shipped further to the Seaway Texas City marine terminal for marine out-loading. From Seaway Jones Creek, Bryan Mound crude has access to Houston area refineries via a Seaway (SW) pipeline (SW 36”) to the Enterprise Crude Houston (ECHO) terminal.

Two pipelines allow Bryan Mound to move crude east into the Texoma System, which is centered on refineries in the Beaumont-Port Arthur and Lake Charles areas. From the ECHO terminal, SPR crude can move to Texoma directly via a Seaway pipeline (SW 30”) or can be moved to Magellan’s East Houston

[23] The diagrams depict commercial infrastructure at the time of printing. Given the continuing evolution of the midstream oil sector in the U.S. Gulf Coast, specific aspects of these maps will change over time.

terminal and then shipped into Texoma on the Zydeco pipeline (Shell [SH] 20” segment running from Houston to Beaumont; formerly the Shell Houston-to-Houma or “Ho-Ho” pipeline).

Since 2011, changes in the Houston area crude oil market have been profound. Several new pipelines have come online, bringing crude into Houston from the Permian Basin in West Texas, from the Cushing hub in Oklahoma, and from the Eagle Ford Formation in South Texas. These new pipelines have flooded the Houston refining market with new crude supplies, leaving minimal spare capacity within the regional distribution system to move SPR crude without displacing domestic flows. Furthermore, the recent reversal and expansion of the Seaway pipeline from Cushing (SW 2x30” on the far left side of Figure 12) has eliminated connectivity for SPR crude into the Midcontinent refining market.

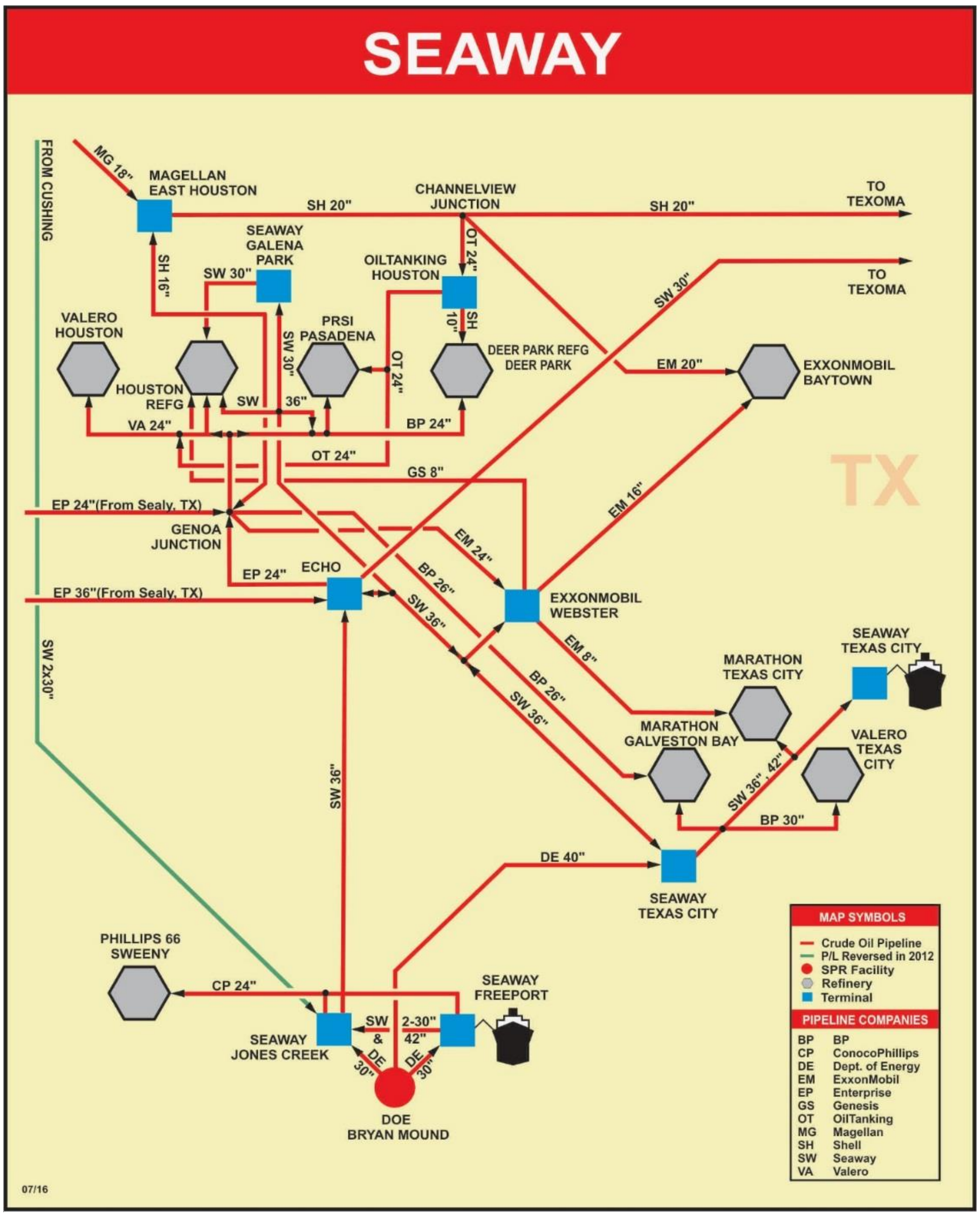

Figure 12: Seaway System Diagram

3.1.2 Texoma System

The Texoma System (Figure 13) includes the Big Hill and West Hackberry SPR sites. Big Hill has a design drawdown rate of 1.1 MMbbl/d and is near four refineries in the Beaumont-Port Arthur area, as well as the Sunoco Logistics Nederland and Phillips 66 Beaumont marine terminals. The West Hackberry site has a design drawdown rate of 1.3 MMbbl/d and is near refineries in the Lake Charles area. West Hackberry is also connected via a DOE-owned pipeline to the Beaumont-Port Arthur refinery area.

Both Big Hill and West Hackberry have connectivity to the Beaumont-Port Arthur and Lake Charles refineries; the Sunoco Logistics terminal in Nederland; the Sunoco Logistics pipelines to Longview, TX (Sun [SU] 10” and SU 12”); and the Zydeco pipeline to Houma, LA (SH 22”), which provides a connection to the Capline system. From Longview, SPR crude can be shipped along the Mid-Valley (MV) pipeline (MV 20”) into the Midwest refining market. Big Hill is also connected to the Phillips 66 marine terminal in Beaumont.

Inbound oil pipelines from the Houston area include Shell’s Zydeco pipeline (SH 20”) and the Seaway Echo connection (SW 30”); both are shown in the lower left of Figure 13. The Zydeco pipeline involved the reversal of a pipeline that previously carried crude oil from Houma, LA to Houston, TX via the Beaumont-Port Arthur area. The reversal of this line eliminated pipeline connectivity from the Big Hill and West Hackberry SPR sites to the Houston area refineries.

As with the Seaway System, the Texoma System has been flooded with new North American crude supplies in recent years, including new supply via TransCanada’s Cushing Marketlink, which supplies crude into the Sunoco Logistics Nederland terminal from Cushing, OK; via the West Texas Gulf pipeline from the Permian Basin; and via the Seaway ECHO and the Zydeco pipelines from Houston. These new supplies provide limited capacity for the Big Hill and West Hackberry SPR sites to push incremental barrels into the system without disrupting existing commercial flows.

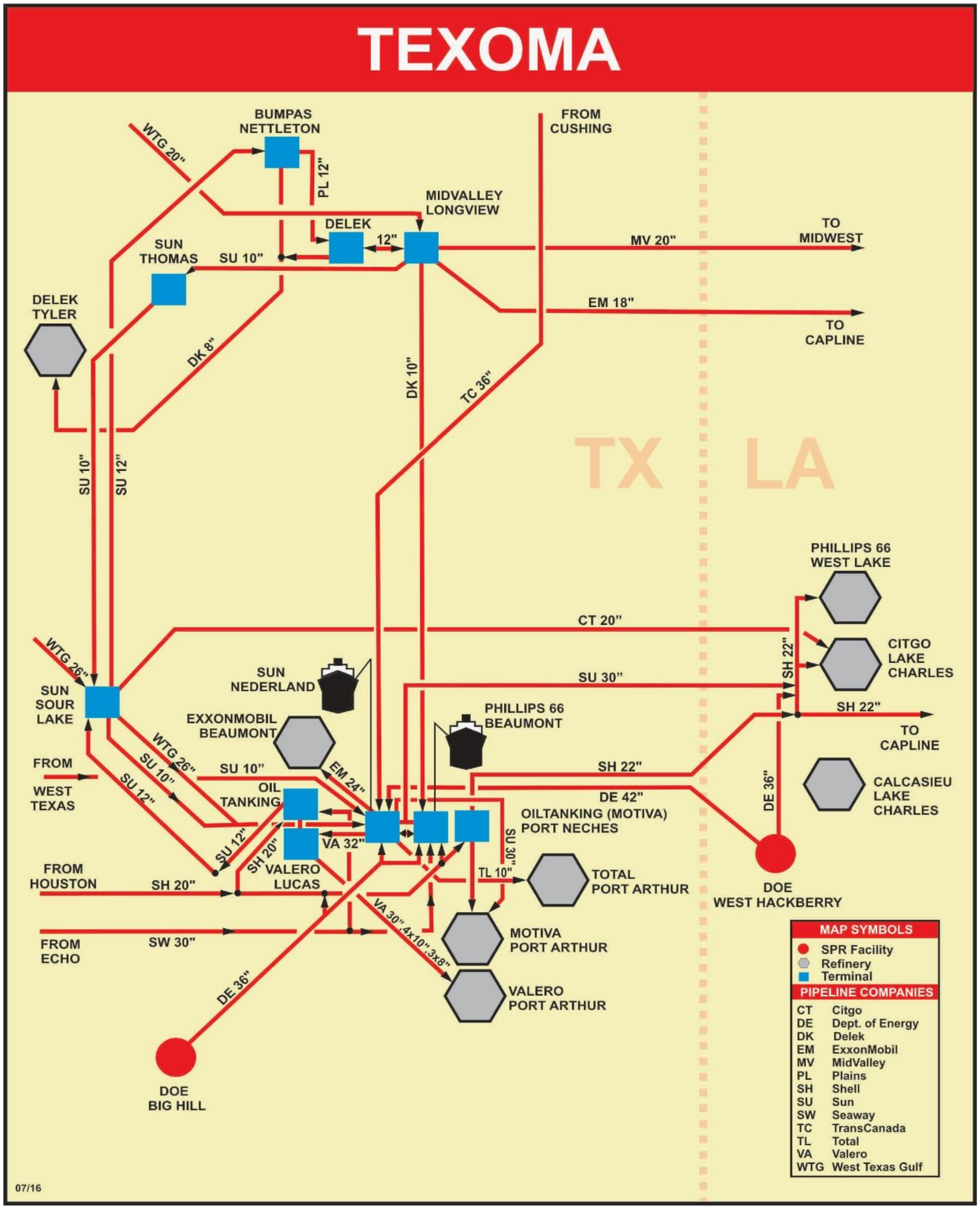

Figure 13: Texoma System Diagram

3.1.3 Capline System

The Capline System (Figure 14) includes the Bayou Choctaw SPR site in Louisiana. Bayou Choctaw has a design drawdown rate of 0.515 MMbbl/d. The Capline System currently includes five refineries: ExxonMobil, Baton Rouge; Placid, Port Allen; Alon, Krotz Springs; Motiva, Convent; and Marathon Garyville. Bayou Choctaw is directly connected to the Placid refinery in Port Allen via the Shell Redstick pipeline (SH 24”), while pipeline connections to other refineries are made via four terminals in the St. James area (Shell St. James, Capline, LOCAP, and Plains). A sixth refinery (Motiva/Norco) will be connected to the system with the completion of a new pipeline (SemGroup [SG] 24”) in fourth quarter calendar year 2016. The only accessible marine loading facility is the Shell St. James terminal. Bayou Choctaw has access to the Midwest refining market via the Capline (CA) pipeline (CA 40”) to Patoka, IL. ExxonMobil is in the process of reversing their North Line pipeline from the Anchorage terminal in Port Allen to Longview, TX. Once this reversal is complete, Capline System access to the Mid-Valley pipeline will no longer be available.

The Capline System is constrained for several reasons. In recent years, the Capline pipeline has operated well below capacity as crude shipments from the Gulf Coast region to Midwest refiners have been displaced by supplies from regional sources (primarily the Bakken formation) and from pipeline imports from Western Canada. As a result, virtually no foreign imports move up the Capline pipeline, and onshore Louisiana and Louisiana Gulf of Mexico production has increasingly backed up on the Gulf Coast. This excess crude supply has been compounded by the reversal of the Ho-Ho pipeline (now called Zydeco), which has eliminated connectivity for Louisiana crude to refining centers in the Lake Charles, Beaumont-Port Arthur, and Houston areas, and has brought new crude supply into the Capline System from Texas. The surplus of crude in the Capline System and the reversal of the Ho-Ho pipeline make it difficult for Bayou Choctaw SPR crude to make its way into the market without disrupting existing commercial flows of domestic crude. Additionally, there is virtually no capacity to provide incremental barrels of SPR crude by marine vessel at the St. James terminal without disrupting Shell’s commercial business.

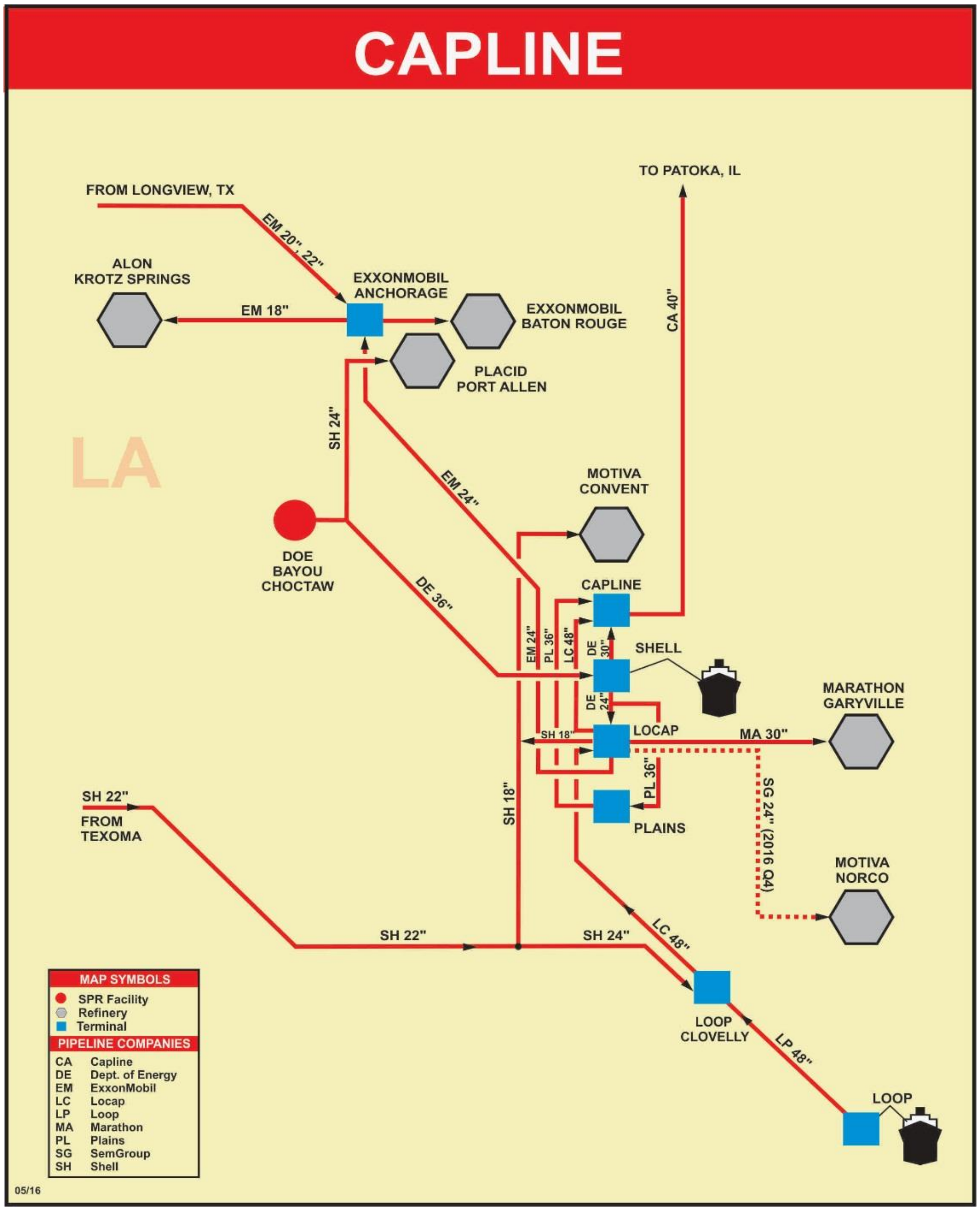

Figure 14: Capline System Diagram

3.1.4 Distribution Contracts

In order to receive and distribute crude oil, the SPR contracts with commercial assets to provide fill, drawdown, and storage services in the Texoma and Seaway systems. The contracts require the terminals to be ready to receive and distribute SPR crude oil within 13 days of a declared emergency (to provide time to prepare storage tanks and distribution assets). In the Capline System, the SPR marine terminal at St. James is connected by the DE 36" pipeline to the Bayou Choctaw site. Shell currently leases and operates the terminal and, similar to the other sites, it serves as a sales and distribution point in the event of a drawdown. Table 14 provides an overview of the contracted marine terminals and the contracted daily distribution capacities.

<table>
<tr><th rowspan="2">Distribution System</th><th rowspan="2">Party</th><th rowspan="2">Terminal(s)</th><th colspan="3">Daily Contracted Capacity (Mbbl/d)</th></tr>
<tr><th>Pipeline</th><th>Marine</th><th>Terminal</th></tr>
<tr><td rowspan="2">Seaway</td><td rowspan="2">Seaway Group</td><td>Texas City</td><td>880</td><td>300</td><td>1,000 [A]</td></tr>
<tr><td>Freeport</td><td>0</td><td>400</td><td>400</td></tr>
<tr><td rowspan="2">Texoma</td><td>Sunoco Logistics</td><td>Nederland</td><td>750</td><td>1,190</td><td>1,915 [A]</td></tr>
<tr><td>Phillips 66</td><td>Beaumont</td><td>50</td><td>200</td><td>250</td></tr>
<tr><td>Capline</td><td>Shell</td><td>St. James [B]</td><td>620</td><td>400</td><td>620 [A]</td></tr>
</table>

[A] Individual transportation mode capacities sum to more than the terminal daily contracted capacity.[24]

[B] Shell leases DOE's St. James terminal for commercial use.

Table 14: Commercial Contracts That Provide Drawdown Distribution Capability for the SPR

3.2 DRAWDOWN AND DISTRIBUTION CAPABILITIES

3.2.1 Design Drawdown Rate

The SPR design drawdown rate is the rate that crude oil can be pumped out of storage caverns if the entire system is activated and fully functional. The current rate of 4.415 MMbbl/d is expressed as the maximum rate at the time of initiation of drawdown and will decline as the drawdown process continues.[25] The drawdown rate for each individual storage site varies, depending on a number of factors, such as the number of operational caverns and wellbores, the SPR's crude oil inventory level, the operational status of critical equipment, and the crude oil stream being released (either sweet only, sour only, or sweet and sour simultaneously).

Figure 15 shows the maximum drawdown rate versus the number of days from initiation of the drawdown. The chart shows that the initial maximum drawdown rate of 4.415 MMbbl/d is sustainable for only the first 90 days of drawdown, or approximately 400 MMbbl of withdrawal. After 90 days, the maximum drawdown rate declines as individual site inventories are depleted, and as the number of caverns containing crude oil declines. After 180 days of drawing down the SPR at the maximum possible rate, a total of 695 MMbbl are withdrawn. This figure is based on the current SPR crude oil inventory level and site configurations. Future drawdown capabilities will shift with changes in crude volumes, the types of crude stored, the number of reserve sites, and changes to the SPR infrastructure.

[24] The terminal daily contracted capacity is the maximum distribution throughput volume that the terminal must accept for SPR crude oil, while the pipeline and marine daily contracted capacities are the maximum distribution throughput that the terminal must accept for SPR crude oil for that mode of transportation. For example, the Texas City terminal must accept 1 MMbbl/d of throughput of SPR crude oil. The total terminal throughput volume can consist of any combination of pipeline and marine volumes up to the maximum daily throughput volume of either transportation mode.

[25] SPR 2014 Annual Report.

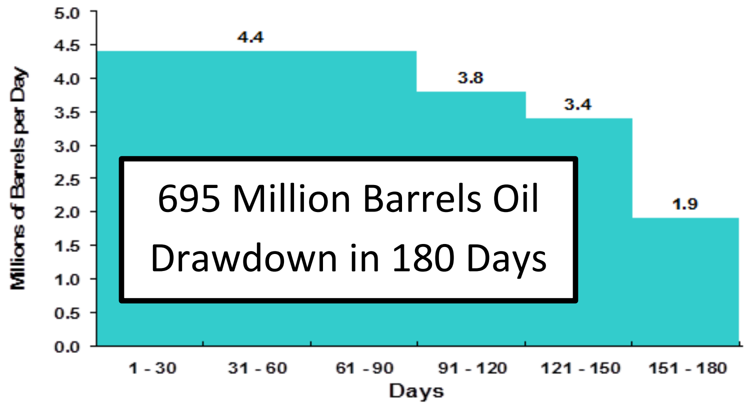

Figure 15: SPR Maximum Drawdown Rate vs. Duration

3.2.2 Physical Distribution Capability

The SPR's physical distribution capability focuses on the physical connectivity that the SPR maintains to distribution assets, such as pipelines, refineries, and terminals. This drawdown estimate does not account for commercial oil supplies flowing through these assets. The SPR's Level I technical performance criteria for this measure is that combined physical distribution system infrastructure, both DOE-owned and commercial, must exceed 120% of the combined site design drawdown rates to allow for terminal and marine vessel operational delays, and commercial refinery demand variances.[26]

The 2014 physical distribution capability of each SPR system, as determined by the 2015 SPR Distribution Capability Assessment, is shown in Table 15. The physical distribution capability for all distribution systems totals 4.999 MMbbl/d. The last column in the table shows the "performance measure" of each distribution system in terms of the ratio of the physical distribution capability to the current design drawdown rate. The data show that the overall SPR distribution system combined performance measure was 113% in 2014. Of the three distribution systems, only Capline exceeds the performance criteria of 120% of the drawdown rate. Due to a reduction in locally connected refinery imports and interstate pipeline imports, the Texoma distribution system is the most constrained, with physical distribution capability equal to just 99% of the design drawdown rate.

Distribution System	Design Drawdown Rate (MMbbl/d)	Physical Distribution Capability (MMbbl/d)	Performance Measure
Seaway	1.500	1.764	118%
Texoma	2.400	2.379	99%
Capline	0.515	0.856	166%
Total Overall SPR System	**4.415**	**4.999**	**113%**

Table 15: SPR Base Year Distribution Capability Assessment for 2014

[26] "The Strategic Petroleum Reserve, A Report on the Capability to Distribute SPR Oil," National Petroleum Council (December 1984), states: "A level of [distribution] redundancy of approximately 20 percent was assumed as an allowance for refinery demand variances, terminal operation delays, and other factors."

Table 16 shows the trend in SPR physical distribution capability from 2012 to 2014. During this timeframe, the SPR's physical distribution capability declined in each distribution system, as well as in the overall SPR system, each year. For the SPR overall, distribution capability declined 29 percentage points, with declines of 44, 17, and 48 percentage points in the respective Seaway, Texoma, and Capline distribution systems.

Distribution System	Assessment Year		
	2012	2013	2014
Seaway	162%	135%	118%
Texoma	116%	112%	99%
Capline	214%	183%	166%
Overall SPR System	**142%**	**128%**	**113%**

Table 16: Annual Distribution Capability Assessments, 2012–2014

The distribution assessment results in Table 16 focus solely on the physical distribution capability of the SPR. This measure is important as an indicator of whether physical barriers exist to distribution of SPR petroleum. However, it does not take into account the movements of petroleum in the market and whether a drawdown of the SPR can add incremental barrels to the market, which is the key to its value in the event of a global market disruption. Measures of "effective" distribution capability will be discussed in the next section.

3.3 CHANGES IN CRUDE OIL MARKETS AND EFFECTIVE DISTRIBUTION CAPABILITY

The third concept relevant to the SPR's ability to put oil on the market is the "effective" distribution capability, which is the distribution rate at which SPR crude oil can be *incrementally* added to the oil market in the event of a supply disruption without displacing domestic production or Canadian imports. Effective distribution capability is dependent on oil market activity, utilization of commercial pipelines and terminals at the time of a drawdown, and the magnitude and geographical location of the oil supply disruption.

Incremental crude delivered into the market acts to mitigate the price escalations and economic dislocation caused by a supply disruption. In order to have a meaningful effect on supply, it is essential that SPR crude oil be delivered into the market without displacing domestically produced crude oil or Canadian imports that are already being transported in pipelines and marine vessels to U.S. refineries. This section provides details on recent changes in crude oil production and infrastructure in the United States and Canada, and how those changes have affected the ability of the SPR to provide incremental crude oil to the market.

3.3.1 Market Changes

From the 1970s until about 2010, U.S. refiners imported increasingly more crude oil from foreign sources. The location of the SPR sites on the Gulf Coast region provided ready access for SPR crude into Texas and Louisiana Gulf Coast refineries. Furthermore, the United States pipeline system was configured to provide domestically produced and imported crude oil from the Gulf Coast to refiners in the Midcontinent and Midwest. Commercial pipeline systems such as Capline, Mid-Valley, and the Seaway pipeline (flowing north to Cushing) allowed SPR crude to move into those markets, also, if needed. In addition, most refineries that the SPR could not access by pipeline on the Gulf Coast, East Coast, and West Coast could be accessed by out-loading SPR crude onto marine vessels. With refiners relying on high volumes of waterborne imported crude from unstable regions, U.S. fuel markets faced significant physical supply and related price risks.

In 2011, the petroleum industry began widespread use of hydraulic fracturing (fracking) technology to develop new crude oil supply from low-permeability domestic sources, including the Bakken formation in the Williston Basin of North Dakota and Montana, the Permian Basin of West Texas and New Mexico, the Eagle Ford formation in South Texas, and the Niobrara formation in Wyoming and Colorado. This new crude oil supply developed rapidly, and was coupled with continued growth in the production and import of Canadian oil sands crude into the United States. The growth in North American crude oil production has been significant, rising from 8.3 MMbbl/d in 2010 to 13.3 MMbbl/d in 2015.[27]

With much of the growth in crude oil production located in areas with historically low production levels (e.g., the Bakken and Eagle Ford formations), a substantial new pipeline infrastructure has been developed to transport crude oil to market. Midstream investments included the construction of new pipelines, reversals of existing pipelines, conversions of pipelines carrying other petroleum products, and the development of rail loading and unloading infrastructure. Significant changes include:

- New pipelines to move crude oil from the Bakken formation in North Dakota/Montana and the Niobrara Formation in Colorado/Wyoming to Midwest and Gulf Coast refining markets and by rail to the East and West Coasts.

- New pipelines moving Canadian oil sands and other Canadian crudes from Alberta, Canada, to Cushing, Oklahoma, and then further south into Gulf Coast refining markets.

- Multiple pipelines connecting the Permian and Eagle Ford Basins in Texas to refineries in Houston, Corpus Christi, Port Arthur, and Louisiana. Corpus Christi has also been the source of tight oil movements to other ports in Texas and Louisiana on coastwise-compliant marine vessels, and for exports of crude and approved condensates to Canada and other markets on other vessels.

- Refiners modifying their operations to accommodate more oil sands crude and domestic tight oil crude. This has reduced waterborne imports in all coastal markets, and has led to a situation where the economic feedstock needs of Midwest refiners are met with only domestic and Canadian crude oil.

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[27] U.S. Energy Information Administration and the Canadian Association of Petroleum Producers (CAPP) Statistical Bulletin for Canada, with the 2015 estimate derived from the CAPP June 2015 production forecast.

Figure 16 shows a map with the recent major infrastructure changes in U.S. crude flows between 2010 and 2015.

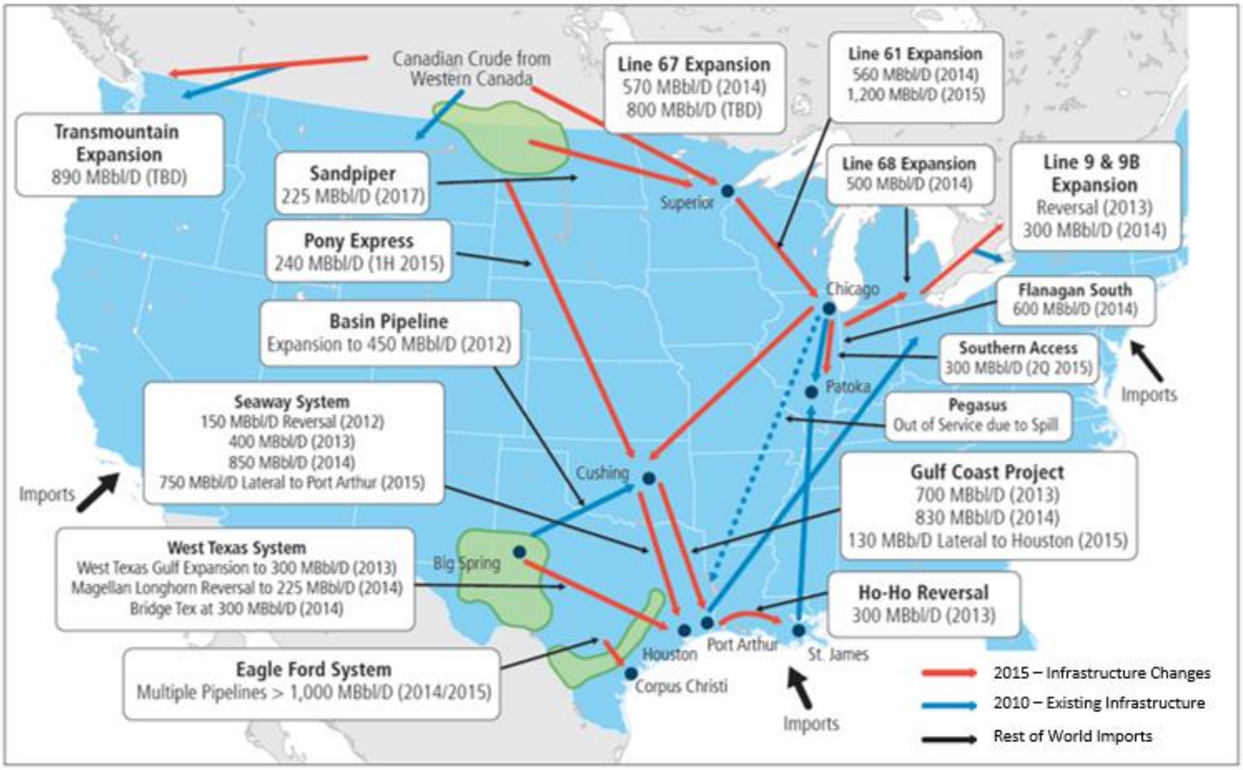

Figure 16: Recent North American Crude Oil Pipeline Additions, Expansions, and Reversals

3.3.2 Implications for the SPR

These new patterns of oil supply and demand among U.S. oil producers and refineries, along with associated changes in the United States midstream, have significantly reduced the ability of the SPR to distribute *incremental* volumes of oil during possible future oil supply interruptions. Nevertheless, moving SPR crude oil to Midwest refineries—an historical pattern—would be of no value during a petroleum supply disruption because non-Canadian imports and Gulf Coast supplies into the Midwest refining complex have essentially disappeared. The United States pipeline distribution system, along with other modes of oil transport, is instead moving large volumes of oil to the Gulf Coast refinery complex, especially from United States tight oil places and Canada. This new geography of U.S. oil production and energy exports has also increased commercial marine traffic at U.S. Gulf Coast marine loading facilities.

While the SPR has throughput contracts for dock space utilization at five marine terminals within the SPR distribution system, use of these docks for the distribution of SPR crude oil will cause displacement of domestically produced oil and/or Canadian imported oil. The changing patterns of U.S. oil imports mean that the magnitude and geographical location of an international oil supply disruption can affect the capacity of the SPR to deliver oil to its customers[28] and the ability of the United States to meet its obligations under the IEP in the event of an IEA collective action in response to a global supply disruption.[29] If the SPR cannot load crude oil onto barges and tank ships without disrupting commercial shipments, SPR sales could be offset by a decrease in domestic crude oil shipments or exports of domestically produced petroleum products. For all of these reasons—the evolution of global oil markets, the participation of the United States in those markets, the changed geography and volume of U.S. oil supplies, reduced oil imports, and the congestion of commercial facilities in the SPR's distribution region—an effective SPR release will increasingly depend on the ability to load *incremental* barrels of SPR crude oil onto marine vessels.

The 2014 test sale of 5 MMbbl of crude oil from the Texoma System highlighted these SPR distribution capacity constraints. It demonstrated that (1) limited pipeline capacity existed to accept SPR barrels in that system, and (2) the lack of availability of coastwise-compliant vessels, as well as dock space, inhibited movement by marine facilities. While the test sale was conducted during a period with no disruptions in the global supply, it still presented fundamental questions about the SPR's capabilities to meet mission requirements.

3.4 ANALYZING SPR DISTRIBUTION CONSTRAINTS

In 2015, DOE sponsored a scenario-based analysis of the SPR's effective distribution capability. The purpose of the study was to determine the volume of crude oil the SPR can add to the market without displacing domestic or Canadian barrels in selected oil supply disruption scenarios that would warrant an IEA collective action response. This detailed analysis accounted for commercial utilization of SPR distribution infrastructure, connected pipelines and contracted docks, to determine the volume of incremental barrels that could be brought to the market under these scenarios. The results quantify the additional marine capability that would be needed for the SPR to meet U.S. obligations in an IEA collective action, and to distribute oil either at its design drawdown rate of 4.415 MMbbl/d or at its Level I technical performance criteria for distribution of 120% of the design drawdown rate.

3.4.1 Distribution Study Methodology

This section details DOE's approach to evaluating the SPR's effective distribution capability. The core concept of the analysis that follows is that no U.S. domestic or Canadian production can be displaced by SPR barrels being introduced into the market.

Key Assumptions

The primary assumptions in the study include the following:

[28] QER Report: Energy Transmission, Storage, and Distribution Infrastructure. (April 2015). Chapter IV: Modernizing U.S. Energy Security Infrastructures in a Changing Global Marketplace.

[29] The IEP is an international treaty that obligates IEA member countries to hold emergency petroleum reserves and provide specific percentages of petroleum to support an IEA collective action, or emergency oil release. Based on IEA member-country consumption data, the U.S. obligation is 43.9% (as of October 2015).

- SPR sites have a total design drawdown capability of 4.415 MMbbl/d.
- Most pipelines from SPR sites to connected refineries and terminals are full with domestic and/or other crudes.
- SPR distribution flows are constrained by connected terminal operational capability, and domestic delivery and foreign import dock utilization.
- The availability of coastwise-compliant barges, articulated tug and barge (ATB) units, and tank ships (tankers) is limited.
- All calculations are based on the EIA's refinery import receipt database and the daily average for calendar year 2015.
- The quality of crude imports disrupted or delivered by SPR is not considered.
- The oil market response to a disruption beyond the use of strategic oil stocks is not considered.[30]

These conditions reflect the current petroleum infrastructure situation on the Gulf Coast, based upon the best available knowledge at the time of this writing, within the limits of the model used here. Real-world variations, including the possibility that some terrestrial midstream capacity might become available as a result of broader market adjustments during a disruption, could lead to different distribution shortfalls from those estimated here. Potential future infrastructure changes (such as the reversal of the Capline pipeline to flow crude south into the St. James, LA, market) are not incorporated into the study but would only increase the current congestion in the Gulf Coast markets. In addition, the recent legislative change that allows commercial export of U.S. crude oil is likely to further increase dock utilization to accommodate both domestic crude exports and increased foreign imports, which could further tighten the storage market absent significant investment from industry.

To reflect the inherent uncertainty associated with projecting midstream availability, the scenario results involving any vessel being available for SPR marine distribution are presented as ranges. The ranges of the results represent variability in the level of dock utilization at SPR-connected distribution facilities. This variability is driven by a number of factors, such as weather, pilot availability, marine traffic, and the level of commercial activity at a given terminal at a given time. Results at the lower end of the effective distribution capability range assume higher rates of commercial dock utilization and

[30] This analysis does not factor in alternative offsets to supply interruptions, such as spare production capacity, commercial stocks, or re-routed barrels from domestic rail shipments or other marine barrels. Many of these factors are accounted for in modeling of the SPR's economic benefits in Chapter 4, but the focus of this specific analysis is solely on the impact of midstream congestion on the SPR's effective distribution capability.

therefore lower rates of SPR dock utilization. Conversely, results at the higher end of the range assume lower rates of commercial dock utilization and therefore higher potential rates of SPR dock utilization.

Methodology

DOE developed and analyzed seven global crude oil supply disruption scenarios in order to determine the effective distribution capability of the SPR. The study included:

1. A baseline scenario in which no physical global oil supply disruption occurs.
2. Three scenarios centered on oil supply disruptions originating in the Middle East.
3. Two scenarios focused on oil supply disruptions in the Western hemisphere.
4. One scenario of an oil supply disruption in Africa.
5. One scenario of an oil supply disruption in Russia.

Table 17 summarizes the seven oil supply disruption scenarios analyzed and the daily rate of oil displaced from the global market associated with each supply disruption.

Description of Event	Rate of Disruption of Daily Global Oil Market Supplies (MMbbl/d)
Iraq – Basra	2.1
Venezuela	1.7
Russia – Complete Urals Outage	4.0
Straits of Hormuz – Initial Crisis Event	8.0
Saudi Arabia – Abqaiq	6.0
Nigeria – Workers' Strike	2.0
Mexico – Hurricane	1.5

Table 17: Global Oil Supply Disruption Scenarios

For each of the scenarios, an analysis was conducted of the SPR's distribution infrastructure, connected pipelines, and contracted terminals to determine the volume of *incremental* barrels of oil that could be added to the market through the SPR distribution system without displacing domestically produced oil and Canadian imported oil. The analysis focused primarily on the ability of the SPR to meet U. S. obligations under the IEP in the event of an IEA collective action release.

The IEP obligations also serve as a proxy for the necessary size of an SPR release required by EPCA.[31] EPCA requires that an emergency SPR release "avoid[s] a severe increase in the price of petroleum products … that is likely to cause a major adverse impact on the national economy." Because U.S. petroleum prices are determined by international crude oil prices, in order to avoid a spike in domestic petroleum product prices, it is necessary to avoid a spike in international crude oil prices. The purpose

[31] Energy Policy and Conservation Act, Section 161(d)(2)(B and C), 1975.

of an IEA collective action is to protect the global economy by taking action (releasing strategic oil stocks) in accordance with an agreed allocation of responsibilities among its member countries.

In each of the oil supply disruption scenarios analyzed, two cases were considered:

1. Only coastwise compliant vessels were available to be used for SPR marine distribution.
2. Any vessel was available to be used for SPR marine distribution.

Each of the scenarios assumes that a sufficiently large global oil supply disruption occurs such that there is an IEA collective action response requiring IEA member countries to meet their coordinated response obligations in response to the disruption. The analysis assumes that the IEA response meets the entirety of the disruption, although it is possible that an IEA release could only partially address a disruption. The percentage shares are based on IEA's calculation of each member country's base period final consumption, which is a function of the total petroleum consumption of both an individual member country, as well as all IEA member countries. As of October 2015, the United States percentage share of an IEA collective action release was 43.9% of the total release volume, which is below the 50% level that occurred during the 2011 IEA collective action in response to the Libyan supply disruption.

The IEA collective action release is viewed as a base case response for the purpose of this analysis, recognizing that the President, under the authorities of EPCA, could direct a release of the SPR at a rate in excess of the IEA collective action commitment. In the event that the SPR was required to contribute a larger share of an IEA collective action or if it had to release barrels on its own, the distribution requirements could be higher. The analysis also examines what the distribution shortfall would be in the event that the SPR is required to put oil on the market at its design drawdown rate, or to meet the Level I technical performance criteria for distribution capability (120% of the design drawdown rate).

Table 18 shows the daily SPR distribution rate required in order for the United States to meet its obligations under two United States IEA percentage share requirements for each of the global oil supply disruptions analyzed.[32] It should be noted that the IEA does not require the United States to meet its obligation using only the SPR.

[32] This assumes the United States meets its share of an IEA Collective Action through the use of the SPR only.

Global Oil Supply Disruption Scenario	Daily Disruption Rate (MMbbl/d)	IEA Collective Action Release (MMbbl/d)	U.S. Share 43.9% (MMbbl/d)	U.S. Share 50.0% (MMbbl/d)
Iraq – Basra	2.10	2.10	0.90	1.10
Venezuela	1.70	1.70	0.70	0.90
Russia – Complete Urals Outage	4.00	4.00	1.80	2.00
Straits of Hormuz – Initial Crisis Event	8.00	8.00	3.50	4.00
Saudi Arabia – Abqaiq	6.00	6.00	2.60	3.00
Nigeria – Workers' Strike	2.00	2.00	0.90	1.00
Mexico – Hurricane	1.50	1.50	0.70	0.80

Note: The analysis rounds percentage share requirements to the nearest 100 Mbbl/d.

Table 18: Required SPR Distribution Rates to Meet IEA Collective Action Obligations

3.4.2 Distribution Study Results

Table 19 contains the results of the SPR effective distribution capability analysis for the baseline scenario and the seven global oil supply disruption scenarios for each of the two cases: 1) only coastwise compliant vessels were available to be used for SPR marine distribution, and 2) any vessels were available to be used for SPR marine distribution. The analysis also accounts for pipeline distribution. It assumes a United States IEP obligation of 43.9% during an IEA collective action release.

Disruption Scenario	Total Global Disruption (MMbbl/d)	IEA Collective Action U.S. Obligation (43.9%) (MMbbl/d)	Effective Distribution Capability*		Additional Capacity Needed (Mbbl/d)
			Coastwise Compliant Vessels Only (Mbbl/d)	All Vessels (Mbbl/d)	
Baseline	–	–	280	620–1,040	–
Iraq – Basra	2.10	0.90	350	740–1,110	0–160
Venezuela	1.70	0.70	680	1,290–1,600	0
Russia – Complete Urals Outage	4.00	1.80	280	670–1,040	760–1,130
Straits of Hormuz – Initial Crisis Event	8.00	3.50	1,070	1,760–2,560	940–1,740
Saudi Arabia – Abqaiq	6.00	2.60	890	1,410–2,120	480–1,190
Nigeria – Workers' Strike	2.00	0.90	290	620–1,040	0–280
Mexico – Hurricane	1.50	0.70	760	1,390–1,740	0

*Effective distribution capability is the ability of the SPR to move incremental barrels of oil to market.

Red color indicates IEA obligations would not be met using only the SPR.

Table 19: Results of the SPR Effective Distribution Capability Analysis

The scenarios vary in terms of the distribution stress they would place on the SPR. For scenarios that involve large losses to U.S. refiners, space would necessarily open up in the Gulf Coast distribution system to accommodate some of an SPR release, creating a higher level of effective distribution capability. In cases where a dislocation occurred in the world market that did not interrupt U. S. import flows, the task of delivering oil to the market would be more difficult, creating a lower level of effective distribution capability.

The results of this SPR effective distribution capability analysis indicate the following:

- If only coastwise compliant vessels are available for use for SPR marine distribution, the United States would not be able to meet its IEA obligations for six of the seven scenarios analyzed.

- Assuming that all vessels are available for SPR marine distribution:

    - The United States would be unable to meet its IEA obligations in three scenarios under any assumptions about commercial oil movements (Russia, Strait of Hormuz, and Saudi Arabia). In these scenarios, the United States would require additional marine distribution capacity of 0.48–1.74 MMbbl/d.

    - The United States would be unable to meet its IEA obligations in an Iraq or Nigeria disruption in which commercial dock utilization is high. Additional marine distribution capacity requirements in these scenarios range from 160–280 Mbbl/d.

    - The United States would clearly be able to meet its IEA obligations with existing infrastructure regarding outages in Mexico or Venezuela.

Figure 17 shows the amount of additional marine distribution capacity required in the three most severe disruption scenarios because a full drawdown is likely to occur only in response to scenarios involving the most severe oil supply disruptions affecting the global crude market. Under these scenarios, 4– 8 MMbbl/d of crude oil could potentially be lost from the market.

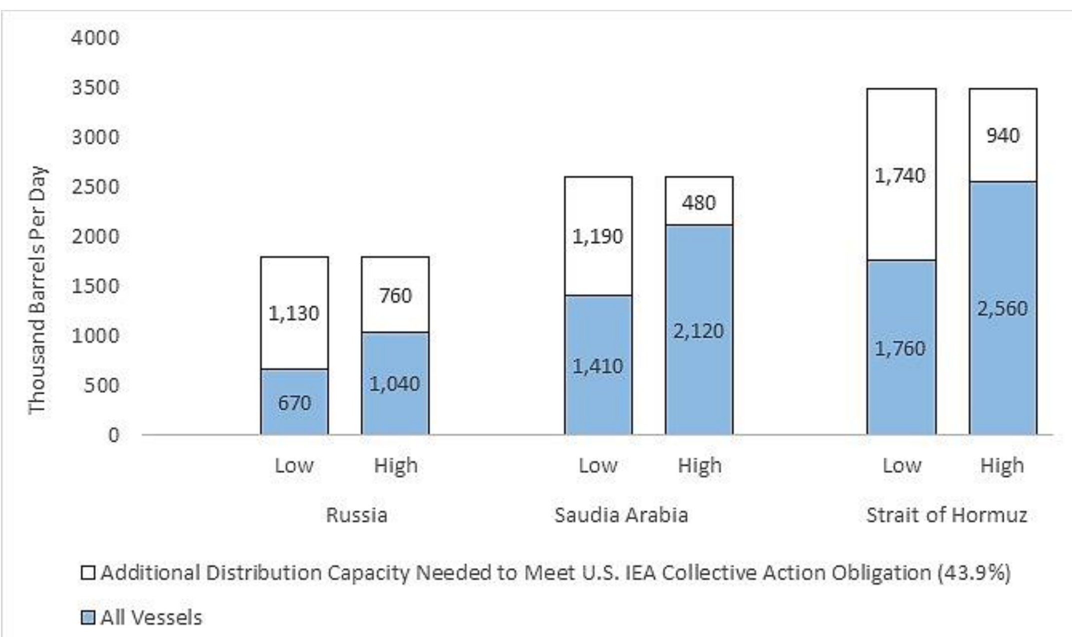

Figure 17: Additional Marine Distribution Capacity Required to Meet Effective Distribution Capability Requirements

Assuming that the IEA fully addressed these shortfalls, the United States' share of a collective action would be between 1.8 and 3.5 MMbbl/d. The additional marine capacity needed to meet this obligation would be between 0.48 MMbbl/d and 1.74 MMbbl/d. Should the United States' percentage of the total release required during an IEA collective action increase to 50%, the largest required additional marine distribution capacities would increase to between 0.88 MMbbl/d (the less constrained case) and 2.24 MMbbl/d (the more constrained case).

Additional calculations were also performed to determine the SPR marine distribution capacity shortfall for a case in which the distribution rate was required to equal the SPR's design drawdown rate and another case in which the distribution rate was required to equal the SPR's Level I technical performance criteria for physical distribution. This is significant because the SPR's full drawdown and distribution capability becomes critically important in a scenario in which the United States must address a global supply disruption without action taken by other IEA members, or provide larger volumes of oil in a short timeframe in order to mitigate sudden price spikes caused by a supply disruption and their associated adverse economic impacts. Figures 18 and 19 show the amount of additional marine distribution capacity needed to equal the SPR's design drawdown rate and Level I technical performance criteria for physical distribution, respectively. The amount of required additional marine distribution capacity ranges from 1.855 MMbbl/d to 3.745 MMbbl/d to equal the SPR's design drawdown rate, and 2.74 to 4.63 MMbbl/d to equal the SPR's Level I technical performance criteria for physical distribution.

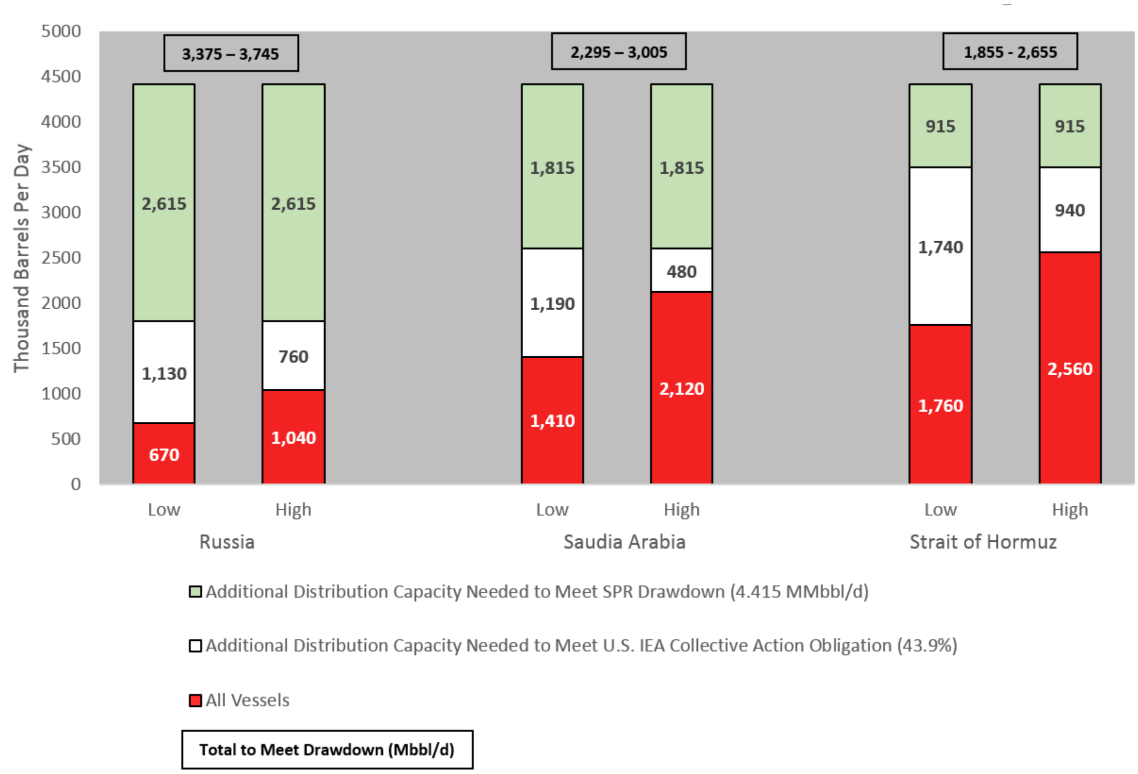

Figure 18: Additional Marine Distribution Capacity Required to Meet the SPR's Design Drawdown Rate

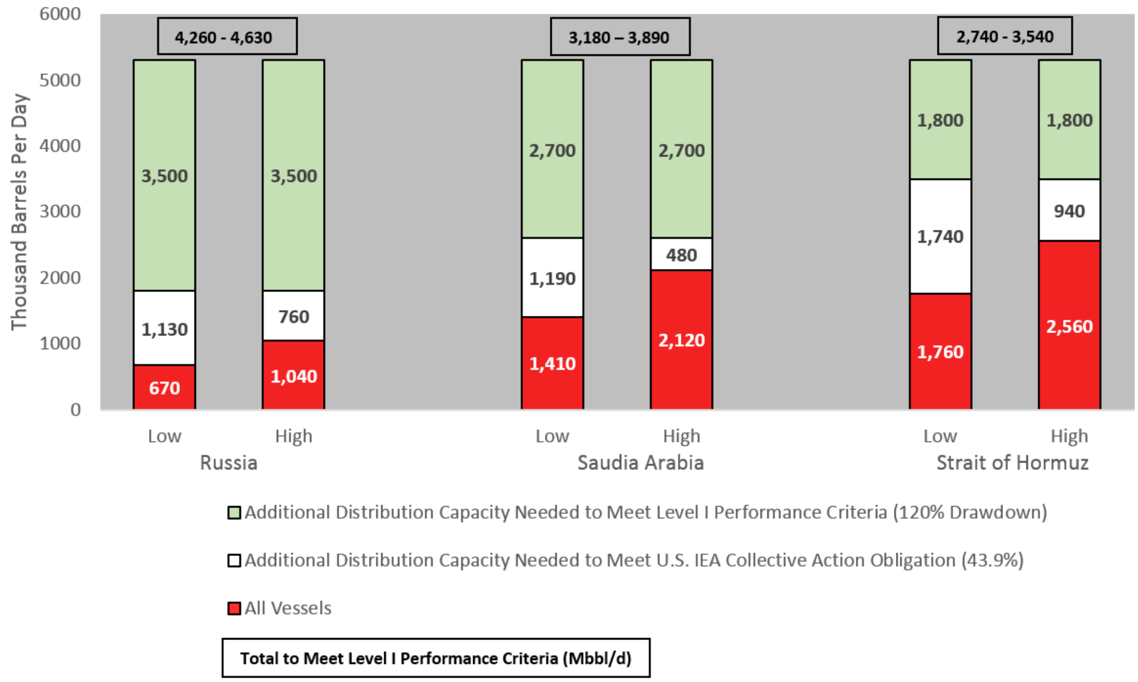

Figure 19: Additional Marine Distribution Capacity Required to Meet the SPR's Level I Technical Performance Criteria for Distribution Capability

3.5 KEY TAKEAWAYS

Large changes in North American crude oil flows have fundamentally altered the commercial systems that connect the SPR to refining centers. DOE has evaluated the Reserve's ability to add *incremental* barrels to the market in a global oil supply disruption (the ability to move barrels to refiners without disrupting the flow of domestic production and Canadian imports). The distribution capability (i.e., the rate at which this oil can be transferred into the market through pipelines or waterborne transportation) is dependent on not only physical throughput capacity but also the movement of other oil supplies in the market and the availability of vessels for waterborne transit.

The analysis of the SPR's effective distribution capability shows that, in most of the disruption scenarios, the SPR cannot meet its current IEA obligation to contribute 43.9% of the barrels in a collective action without marine terminal enhancements. Depending on the size of the contribution and other market assumptions, up to 1.74 MMbbl/d of additional marine distribution capacity may be required. If the potential United States' share of a collective action increases, these distribution problems become more acute. For example, if the United States contributed 50% of a collective action, the SPR would need up to 2.24 MMbbl/d of additional marine distribution capacity. To meet the SPR's design drawdown rate, up to 3.75 MMbbl/d of additional marine distribution capacity would be required, and to equal the SPR's Level I technical performance criteria for physical distribution, up to an additional 4.63 MMbbl/d of additional marine distribution capacity would be required.

CHAPTER 4 – COSTS AND BENEFITS OF SPR OPTIONS

The primary benefit of strategic petroleum stocks is that they can substitute for disrupted volumes in a supply crisis and mitigate the economic losses that stem from the resulting price shocks. After an overview of potential future world oil market conditions, this chapter discusses DOE's approach to quantifying the economic value of the SPR and employs this framework to evaluate some of the costs and benefits of various SPR size and distribution scenarios moving forward. The chapter also discusses additional economic and strategic benefits of the SPR that are difficult to quantify, but nonetheless add value for the United States. This is not a formal cost-benefit analysis.

4.1 FUTURE OIL MARKET CONDITIONS

The value of the SPR over the coming decades will be affected by the evolution of future world crude oil markets in terms of future oil price levels and quantities of oil produced and consumed globally. The analysis presented in this report estimates the value of the SPR under a number of oil market scenarios based on the EIA's 2015 *Annual Energy Outlook* (AEO), which projects world production and prices through 2040 based on laws in place at the time of writing and assumptions about technology, economic growth, and other factors.[33] The AEO includes assumptions and modeling of future economic activity, energy demand, oil and gas production, and U.S. crude oil imports. It does not account for the December 2015 liberalization of U.S. crude oil exports.

4.1.1 2015 U.S. Liquids Supply and Demand

Table 20 presents the 2015 baseline liquids supply and demand data from the 2015 AEO Reference case. The baseline shows that U.S. crude and condensate production was estimated to average 9.33 MMbbl/d. Net imports were estimated at 6.42 MMbbl/d at the time that the AEO was prepared; however, the reported 2015 imports were higher at 7.35 MMbbl/d.[34] Other sources of liquids supply in the AEO baseline include refinery and processing gain, biofuels, gas plant liquids, and petroleum product imports. Total liquids consumption in the baseline was 19.26 MMbbl/d and petroleum product exports were 4.12 MMbbl/d.

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[33] U.S. Energy Information Administration, Annual Energy Outlook. (2015). http://www.eia.gov/forecasts/aeo/.
[34] U.S. Energy Information Administration, Monthly Energy Review. (March 2016). http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

Category	MMbbl/d
Crude and Condensate Supply	
Crude and Condensate Production	9.33
Net Crude and Condensate Imports	6.42
Other Crude Supplies	0.21
Total Crude and Condensate Supplied to Refineries	**15.96**
Other than Crude and Condensate Supply	
Refinery and Processing Gain	1.07
Net Biofuels Supply	1.15
Gas Plant Liquids Production	3.20
Petroleum Product Imports	1.98
Subtotal Other Than Crude and Condensate Supply	**7.40**
U.S. Total Liquids Supplied	**23.36**
Total Liquids Consumption	19.26
Petroleum Product Exports	4.12
Total Liquids Demand, Including Exports	**23.38**

Table 20: 2015 U.S. Liquids Supply and Demand Balance

4.1.2 Projected U.S. Liquids Supply and Demand

The EIA's 2015 AEO includes a Reference case and five side cases (Low Oil Price, High Oil Price, Low Economic Growth, High Economic Growth, and High Oil and Gas Resources). This report presents an analysis of SPR benefits based primarily on the Reference case and the sensitivity case for the Low Oil Price case. The Low Oil Price case was created by increasing global supply and decreasing non-Organization for Economic Cooperation and Development (OECD) demand relative to the Reference case. The High Oil Price case was created making an opposite shift. A summary of the assumptions underlying the Reference, High, and Low Oil Price cases, and the 2040 price levels, are presented in Table 21.

Case Name	Description
Reference	Real GDP grows at a rate of 2.4% from 2013 to 2040, under the assumption that current laws and regulations remain generally unchanged.[35] Supply and demand assumptions are at Reference values. United States energy consumption grows at a modest rate of 0.3% per year. Declines in energy consumption result from the adoption of energy-efficient technologies. Brent crude prices rise to $141/bbl (in 2013 dollars).
Low Oil Price	Low oil prices result from a combination of low demand assumptions in nations outside of the OECD and higher global supply assumptions. The Organization of Petroleum Exporting Countries (OPEC) increases its liquids supply market share from 40% to 51% by 2040, and the cost of production technologies is lower than in the Reference case. Brent prices remain around $52/bbl (in 2013 dollars) through 2017, and rise to $76/bbl in 2040. Other energy market assumptions are the same as in the Reference case.
High Oil Price	High oil prices result from a combination of higher demand assumptions for liquid fuels in non-OECD nations and lower global oil supply assumptions. OPEC's market share averages 32% through the projection. Non-OPEC production expands more slowly than in the Reference case. Brent prices rise to $252/bbl (in 2013 dollars) in 2040. Other energy market assumptions are the same as in the Reference case.

Table 21: Key AEO 2015 Cases

The benefit analysis presented in this report was completed in the first 2 months of 2016 and the latest cases available were from the EIA's 2015 AEO. The continued oversupply of crude oil and resulting very low crude prices at the end of 2015 and the beginning of 2016 were not anticipated at the time that the EIA's 2015 AEO was being prepared.

Some of the key crude oil and liquids results of the Reference, High, and Low Oil Price cases are presented in Table 22. This table shows crude oil prices, crude oil production, total liquids supplied, total U.S. liquids consumption, and net imports of crude and products. It also presents the forecast trends in oil production by world region. While OPEC production increases 41% in the Reference case, the increase is 86% in the Low Oil Price case. In the Low Oil Price case, the projected increases in the share of global production from OPEC countries and in U.S. oil consumption have direct energy security consequences for the United States. As OPEC's share of the market increases, more oil will be at risk of supply disruption. The more oil the United States consumes, the more vulnerable the economy is to price escalations.

[35] This growth rate is slightly higher than current administration projections for U.S. GDP and is used to maintain internal consistency within the larger model. If GDP grows at a slower rate over the projection period, the benefits discussed in this chapter will decrease slightly.

EIA 2015 Annual Energy Outlook		2015	2020	2025	2030	2035	2040	Percent change 2015 to 2040
Reference Case								
Brent oil price	2013 $/bbl	$55.62	$79.13	$91.13	$105.64	$122.20	$141.28	154%
WTI oil price	2013 $/bbl	$52.72	$72.96	$85.02	$99.48	$116.25	$135.67	157%
Total liquids supplied *	mmb/d	23.36	24.79	25.16	25.21	25.39	25.55	9%
US liquids consumption	mmb/d	19.26	19.65	19.61	19.41	19.29	19.27	0%
Net imports of crude and products	mmb/d	4.28	2.71	2.85	2.87	3.42	3.33	-22%
World crude and condensate production								
US		10.61	11.58	11.28	11.01	10.37	10.41	-2%
non-US OECD		9.27	9.60	10.16	10.82	11.34	11.82	28%
OPEC		30.78	31.89	33.51	36.62	40.46	43.52	41%
non-OECD		27.94	29.11	30.25	31.32	32.15	33.35	19%
total		78.60	82.18	85.20	89.77	94.32	99.10	26%
Low Oil Price Case								
Brent oil price	2013 $/bbl	$51.81	$57.70	$64.22	$68.75	$72.02	$75.52	46%
WTI oil price	2013 $/bbl	$45.85	$51.56	$58.66	$62.80	$67.65	$72.08	57%
Total liquids supplied	mmb/d	23.14	24.99	25.05	24.82	24.16	23.78	3%
US liquids consumption	mmb/d	19.08	20.00	20.13	20.10	20.16	20.44	7%
Net imports of crude and products	mmb/d	4.50	3.83	4.40	5.19	6.27	7.34	63%
World crude and condensate production								
US		10.16	10.93	10.45	9.63	8.72	8.09	-20%
non-US OECD		9.35	8.58	8.32	8.30	8.45	8.63	-8%
OPEC		31.34	36.25	41.27	46.79	52.33	58.27	86%
non-OECD		28.09	28.22	28.43	29.03	29.25	30.10	7%
total		78.94	83.98	88.47	93.75	98.75	105.09	33%
High Oil Price Case								
Brent oil price	2013 $/bbl	$121.52	$148.61	$169.25	$193.80	$220.70	$252.05	107%
WTI oil price	2013 $/bbl	$115.35	$141.79	$162.52	$187.54	$214.96	$246.38	114%
Total liquids supplied	mmb/d	24.05	26.77	27.58	27.87	28.04	27.85	16%
US liquids consumption	mmb/d	19.19	18.97	18.61	18.04	17.75	17.70	-8%
Net imports of crude and products	mmb/d	3.49	-0.03	-1.38	-1.82	-1.58	-0.63	-118%
World crude and condensate production								
US		11.02	13.36	13.96	13.47	12.36	10.94	-1%
non-US OECD		9.27	10.08	11.31	12.41	13.24	13.83	49%
OPEC		28.27	25.25	25.45	27.72	31.05	35.03	24%
non-OECD		28.68	29.98	31.05	33.40	35.75	39.07	36%
total		77.24	78.67	81.77	87.00	92.40	98.87	28%

* Total liquids supplied includes crude and condensate, refinery and processing gain, net biofuels supply, natural gas plant liquids, and petroleum product imports.

Table 22: Results of Key 2015 AEO Cases

Implications of AEO Projections for Future Obligations that the United States has Under the International Energy Program

The AEO projections illustrate how United States obligations as an IEA member could evolve in the future. Using 2015 EIA data on net oil imports, the days of coverage represented by the current SPR inventory level of 695.1 MMbbl is 149 days of net imports (at 4.65 MMbbl/d). The IEA requires Member countries to hold 90-days' worth of net petroleum imports counting commercially-held and government-held stocks. However, IEP obligations also require the United States to contribute to an IEA coordinated response (called a "Collective Action") based on the percentage share of U.S. oil consumption relative to that of all IEA Member countries. As of October 2015, the United States would have had to contribute 43.9% to an IEA Collective Action. As shown in Figure 20, assuming the AEO 2015 projections and absent new public policies further reducing U.S. oil consumption, the United States obligation to contribute to a collective action is likely to remain relatively unchanged through 2040.

In 2040, the percentage obligations of the United States to an IEA Collective Action are estimated to range from 42.8% to 44.5%. In all of the AEO scenarios, the United States would need to contribute more than 42% of an IEA collective release in the event of a crisis. This has implications for both the required size of the SPR's inventory as well as its distribution capability.

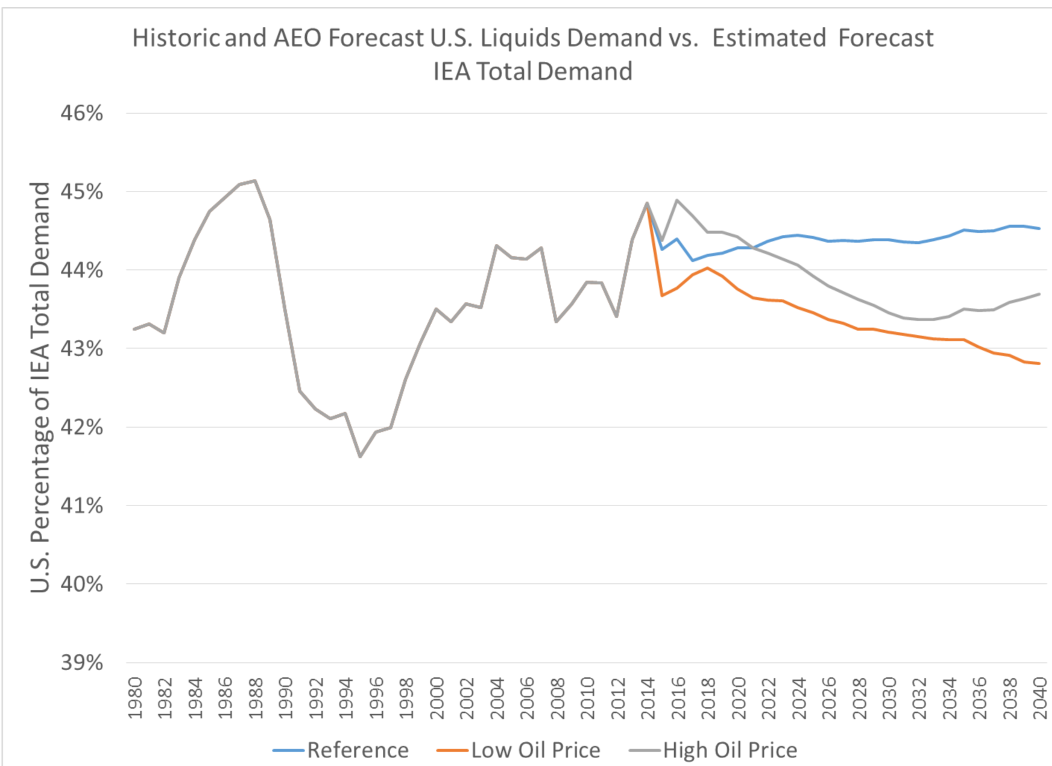

Figure 20: U.S. Total Liquids Demand Relative to IEA – Three AEO Cases

4.2 OIL SUPPLY DISRUPTION RISK

Evaluation of the future benefits of the SPR goes beyond charting the trajectory of future IEA requirements. While in all likelihood the United States share of an IEA collective action to address an oil supply disruption will remain substantial, the risk of a large supply disruption befalling the world oil market is uncertain. To address this uncertainty, in 2015 DOE sponsored a study conducted by the Stanford University Energy Modeling Forum (EMF) that quantified world oil market risk. This project used the same approach as a widely cited 2005 EMF study on the same topic.[36]

EMF's framework evaluates the likelihood of one or more foreign oil disruptions over the next 10 years. Although it was recognized that domestic and weather-related oil disruptions could also be very damaging, the analysis focused on geopolitical, military, and terrorist causes for disruptions outside the United States. The risk assessment was conducted through a series of two workshops attended by leading geopolitical, military, and oil market experts who provided their expertise on the probability of different events occurring, and the corresponding implications for major disruptions in key oil market regions. Special attention was paid to differentiate oil supply disruptions by their magnitude, their likelihood of occurrence, and their duration.

In the EMF framework, the world oil market was divided into five primary regions of production that are at risk for disruption: Saudi Arabia, Other Persian Gulf, Africa, Latin America, and Russia/Caspian. Together, these regions will account for 57% of world oil production in 2020 (as projected by EIA). The panel of experts also considered choke-point disruptions in vulnerable shipping lanes. Disruptions from the United States market and smaller global producers were not included. Excess surge production capacity was considered as a source to mitigate oil disruptions and therefore a primary output of the assessment is "Net Disruptions" or the total disruption minus the excess capacity available and brought on line. The final results of the risk assessment convey a range of insights across the three dimensions of magnitude, likelihood, and length of a disruption, for the five major supply regions.

The study concluded that over a 10-year timeframe (2016–2025):

- The probability of a net disruption of 2 MMbbl/d or more lasting at least one month is approximately 80%.
- The probability of a net disruption of 2 MMbbl/d or more lasting at least six months is approximately 63%.
- The probability of a net disruption of 2 MMbbl/d or more lasting at least 18 months is approximately 37%.
- The probability of a net disruption of 3 MMbbl/d or more lasting at least one month is 67%.
- The probability of a net disruption of 5 MMbbl/d or more lasting at least one month is 42%.

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[36] Huntington, Hill, and Phil Beccue. (October 3, 2005). Stanford Energy Modeling Forum. *An Assessment of Oil Market Disruption Risks: Final Report, EMF SR8*.

Table 23 is a summary of the probabilities of a disruption for the dimensions above, including size and duration, over the study's 10-year timeframe of 2016–2025.

Duration	Size of Disruption (MMbbl/d)			
	≥ 0	≥ 2	≥ 3	≥ 5
Short – At least 1 month	96%	80%	67%	42%
Long – At least 6 months	82%	63%	–	–
Very Long – At least 18 months	53%	37%	–	–

Table 23: Probability of an Oil Disruption by Size and Duration

These expert assessments, which are substantively similar to those developed in the 2005 study on the same topic, suggest continued risk in the global market, notwithstanding supply-demand conditions at the time of writing or expanding North American oil production. This result anchors the probabilistic analysis discussed below.

4.3 QUANTIFYING THE ECONOMIC BENEFITS OF THE SPR

The economic benefits analysis of the SPR presented in this report encompasses benefits related to mitigating the adverse consequences of crude oil supply disruptions on the United States economy as measured by (1) reductions in real GDP, and (2) higher payments made by the United States for imported crude oil.[37] These estimates of economic consequences were developed using the BenEStock model developed by Oak Ridge National Laboratory (ORNL). This model probabilistically simulates oil supply disruptions over the next 25 years, and then estimates the economic consequences of each disruption scenario with and without an SPR. Twenty-thousand runs of such 25-year scenarios are examined using a probabilistic Monte Carlo analysis to determine the net present value (NPV) of the economic benefits of the SPR. The analysis compares benefits across different SPR size profiles and distribution capabilities between 2016 and 2040. The Monte Carlo simulation is used to produce estimates of the expected (or average) economic benefit and the probability distribution of economic benefits.

BenEStock characterizes emergency stocks in terms of stock volume (in MMbbl), and fill, drawdown, and refill rates (in MMbbl/d). It tracks the United States SPR, other IEA public stocks, other IEA industry-obligated stocks, and non-IEA stocks.

Oil supply disruptions were simulated against reference paths for oil prices, demands, and supplies taken from EIA's 2015 AEO. Within each year over the model 25-year horizon (2016–2040), an oil supply disruption may occur. The timing, size, and length of the disruptions were randomly sampled from the

[37] This approach seeks to account for the fact that the oil price elasticity of the GDP, as a measure of the impacts of oil shocks on the economy, is an imperfect measure that may not fully account for the transfer of oil wealth, purchasing power losses, and terms of trade effects associated with suddenly higher oil import costs. These imports-related effects account for about 20% of estimated economic benefits.

underlying annual probability distributions taken from the EMF 2015 study. If a disruption occurred in a given year, its impacts were modeled on a monthly basis for up to 36 months after disruption onset, with disruptions of up to 18 months in duration.[38] Over the course of a disruption, consumption and production patterns adjust and prices generally fall from their initial disruption level, although the monthly price can also vary with the pattern of emergency stock use.

These gross oil supply disruptions were directly offset by spare world oil production capacity. The extent of spare production capacity and the likelihood of its use were also assessed by the experts in the EMF study. If the net disruption after these offsets was greater than the specified drawdown threshold level (1 or 2 MMbbl/d), the emergency stocks were released in a coordinated IEA collective action in an attempt to offset it. Drawdown rates and timing for each stock type (i.e., United States, other IEA public stocks and obligated industry stocks, and non-IEA stocks) are limited by the specified technical maximum drawdown rate for that year, the specified drawdown rule or strategy, and the rate of exhaustion. After a drawdown concludes and the disruption price effect subsides, the emergency stocks are assumed to be refilled over a five-year period. The model does not include a response from commercial stocks in the United States.[39]

The oil shortfall was calculated as the size of the remaining disruption after offsets and emergency stock draws. If the oil shortfall was greater than zero, world oil price was affected.[40] A risk premium caused by imperfect market information and uncertainty will prevent stocks from completely eliminating the price increase, even if the net disrupted volume is fully offset by stock drawdowns. For the Base case assumptions, this irreducible risk premium is modeled as being 10% of the unmitigated price effect of the disruption. World oil price is determined assuming that world demand responds to that price change (non-OPEC supply is essentially fixed) and the price increases sufficiently for demand to accommodate the remaining oil shortfall after stock drawdown. The model also accounts for increasing output of U.S. tight oil supply over the course of the disruption because this source is believed to be more flexible than conventional oil production.

Oil price increases are then translated into the economic costs to society. These costs are composed of GDP losses plus the increase in net oil import costs. The oil price's responsiveness to supply shocks and the economy's responsiveness to oil price shocks are based on "elasticities" derived from the economic literature.

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[38] Disruptions, if occurring, are arbitrarily assumed to begin in the first month of the year. Attention is paid to the case where, for longer disruptions, disruption effects extend into the following year. If the disruption is greater than 12 months in duration, then no new disruption can occur in the successive year, and refill is delayed until the year after.

[39] While U.S. commercial stocks could conceivably address part of a supply disruption, private stockholders could also hold inventories in a supply crisis in the anticipation that their value would continue to rise. Unlike other IEA members, the United States does not mandate industry storage. The exact nature of private oil inventory movements in a crisis constitutes an area for future research.

[40] In BenEStock, a Base case oil shortfall risk multiplier of 10% was assumed, meaning that the shortfall can never fall below 10%.

4.3.1 Monte Carlo Simulation Approach

Monte Carlo simulations with 20,000 replications for each 25-year scenario were performed to produce estimates of the expected (or average) economic benefit and the probability distribution of economic benefits. For each iteration, probabilistic disruption sizes and durations were sampled for the five at-risk supply regions for every year over the 25-year horizon. Market outcomes for each year along this sample time path were calculated based on the random events and stockpile responses. Output values, including benefits, were collected. This allowed the determination of expected values and confidence intervals around those average outcomes.

4.3.2 Model Structure and Assumptions

Inputs to the BenEStock model can be categorized into one of six modules (equation groups and categories of parameters). The six modules are summarized in the green and red boxes in Figure 21, and the model's key assumptions are summarized in Table 24. Below these two exhibits are additional details on each model input. Outputs from the model, including supply, demand, prices, and GDP levels, are shown in the yellow boxes of Figure 21. Two world states are simulated side-by-side (e.g., one state could be no United States SPR and the second state assumes an SPR of a given size) and consumption levels, production levels, prices, and so forth are calculated for each state. The assumptions for each program, including a maximum drawdown rate, storage volume size, and emergency stock behavior, can be specified separately. Comparisons of the combined United States GDP losses and the cost of foreign oil between scenarios yield the expected benefits of one particular SPR configuration compared to another. The benefits model accounts for oil acquisition costs, but not the operating costs of the SPR or any other costs.

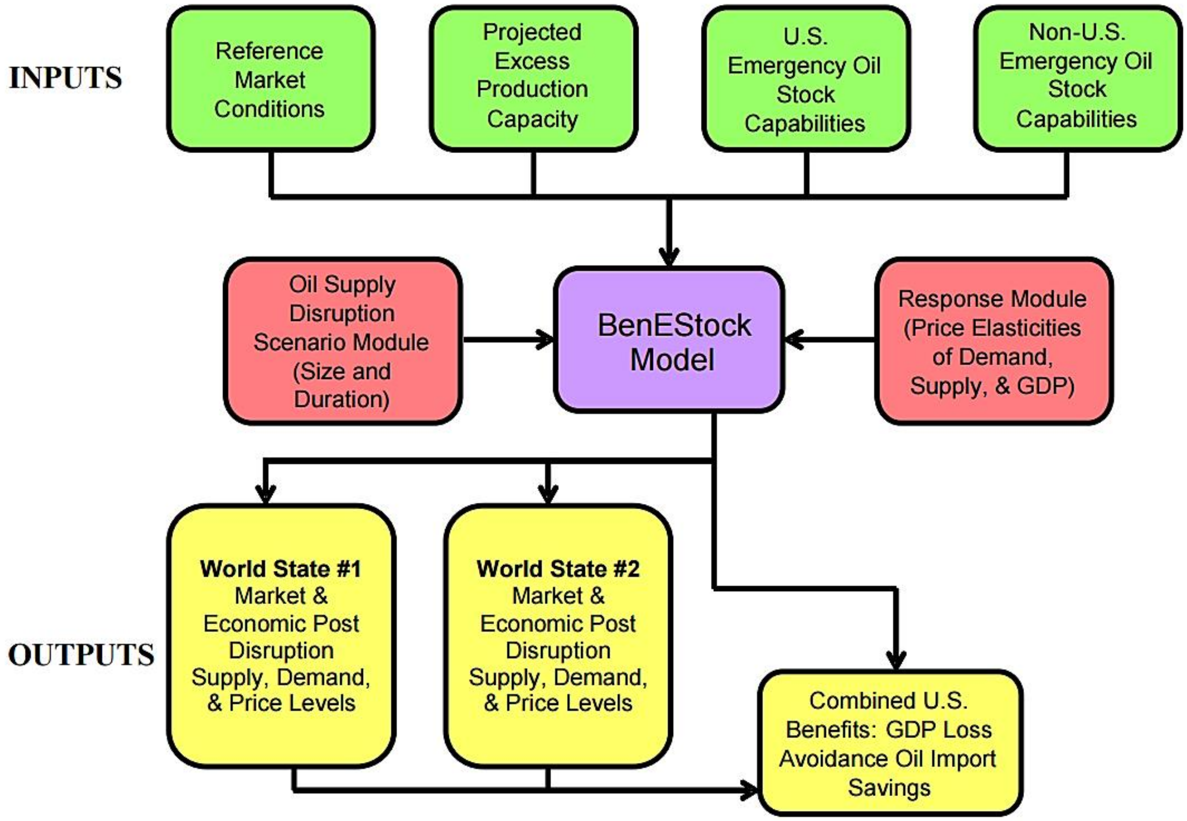


Figure 21: Flow Diagram of the BenEStock Model

Input Variable	Values for 2016 LTSR
Oil Market Forecast (reference oil prices, regional demands and supplies, GDPs)	AEO 2015
Global Supply Disruption Probabilities – Regional probabilities by % loss (and year, if time varying) and by duration	EMF 2015; Monte Carlo simulation
GDP Elasticity	Truncated normal distribution with mean from ORNL 2015 systematic review of the literature. Mean of -0.0195, and range of -0.01 to -0.03.
Net Demand Elasticity	ORNL 2015 systematic review of the literature with range or distribution. Includes representation of tight oil surge elasticity.
Drawdown Strategies	Coordinated IEA draw (for IEA share of world elastic consumption, assume that IEA obligations are evenly divided between the United States and the rest of IEA). Non-IEA stocks make up the rest (if available). The assumed strategy is the maximum draw (up to the disruption size) for the first three months, with a sustainable draw thereafter for the remainder of the disruption (IEA study assumption). This strategy reflects one approach given the uncertainty about shock length. The strategy is also constrained by the actual maximum drawdown capability for each category of emergency stock, which can depend on the remaining stock in the Reserve.
United States SPR Size	Case dependent.
U.S. Maximum Draw Capability	4.415 MMbbl/d starting point; declines with size and remaining stock.
Drawdown Threshold	2.0 MMbbl/d net loss of global supply for non-U.S., 1.0 MMBD for U.S. except for simulation cases that impose limited drawdown capabilities when the SPR size falls below 500 (then 2 MMBD) under Section 161(h) of the EPCA.
Effective OPEC Excess Capacity (by region and year) and availability	Randomly distributed based upon EMF 2015; 1.1 MMbbl/d expected value. Spare capacity is assumed to be phased in over 90 days after a disruption. It is unavailable for the first month. After the first month, 1/3 of the spare capacity becomes incrementally available each month, with full deployment in the fourth month after a disruption. In addition, a region's spare capacity is assumed unavailable if that region is disrupted.
IEA Drawdown Coordination	50%–50% share for U.S. and non-U.S. IEA. IEA quantity made available does not decline along with U.S. SPR size reductions.
Other IEA Public Emergency Stock Sizes	948 MMbbl* of public IEA stock (2016–2040 average); 100% available, 10% unrecoverable.
Other IEA Obligated Industry Emergency Stock Sizes	949 MMbbl* of obligated industry emergency IEA stock (2016–2040 average), approx. 25% assumed to be available for drawdown.
Maximum Other IEA Stock Draw Rate (average of the first 3 months)	Approximately 9 MMbbl/d (Average 1st 3 Months assuming 2016-2040 average stock level).
Non-IEA Emergency Stock Sizes	Average of 540 MMbbl of non-IEA public stock across time horizon; assumed to be 50% available.
"Risk Premium" on Price (% not possible to offset)	Based on percent of net disruption (after offsets but before drawdown) that essentially cannot be mitigated, leaving a residual price effect. This factor is 10% and reflects risks and uncertainties by market participants about how and when the market will re-balance.
Disruption Time Horizon	Maximum disruption/drawdown length of 18 months, economic losses modeled for 36 months.
Model Time Horizon	2016–2040.
Discount Year, Discount Rate	Base year is 2016 and discount rate is 7% in Base case.
Timing and Treatment of SPR Sale/Fill to Reach Alternate Sizes	Rate fixed at target size/5 years; assume minimal/zero impact on non-disrupted prices, minimal/zero macro impact.

* Many of the Non-US Emergency Stocks targets are specified in terms of either days of consumption or days of net imports. Our forecasts of these values will change when the AEO version used in the model changes, and projections in IEA country imports changes. Displayed values are for the AEO 2015 Base Case.

Table 24: Key Assumptions of the BenEStock Model

- **BenEStock Disruption Risk Characterization:** The oil market was characterized by the probability, magnitude, and duration of gross world oil supply disruptions. This risk profile, derived from the EMF project, includes five supply regions with discrete probabilities for different supply outages arrayed by size and duration. The values (in terms of percentage supply losses) from the EMF 2015 assessment, which focuses on the next 10 years, were extrapolated for a 25-year period in the model.

- **Projected Excess Production Capacity:** Consistent with the EMF 2015 study's expert assessment, spare capacity considered by the BenEStock model is restricted to OPEC countries. Shares and probabilities of OPEC spare capacity by OPEC sub-region are derived from the EMF 2015 study. EIA defines effective OPEC capacity as unused capacity that can be sustainably accessed within 30 days and sustained for at least 90 days. It excludes spare capacity in disrupted countries.

- **U.S. and Non-U.S. Emergency Oil Stock Capabilities:** United States and foreign emergency stockpiles are characterized by attributes, including size and various physical operational characteristics.

    - **Emergency Oil Stock Sizes and Availability:** The United States and other IEA countries holding emergency oil stocks are assumed to engage in withdrawal action only if spare production capacity is not enough to offset simulated supply disruptions. Projected levels of publicly controlled stocks and obligated private industry stocks are assumed to adjust with imports and consumption levels, in accordance with the current laws of member countries, or are held constant at known 2015 stock levels if no legislative information is available. In 2015, public IEA stock levels were approximately 1.6 Bbbl, of which 695.1 MMbbl were in the SPR.

    - **Distribution Rates:** In the model, the coordinated SPR distribution begins after a supply disruption threshold is exceeded. The default drawdown strategy, which is based on an IEA approach, is for all stockpiles to be drawn down at their maximum rate for the first three months of the disruption, with the remaining stockpiles released at the maximum sustainable rate (equal to reserve size divided by disruption length) over the remainder of the disruption. This accounts for the lack of perfect information about the length of a disruption, and minimizes the cost of inaction per barrel of supply lost which is generally larger earlier in the disruption than later. The maximum drawdown rate of the SPR is modeled as 4.415 MMbbl/d and the maximum distribution capacity depends on the distribution scenario and whether it is assumed that additional dedicated dock capacity has been added. For other IEA government-owned stocks, the maximum rates are based on the information provided by IEA and are size dependent. IEA-obligated industry stocks are thought to be available sooner and at greater volumes, so they are assumed to have a maximum draw rate capable of exhaustion in two months.

- **Market Responsiveness:** The BenEStock response module models the change in oil prices due to the supply disruptions (based on the net world price elasticities of supply and demand) and the sensitivity of the economy to the net price effects of the shocks (based on the oil price elasticity of the United States GDP) to estimate the economic impacts. These estimates are derived from the empirical oil-economy literature.

  - **Net Supply and Demand Response:** The model employs a net demand elasticity that combines and summarizes world demand and supply responses to changing prices. The world demand elasticity component is not constant. It is a function of the time elapsed since the start of the disruption, reflecting the process of demand slowly adjusting over time to sudden price changes. The demand elasticity component is also an increasing function of disruption size, meaning that the price rise per million barrels per day of supply loss declines as disruptions get increasingly large. This prevents prices from becoming unrealistically high for very large disruptions under a fixed short-run elasticity. Short-run supply elasticity is only applied to the United States tight oil fraction of world oil supply.[41] The estimated values for U.S. tight oil supply elasticity used in the BenEStock model increase with time elapsed since the start of the disruption, rising from 0.024 in the first month after the disruption to a longer-run two-year elasticity value of 0.223.

  - **GDP Elasticity:** Estimates of the GDP impact of oil shocks involve a direct relationship between price outcomes and the GDP of oil-importing countries. This approach accounts for several mechanisms and channels through which changes in crude oil prices impact the economy, including reallocations of expenditures on goods and services within the economy, friction in capital and labor market adjustments, reductions in capacity utilization rates, difficulty in adjusting prices, monopolistic behavior, inflationary effects, and responses by the monetary authorities. The mean GDP elasticity used in this study is -0.02. The range is -0.01 to -0.03, with a truncated normal distribution. These values were based on an appraisal of the extensive literature on the economic impacts of oil price shocks, which showed that the range of estimates of the GDP elasticity is wide. For the United States, the range of estimates is typified by the studies of Hamilton and Kilian and Vigfusson, in which the implied elasticities were -0.014 to -0.069 and +0.004 to -0.052, respectively, based on data in the papers.[42]

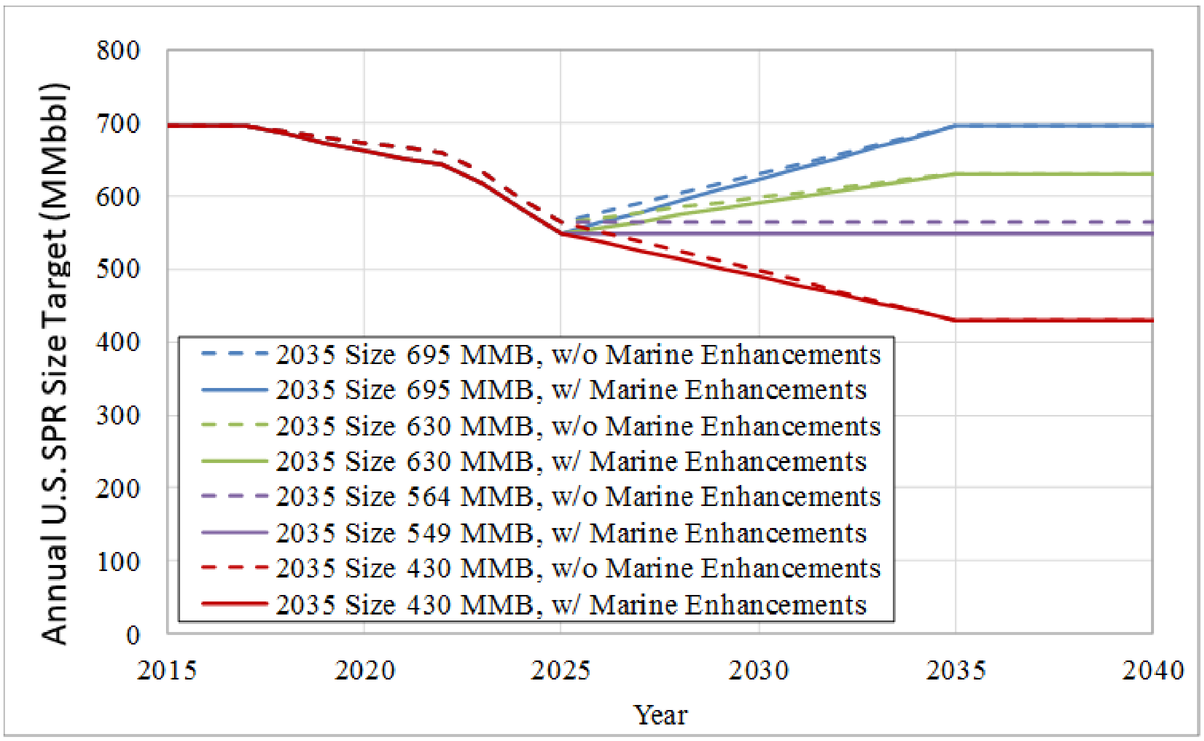
[41] Although more expensive than some conventional oil wells, tight oil wells can be drilled and reach peak production levels more quickly (but they also have faster production decline rates). The flexibility offered by the shorter turn-around time for tight oil wells means that these producers can respond more quickly to changes in oil prices than other non-OPEC producers.

[42] Hamilton, J.D. (2005). Oil and the Macroeconomy. *The New Palgrave Dictionary of Economics*. Palgrave MacMillan, London. Available online at http://www.dictionaryofeconomics.com/dictionary; Hamilton, J.D. (2012); Oil Prices, Exhaustible Resources, and Economic Growth. No. w17759. National Bureau of Economic Research, 2012; Kilian, L., & Vigfusson, R. (2014). The role of oil price shocks in causing US recessions. CEPR Discussion Paper No. DP10040.

4.4 SPR SIZE AND DISTRIBUTION CASES

The economic benefits of the SPR over the next 25 years were examined for the LTSR across 16 model cases, consisting of four SPR size profiles across four scenarios with varying assumptions about the world oil market and the SPR's distribution capability.

SPR Size Options: Four SPR size options were evaluated under each scenario. The Reference case size in each scenario assumes that the SPR's size is solely determined by the inventory sales that have been legislated to take place in the coming decade. The Reference case inventory sales and resulting size vary somewhat, depending on which oil price path is used (because SPR modernization sales limits are based on revenue, not volume) and on whether marine terminal enhancements are made (which would be funded through the sale of $1.2 billion of inventory). As a result, Reference case assumptions for the SPR volume in 2025 range from 549 MMbbl to 564 MMbbl. The four size options differ primarily in terms of changes after 2025. The model analyzes cases in which the inventory is rebuilt after 2025 to its current level of 695 MMbbl, inventory is rebuilt to 630 MMbbl, and the inventory is reduced to 430 MMbbl. These inventory trajectories, which are assumed to develop between 2026 and 2035, are charted in Figure 22.



Note: United States SPR Size Profile Time Paths. SPR size goals are determined by mandated sales under Section 403 of the Bipartisan Budget Act of 2015 (2018–2025), and Section 32204 of the FAST Act Sales (2023–2025), and sales authorized by Section 404 of the Bipartisan Budget Act of 2015 (2017–2020). Ultimate target sizes are reached by 2035.

Figure 22: U.S. SPR Size Profile Time Paths, AEO 2015 Base Case

World Oil Market: The benefits of the SPR were evaluated using two oil market assumptions, representing moderate and low oil price growth. The first oil market scenario (labeled in tables as AEO15Base) is from EIA's 2015 AEO Reference case, while the second case (labeled AEO15LWOP) is from the 2015 AEO Low Oil Price case. Prices for 2016 and 2017 are from EIA's Short-Term Energy Outlook (January 2016).

Effective Distribution Capability: The scenarios also vary in terms of what level of effective distribution capability is assumed. The "without marine enhancements" cases account for the SPR's current effective distribution capacity being limited by congestion in commercial midstream infrastructure. The "with marine enhancements" cases assume that bottlenecks are removed in 2025 through additional marine terminal distribution capacity as part of the SPR modernization program.

4.5 RESULTS

4.5.1 Results by Stock Sizes

Table 25 shows the United States economic benefit results for each SPR size option under each oil price/distribution capability scenario accounting for macroeconomic benefits minus oil acquisition costs. The first column is the assumed SPR stock size in million barrels. The second column shows the net present value of U.S. benefits for the 2016–2040 simulation period in billions of constant 2012 dollars. All of the cases examined show positive benefits, ranging from $281 billion to $428 billion.

SPR Size (MMbbl)	U.S. Benefits of an IEA Collective Action (Net Present Value in 2012 $ Billion)
Reference Oil (AEO15Base), Varying Sizes	
695	$320.9
630	$320.8
564	$320.5
430	$281.0
Low Oil (AEO15LWOP), Varying Sizes	
695	$428.1
630	$427.4
557	$426.3
430	$386.4

Notes:

(1) All drawdowns are IEA coordinated. Expected net present value, 2016–2040 time horizon, discounted at 7% to year 2016.

(2) The United States benefits of an IEA Collective Action result from reducing the increase in the world oil prices that would have occurred without the Collective Action. Consequently, the estimated benefits to the United States reflect the additional oil supplies assumed to be provided to the world market from the SPR and other IEA Member countries

(3) United States benefits are the avoided disruption costs net of the NPV SPR program change and emergency sales revenues and oil purchase (for program size changes) and repurchase costs (after disruption) but *excludes* revenues used for marine enhancements.

(4) Benefits for sizes below 530 MMbbl reflect a higher drawdown threshold due to limited drawdown authority due to Section 161(h) of EPCA, which states that a limited drawdown cannot be made if it brings the SPR inventory below 500MMB. For the 430 MMB case, the SPR is drawn down for disruptions of 2MMB/D or larger.

Source: ORNL simulations with BenEStock model. (July 2016). P.N. Leiby, D. Bowman, G. Oladosu, R. Uria-Martinez, and M. Johnson.

Table 25: Estimated Benefits of SPR Stocks of Varying Stock Sizes

The benefits for larger SPR sizes level-off because the probability of their full use is lower than for smaller SPR sizes. The value of a bigger SPR stems from the ability to address oil supply losses that a smaller reserve could not replace. However, relatively large and lengthy crude oil disruptions are less likely than small and shorter disruptions. Thus, as the modeled reserve size increases, the incremental value of a larger inventory decreases because extremely large and long disruptions are less likely to occur. The benefits of the SPR will become flat after the Reserve is large enough to address every potential supply disruption in the EMF risk profile.

The large differences between the Base cases and the 430 MMbbl cases occur because the SPR would lose the ability to implement the limited drawdown authority under Section 161(h) of EPCA if it drops below 530 MMbbl. Section 161(h) of EPCA allows the SPR to be drawn down for cases other than a severe energy supply disruption as long as the Reserve is not drawn below 500 MMbbl. This authority is modeled in BenEStock by allowing the SPR to be drawn with a 1 MMbbl/d supply loss threshold as long as its size is above 530 MMbbl; otherwise the SPR is drawn with a 2 MMbbl/d supply loss threshold.[43]

[43] The 1 MMbbl/d and 2 MMbbl/d supply loss thresholds cited are for modeling purposes only and are not intended to characterize the disruptions that would necessarily need to exist to use the authority under EPCA Sections 161(d) or 161(h).

Thus, the drawdown threshold for the Reserve is higher for the 430 MMbbl cases, which means that some smaller disruptions cannot be addressed by the SPR. This underscores the economic consequences of taking limited drawdown authority away from the President.

In the Low Oil Price cases, the benefits increase relative to the corresponding Reference Oil Price cases. This seemingly counterintuitive result stems from the fact that, in the Low Oil Price case, the United States consumes more oil, imports from at-risk regions of the world increase, and the risks of disruption are higher in these regions relative to the Base Oil Price case.

In modeling the economic benefits of the SPR, the most influential input variable is the GDP elasticity with respect to the oil price. To illustrate how this parameter impacts the results, a sensitivity analysis was performed to evaluate alternative estimates. The mean GDP elasticity used for this study (-0.02) is close to the overall mean value for the United States from the literature. The benefits estimates vary nearly proportionally with the change in GDP elasticity. Assuming an elasticity, of -.01 (meaning the economy is less vulnerable to an oil shock), the baseline benefits drop from $320.5 billion to $211.8 billion. If the elasticity is increased in magnitude to -.03, the benefits of the SPR increase to $420.1 billion. Ongoing research is focused on how this relationship is evolving; some studies suggest that the U.S. economy is less vulnerable today to the impacts of oil price shocks than it was in the 1970s.[44]

Although the economic benefits of restoring some or all of the SPR's inventory that will be sold in the next decade are positive, the returns of future oil acquisition might not justify rebuilding the Reserve. The above benefits are net of oil acquisition costs, so the economic damage that would be averted by a larger SPR would "cover" the cost of purchasing more oil (although the purchase costs would need to be appropriated up front and the benefits would be distributed over time). However, the above results do not account for any differences in operating costs for the SPR size options other than oil purchase, sale and repurchase costs. The SPR has high fixed costs, so the changes in size discussed above would not have a significant impact on the cost of maintaining the SPR program.

More importantly, the table does not account for the additional cavern capacity (storage space) that would need to be created to accommodate additional crude oil inventory. As discussed in Chapter 2, natural and induced cavern creep will reduce available cavern space in the coming years. Additionally, consideration must be given to the possibility of caverns being removed from service over time due to operational issues and/or subsurface conditions. To rebuild the SPR's inventory in the 2020s and 2030s, at least some additional caverns would need to be developed at an estimated cost of about $10 million/MMbbl (2016 $). The total capital cost of restoring the SPR's inventory could exceed $1 billion.

4.5.2 Results by Distribution Capability

The BenEStock model can also be used to evaluate the economic benefits of varying levels of SPR drawdown and/or distribution capability. To evaluate the economic value of developing additional

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[44] Notable examples include Brown, S. P. A., & Huntington, H. G. (2015). Evaluating U.S. oil security and import reliance. *Energy Policy* 79, 9–22 and Baumeister, C., & Peersman, G. (2013). Time-varying effects of oil supply shocks on the US economy. *American Economic Journal: Macroeconomics*, 5(4), 1-28.

marine distribution capability, the model was used to evaluate the economic benefits of the SPR with and without marine enhancements. In the cases without marine enhancements, the Reserve's drawdown capability was limited to the effective distribution capability levels discussed in Chapter 3 of this report. In the marine enhancements by 2025 cases, the Reserve was able to send oil to the market at its design drawdown rate.

As shown in Table 26, in all of the cases, removing the distribution constraint yields a meaningful economic return. The difference between the pairs of distribution enhancement scenarios is between $6.2 billion and $9.0 billion in both the world Low Oil Price cases and the AEO Base price cases.

SPR Size (MMbbl)	Benefit of Marine Enhancements (Discounted to 2016)	Benefit of Marine Enhancements (Discounted to 2025)
Reference Oil: AEO15Base – Varying Size		
695	8.0	14.7
630	7.4	13.5
549	6.5	12.0
430	6.2	11.4
Low Oil: AEO15LWOP – Varying Sizes		
695	9.0	16.5
630	8.1	14.8
536	6.5	11.9
430	6.7	12.4

Notes:

(1) All drawdowns are IEA coordinated. Expected net present value, 2016–2040 time horizon, discounted at 7% to year 2016.

(2) United States benefits are the avoided disruption costs net of the NPV SPR program change and emergency sales revenues and oil purchase (for program size changes) and repurchase costs (after disruption) but excludes revenues used for marine terminal enhancements.

(3) Benefits for sizes below 530 MMbbl reflect limited drawdown authority due to Section 161(h).

Source: ORNL simulations with BenEStock model. (July 2016). P.N. Leiby, D. Bowman, G. Oladosu, R. Uria-Martinez, and M. Johnson.

Table 26: Estimated Benefits of SPR Stocks with and without Marine Enhancements to Fix Distribution Constraints

The benefits of the marine enhancements may appear small, relative to the benefits of total world-emergency oil stocks as a whole. The facilities would not be operational until 2026, which means that the benefits are significantly discounted. The above table also shows the docks discounted to 2025. Further, the marginal capability that the docks add is being assessed in the context of an IEA collective action in which the United States is releasing oil in concert with other countries. This means that the additional capability represents a smaller incremental benefit than if the United States was releasing oil on its own.

The benefits of the enhanced SPR distribution capability exclude the $1.2 billion in sales revenue that would fund the marine terminal enhancements. This allows for a rough calculation of the economic returns of these investments. DOE estimates that the present value of the total lifecycle costs for marine enhancements would be approximately $2 billion between now and 2040. This figure includes both the capital expenditure to build the docks and the operating, maintenance, and personnel costs associated with these assets over the same period. This yields a ratio of benefits to cost between 4.5:1 and 3:1, which makes a strong case for the value of these enhancements. In addition, these benefit calculations do not include any scenarios during which the United States executes an SPR emergency release absent IEA participation and utilizes a higher percentage of the additional distribution capacity afforded by the marine enhancements (as discussed in Chapter 3).

This distribution assessment accounts for the likelihood of a disruption and reports the average benefits of the marine enhancements over thousands of simulated scenarios. In a major oil market disruption, the avoided economic losses provided by marine terminal distribution enhancements could be extremely high. In 5% of the cases, the discounted benefits of the marine terminal distribution enhancements are $40 billion or more. Similar to an insurance policy, the value of these assets, if available for utilization during an oil supply disruption with infrastructure congestion, would be very high.

4.6 GEOSTRATEGIC BENEFITS

The preceding economic analysis does not necessarily encompass *all* of the benefits that the United States might gain from the SPR. The additional geostrategic benefits that might accrue to the United States from the SPR include (1) blunting the effectiveness of crude oil embargos; (2) incentivizing holders of spare crude production capacity to increase production levels during disruptions events; (3) decreasing the cost of diplomatic, economic, or military intervention into adversarial or politically unstable oil-producing areas; and (4) anchoring the world's collective energy security system. These geostrategic benefits of the SPR, which are not captured in the BenEStock modeling methodology, are discussed in the following sections.

4.6.1 The SPR Deters Crude Oil Embargos

The existence of the SPR can mitigate the impact of crude oil embargos that might be imposed to damage the economies of importing countries by providing a reliable means to quickly replace lost crude oil in the market. Through this response, the SPR can act as a deterrent to the threat of oil embargoes and politically motivated withholding of oil supply by removing the incentive and reward of such an action. Since the development of the global oil stockpiling system in the mid-1970s, adversaries in oil-exporting countries have had to reevaluate the benefit and cost of cutting off energy supplies. Such an action runs the risk of not only failing to achieve its objective of economic damage to importing countries, but could impose economic and political hardships on the exporter, who may face the loss of crucial oil revenues, and thus political influence and domestic stability, from the decrease in sales. These considerations reduce the strength of the "oil weapon" in oil-exporting countries.

The SPR, in tandem with the IEA CERM, has been an effective deterrent against oil embargoes for the past 40 years. Iran and Venezuela are among the states that have threatened to curb their oil supplies to the United States or other IEA members in recent years.[45] These states ultimately chose not to act on their threats as doing so would have deprived them of significant export revenues while not rendering comparable economic harm on the target state due to the availability of strategic reserves to replace lost supply.

4.6.2 The SPR Incentivizes Faster Deployment of Global Spare Crude Oil Production Capacity

The ability of the SPR to rapidly respond to global oil supply disruptions incentivizes holders of spare crude production capacity to increase production levels during disruption events to capture the economic rents (that is, unusually high profits) from elevated prices, rather than see it go to the holders of the strategic reserves. While the decision to release spare capacity is based on a host of factors internal to OPEC, the existence of strategic oil stocks likely increases the willingness of OPEC to ramp-up production to some degree.

Historically, implicit or explicit threats of an SPR drawdown have encouraged OPEC, primarily through Saudi Arabia, to release more supply to calm global markets.[46] In 2000, an implicit threat that the United States might consider an SPR drawdown led OPEC producers to modestly increase production several times throughout the year. More recently, following supply disruptions stemming from the Libyan uprising in early 2011, Saudi Arabia and other Gulf countries added 1.2 MMbbl/d to the market due, in part, to implicit United States resolve to use the SPR. Oil-exporting countries also have an incentive to release spare capacity during an oil supply disruption to reduce market volatility and to avoid demand destruction resulting from protracted high prices. While the determinants of policy decisions surrounding spare capacity cannot be precisely identified, strategic oil stocks likely exert a positive impact on these decisions.

4.6.3 The SPR Reduces the Oil-Supply Costs of Foreign Policy Choices

Because of the existence of, and demonstrated political commitment and resolve to use the SPR when needed, either unilaterally or through an IEA collective action, the United States can entertain more policy options for diplomatic, economic, and military intervention in the world's oil-producing regions, which are frequently flashpoints for geopolitical risk. The SPR can reduce the oil supply-related concerns of the United States and its allies in cases where a foreign policy action might compromise world oil supplies.

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[45] Llana, Sara Miller. (July 26, 2010). "Hugo Chávez oil threats: Why Chávez won't cut off oil to the US," *The Christian Science Monitor*. http://www.csmonitor.com/World/Americas/2010/0726/Hugo-Chavez-oil-threats-Why-Chavez-won-t-cut-off-oil-to-the-US; Erbink, Thomas, and Joby Warrick. (February 15, 2015). "Iran threatens to cut some oil exports to Europe, Touts nuclear advances," *The Washington Post*. https://www.washingtonpost.com/world/iran-activates- nuclear-reactor-says-underground-bunker-is-fully-operational/2012/02/15/gIQAHN2WFR_story.html.

[46] Goldwyn, David L., and Cory R. Gill. (October 21, 2015). "The SPR as a Foreign Policy Asset," (unpublished report to the U.S. DOE Office of Petroleum Reserves).

For example, the SPR makes it easier for the United States to garner support for U.S.-led energy sanctions against oil-exporting adversaries. This occurs because the SPR oil can ease the market concerns and related price increases caused by the "tightened" oil market associated with the lower levels of supplies reaching the market under a sanctions regime.

The sanctions imposed between 2006 and 2012 on Iran by the United Nations and the European Union because of concerns related to Iranian nuclear activities were easier to impose in the presence of global strategic oil stocks. The SPR can be leveraged by U.S. policymakers, unilaterally if necessary, to replace lost supply volumes if the sanctions should need to be re-imposed in a tight world market. Having both the volumes to substitute for a threatened supply loss, and the delivery capacity to bring that supply to market, is a powerful diplomatic tool.

4.6.4 The SPR Anchors the World's Collective Energy Security System

The SPR anchors the world's collective energy security system. By ensuring that the SPR remains a reliable asset within the IEA collective action framework, the United States leads by example, encouraging other countries to maintain their own reserves of crude oil and petroleum products, and to deploy those reserves in a collective manner. This leverages the effectiveness of the United States strategic reserves and benefits the United States to a greater degree than would be possible with only the SPR.

The relevance of the United States leadership role in global energy security extends beyond the IEA. As non-IEA nations begin to play a greater role in world oil trade, they are beginning to develop oil stockpiles. DOE actively supports these efforts. This trend notwithstanding, the SPR still plays a preponderant role in international oil stockpiling, as illustrated in Figure 23.

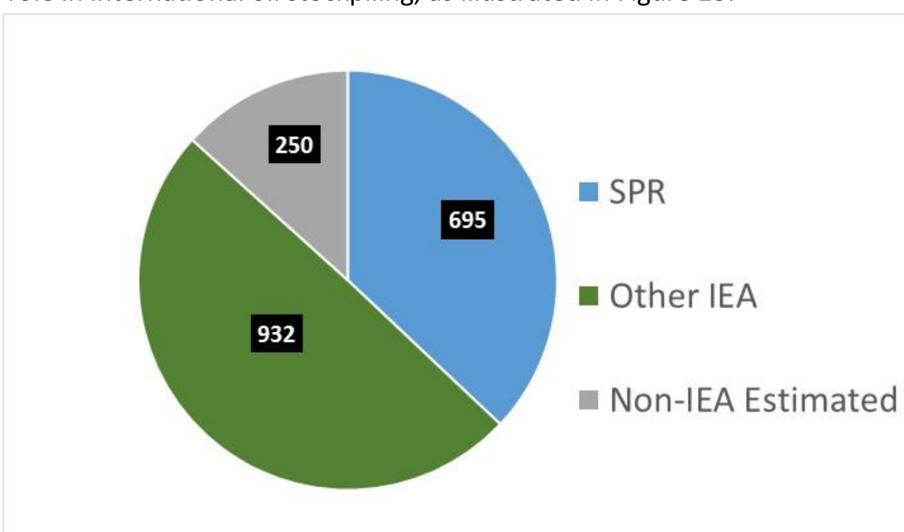

Figure 23: World Strategic Oil Reserve Stockpiles, 2016 (MMbbl)

4.6.5 Current U.S. Oil Production and the SPR

The purpose of this report is to inform decisions that will impact the direction of the SPR over the next 25 years. Currently, two market trends should be discussed in this context. First, commercial storage inventories in the United States and elsewhere are at historic highs. This is the result of global oil supply outpacing global oil demand in the last few quarters. While this adds a temporary layer of resiliency to the world market, it should not be conflated with a replacement for strategic oil stocks. The current market imbalance will likely unwind and inventory levels will likely fall from current historically high levels. In the context of the SPR Long-Term Strategic Review, current crude inventory levels should not influence decisions regarding the long-term future of the Reserve.

Second, the United States is producing oil at a historically high level. Some market observers contend that the United States is the new "swing producer" in the world market. This is only partially true. While U.S. production plays a relatively greater role in determining the world oil price than in the years immediately preceding the shale revolution (which is accounted for in the modeling discussed in this chapter), the United States cannot surge production in the same manner as OPEC members who hold spare capacity. U.S. producers also cannot introduce oil to the market at the scale and pace of IEA stockholders. In a true crisis, considerable economic harm would occur from price escalations that take place before U.S. producers could scale-up their output. Furthermore, the scale of many of the supply disruption scenarios developed by experts in the EMF study eclipses potential U.S. output expansions. Increased U.S. production certainly increases the resiliency of the world oil market, but it does not substitute for dedicated energy security stockpiles.

CHAPTER 5 – SPR MODERNIZATION

This chapter provides an overview of the legislative authority and Congressional intent in support of an SPR modernization program. It discusses the two projects that make up the SPR modernization program, as well as project funding requirements and impacts.

5.1 LEGISLATIVE AUTHORITY

The Bipartisan Budget Act of 2015 was enacted into law in November 2015. Section 404 of this Act establishes a new fund in the United States Treasury to be known as the Energy Security and Infrastructure Modernization (ESIM) Fund. The purpose of the ESIM Fund is to provide for the construction, maintenance, repair, and replacement of SPR facilities. Section 404 also authorizes the Secretary, subject to prior appropriation, to drawdown and sell crude oil from the SPR in an amount up to $2 billion, over the four-year period encompassing FY 2017–2020, for the purpose of carrying out an SPR modernization program. The revenues received from these sales shall be deposited into the ESIM Fund during the fiscal year in which the sale occurs, and such amounts shall remain available in the ESIM Fund without fiscal year limitation. The authority of the Secretary to drawdown and sell crude oil from the SPR under this section expires at the end of FY 2020.

5.1.1 Purpose

In establishing the ESIM Fund, Congress made the following findings:

- The SPR is one of the nation's most valuable energy security assets.
- The age and condition of the SPR have diminished its value as a federal energy security asset.
- Global oil markets and the location and amount of U.S. oil production and refining capacity have dramatically changed in the 40 years since the establishment of the SPR.
- Maximizing the energy security value of the SPR requires a modernized infrastructure that meets the drawdown and distribution needs of changed domestic and international oil and refining market conditions.

Section 404 also directs the Secretary to establish an SPR modernization program to protect the United States economy from the impacts of emergency supply disruptions. This program may include:

- Operational improvements to extend the useful life of surface and subsurface infrastructure.
- Maintenance of cavern storage integrity.
- Addition of infrastructure and facilities to optimize the drawdown and incremental distribution capability of the SPR.

5.1.2 Quadrennial Energy Review Findings

The Act directly supports the findings and recommendations regarding the SPR contained in the April 2015 *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure* (QER). The QER found that the SPR's ability to offset future energy supply disruptions has been adversely affected by domestic and global oil market developments, coupled with the need for infrastructure upgrades. Changes in the United States midstream energy sector (e.g., competing commercial demands, oil pipeline reversals, increased utilization rates for pipeline and marine terminals), as well as lower United States dependence on imported oil, have created challenges in certain modeled scenarios to effectively distributing oil from the SPR.

An effective modernization program for the SPR should address the challenges presented by changing oil market conditions. It should be undertaken with a more-up-to-date appreciation of the nature of energy security in an interconnected world. In spite of the changes in the United States oil profile, the United States economy will remain vulnerable to future international oil supply disruptions without the protection afforded by the SPR. Implementing an effective and comprehensive modernization program will ensure that DOE will be able to move high volumes of incremental barrels of oil rapidly to global markets in the event of global supply disruptions.

The QER recommended that DOE invest to optimize the SPR's emergency response capability. The recommendation anticipated that $1.5–$2.0 billion is needed to increase the incremental distribution capability of the SPR by adding dedicated marine terminal capacity to the SPR distribution system, as well as undertaking a life extension program for key SPR infrastructure components.

5.2 SPR MODERNIZATION PROGRAM

In 2014, OPR conducted an internal review of the SPR's infrastructure and capabilities. The review compared current operational capability to the SPR's Level I technical performance criteria and identified gaps within the SPR's infrastructure and distribution systems. The results indicated that significant investment in SPR infrastructure is critical to maintain the SPR's operational readiness.

DOE has identified two specific projects—*Life Extension II* and *Marine Terminal Distribution Capability Enhancements*—that will make up the SPR modernization program. Based on preliminary cost estimates, it is anticipated that up to $800 million in total project costs could be required for the Life Extension II project, and up to $1.2 billion in total project costs could be required for the Marine Terminal Distribution Capability Enhancements project. Because both capital asset projects have total project costs that exceed $10 million, each will be subject to the requirements of DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, which outlines a sequence of Critical Decision (CD) milestones and requirements over the course of a project. A short discussion and summary of each project follows.

5.2.1 Life Extension II

As discussed in Chapter 2, SPR infrastructure underwent its first (and only) life extension project in the late 1990s. At a cost of $324 million, this project addressed the essential improvements necessary to ensure continued drawdown capability and standardized systems and equipment across the four SPR storage sites. The project did not address the need for replacement or upgrade of a significant amount of equipment across multiple systems. Consequently, this equipment today is near, at, or beyond the end of its design life. In addition to this equipment, other equipment that was replaced during the first life extension project is also approaching its 25-year design life, and will also need replacement.

This aging infrastructure is further strained by a growing backlog of major maintenance projects. As a result, unanticipated SPR-related equipment failures are occurring and impacting the Reserve's operational readiness capability. Since the beginning of FY 2013, five separate major equipment incidents, including two raw water piping failures, two brine disposal piping failures, and the failure of a crude oil storage tank internal floating roof, have adversely affected the ability to conduct SPR-related drawdown or fill operations at the incident-affected storage site until repairs could be completed. Figures 24 and 25 are examples of two of these failures.

Figure 24: Big Hill SPR Site Raw Water Header Piping Failure April 2016

Figure 25: Bryan Mound SPR Site Storage Tank Internal Floating Roof Failure May 2015

Additionally, with crude oil sales mandated by the Bipartisan Budget Act of 2015 and the FAST Act, DOE anticipates that it will have to sell more than 124 MMbbl of crude oil from the SPR beginning in FY 2017 through FY 2025. These sales will pose an additional challenge to the reliability and maintainability of existing equipment, as the operations required by such sales necessarily impact the useful life of equipment.

The new life extension project will modernize aging SPR infrastructure through systems upgrades and associated equipment replacement to ensure that the Reserve is able to meet its mission requirements and maintain operational readiness for the next several decades. Examples of infrastructure systems that may be upgraded include the following:

- Crude oil transfer systems.
- Raw water systems.
- Brine disposal systems.
- Power distribution and lighting systems.
- Physical security systems.
- Firefighting systems.
- Crude oil processing (degasification) plant.
- Auxiliary systems and facilities.

DOE is currently evaluating 98 separate tasks affecting all four SPR storage sites as part of the alternatives analysis review process, with plans to establish the final project scope at the time of approval of the performance baseline.

The current project status is as follows:

- Critical Decision-0, Mission Need was approved in October 2015.
- Approval of Critical Decision-1, Alternative Selection and Cost Range is anticipated to occur in November 2016.

The preliminary project schedule, which is subject to further revision as the project's scope, cost, and execution become more clearly defined, is shown in Table 27.

Major Milestone	Target Completion Date
CD-0, Approve Mission Need	October 2015
CD-1, Approve Alternative Selection and Cost Range	November 2016
CD-3A, Approve Procurement of Long Lead Time Equipment	November 2016
Commence Project Design	January 2017 to June 2017
Commence Procurement of Long Lead Time Equipment	January 2017 to June 2017
Complete Project Design	September 2018 to February 2019
CD-2, Approve Performance Baseline	January 2019 to June 2019
CD-3, Approve Start of Construction/Project Execution	January 2019 to June 2019
Award Construction Contracts	January 2019 to June 2019
CD-4, Approve Project Completion/Start of Operations	January 2022 to June 2022

Table 27: SPR Life Extension Project Preliminary Schedule

5.2.2 Marine Terminal Distribution Capability Enhancements

At 695.1 MMbbl, the SPR is the largest government-owned petroleum stockpile in the world. As discussed in Chapter 3, the SPR's effective distribution capability—the Reserve's ability to deliver SPR oil to domestic consumers without displacing commercial oil shipments—is compromised in certain disruption scenarios by new patterns of oil supply and demand among U.S. oil producers and refineries and associated changes in the United States midstream. This can significantly reduce the ability of the United States to distribute incremental volumes of reserve oil to the market during possible future oil supply disruptions.

To optimize the impact and value of the SPR in the event of an emergency, the SPR's three distribution systems—the Seaway, Texoma, and Capline systems of pipelines, refineries, and terminals—in the Gulf of Mexico need to be able to both deliver oil to Gulf Coast refineries, as well as load crude oil onto marine vessels for further distribution. If DOE is unable to implement crude oil distribution from the SPR without disrupting commercial movements, SPR sales could be offset by a corresponding decrease in domestic crude oil shipments. The construction and availability of dedicated marine terminals and associated facilities for loading SPR crude oil will enhance DOE's ability to add incremental barrels of oil from the Reserve to the energy market in a crisis.

Also discussed in Chapter 3, DOE sponsored a barrel-by-barrel analysis of the SPR's effective distribution capability under selected scenarios. The analysis quantifies shortfalls in the SPR's effective distribution capability and the additional marine distribution capacity that would be needed for the SPR to address these marine shortfalls. Table 28 shows the requirements associated with four possible distribution capability levels, per the analysis.

Distribution Capability Level	Marine Distribution Capacity Shortfall
IEA Collective Action – U.S. obligation of 43.9%	Up to 1.74 MMbbl/d
IEA Collective Action – U.S. obligation of 50%	Up to 2.24 MMbbl/d
SPR Design Drawdown Rate of 4.415 MMbbl/d	Up to 3.75 MMbbl/d
SPR Level I Technical Performance Criteria for Physical Distribution (120% of Design Drawdown Rate) of 5.298 MMbbl/d	Up to 4.63 MMbbl/d

Table 28: Distribution Capability Level Capacity Shortfalls

As discussed in Chapter 4, if the SPR's distribution capability remains constrained, the ability of the Reserve to address economically damaging oil supply shocks decreases. The economic value of developing additional marine distribution capability is based on comparing the total economic benefits of the SPR with and without these enhancements. The analysis showed that, depending on assumptions about the SPR's inventory and oil market conditions, removing the constraints on distributing SPR oil through dedicated marine terminals could result in a significant economic return.

DOE has initiated administrative action to commence work on the marine distribution capability enhancements project. The purpose of this project is to increase the effective distribution capacity of the SPR through the addition of dedicated marine terminals and associated facilities.

Critical Decision-0, Mission Need was approved in August 2016.

The preliminary project schedule, which is subject to further revision as the project's scope, cost, and execution become more clearly defined, is shown in Table 29.

Major Milestone	Target Completion Date
CD-0, Approve Mission Need	August 2016
Commence National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) Analysis	January 2017
Complete NEPA EIS Analysis	July 2018
CD-1, Approve Alternative Selection and Cost Range	October 2018
Commence Preliminary Project Design	October 2018
Complete Preliminary Project Design	June 2019
CD-2, Approve Performance Baseline	December 2019
CD-3A, Approve Procurement of Long Lead Time Equipment	December 2019
Complete Land Acquisition and Rights-of-Way	January 2020
Commence Procurement of Long Lead Time Equipment	January 2020
Commence Final Project Design	January 2020
Complete Final Project Design	December 2020
CD-3, Approve Start of Construction/Project Execution	March 2021
Award Construction Contracts	March 2021
CD-4, Approve Project Completion/Start of Operations	October 2023

Table 29: SPR Marine Terminal Distribution Capability Enhancements Project Preliminary Schedule

5.3 FUNDING REQUIREMENTS AND IMPACTS

As discussed earlier, funding to implement the SPR modernization program, in an amount up to $2 billion, would come from the sale of SPR crude oil, with sales authorized from FY 2017 through FY 2020. In order to conduct the sales and raise the revenue required to implement the modernization program, DOE requires a congressional appropriation prior to the commencement of sales for each fiscal year. The funding level of the appropriation shall be informed by an itemization of the amounts of funds necessary to carry out a modernization program, which DOE will prepare and submit in its annual budget request to Congress.

Meeting the target completion dates for each of the major project milestones described in the preliminary project schedules for both of the SPR modernization projects will be dependent on the timely availability of funds necessary to accomplish the milestones within each fiscal year. Failure to receive an appropriation for the requested fiscal year may directly impact several programmatic areas:

- Major project milestones may be delayed, pushing project start and completion dates further into the future.
- Delaying the life extension project will increase the size of the backlog in the SPR's major maintenance project account. With a significant amount of the SPR's equipment currently approaching, at, or beyond its design life, this would increase the risk of equipment failures, with associated impacts on the SPR's operational capability to respond to emergency supply disruptions and/or conduct mandated crude oil sales.
- Delaying the Marine Terminal Distribution Capability Enhancements project will increase the risk of potential adverse impacts on the United States economy in the event of an emergency supply disruption. The gap between current effective distribution capacity and marine distribution capacity shortfalls will continue, and may become more pronounced, until new marine distribution capacity—through the addition of dedicated marine terminals—is constructed and becomes operational.
- Because SPR modernization sales are legislatively limited to four fiscal years, failure to conduct a sale in any of the four fiscal years would require additional, larger volumes of crude oil to be sold in those years where an appropriation is received.

CHAPTER 6 – LEGAL AUTHORITIES

The purpose of this chapter is to provide the background and a summary of the legislative history surrounding the Energy Policy and Conservation Act of 1975, as amended (EPCA). It provides an overview of the key sections of EPCA related to the SPR and NEHHOR, as well as a detailed discussion on release authorities, and concludes with two issue areas within EPCA.

6.1 BACKGROUND

During the 1973 Arab-Israeli War, members of the Organization of Arab Petroleum Exporting Countries (OAPEC) cut off exports and imposed an embargo against the United States to protest American military support for Israel. The embargo both banned petroleum exports to targeted nations and introduced cuts in oil production. The onset of the embargo contributed to an upward spiral in oil prices with global implications. The price of oil per barrel first doubled, then quadrupled, imposing skyrocketing costs on consumers, long lines at filling stations, and contributing to a major economic downturn. The United States, which faced a growing dependence on oil consumption and dwindling domestic reserves, found itself more reliant on imported oil than ever. Once the broader impact of these factors set in throughout the United States, it triggered new measures beyond initial efforts focused on energy conservation and development of domestic energy sources. These measures included the creation of the SPR.[47]

Partly in response to the Arab oil embargo and its impacts on United States consumers and the economy, Congress passed EPCA, which was signed into law on December 22, 1975. One of the primary purposes of EPCA was to "provide for the creation of an SPR capable of reducing the impact of severe energy supply interruptions." In this regard, EPCA provided the authority for the establishment of an SPR for storage of up to one Bbbl of petroleum products.[48] It also specified the SPR-related authorities of the Secretary of Energy (as originally enacted, the Administrator of the Federal Energy Administration), including the details of initial oil acquisition and storage, and certain characteristics and requirements of the SPR. Subsequent to the enactment of EPCA in 1975, the law has been amended several times to address SPR-related issues, as well as to include authority to establish, maintain, and operate the NEHHOR.

6.2 LEGISLATIVE HISTORY

After EPCA was enacted in 1975, the legislation was amended numerous times to reflect evolving energy realities. Some of these revisions were made in response to major events, such as the 1990 amendments that were spurred on by the Exxon Valdez oil spill. Other changes came as part of larger

[47] Office of the Historian, U.S. Department of State. Oil Embargo, 1973-1974. https://history.state.gov/milestones/1969-1976/oil-embargo. Myre, Greg. (October 16, 2013). The 1973 Arab Oil Embargo: The Old Rules No Longer Apply. http://www.npr.org/sections/parallels/2013/10/15/234771573/the-1973-arab-oil-embargo-the-old-rules-no-longer-apply.

[48] EPCA Section 3(3) defines "petroleum product" to mean crude oil, residual fuel oil, or any refined petroleum product (including any natural liquid and any natural gas liquid product).

energy or fiscal legislation. Table 30 provides a summary of the historical legal changes and/or amendments to EPCA that affected the SPR.

Date	Legal Changes and/or Authorization Updates
December 1975	United States Congress passed EPCA which, among other initiatives, authorized the SPR and United States participation in the IEA (Public Law 94-163, Section 154, SPR Plan). Authorized an SPR of up to one billion barrels with an initial capacity of 150 MMbbl.
May 1978	Congress authorized expansion of the SPR's physical capacity to 750 MMbbl.
July 1985	The EPCA Amendments of 1985 (Pub L. 99-58) extended the provisions of Title I, Part B, of EPCA relating to the SPR until June 30, 1989, and directed the Secretary of Energy to conduct a sale or exchange of 1.1 MMbbl of crude oil to test the drawdown and distribution capabilities of the SPR.
September 1990	Congress amended EPCA (Public Law 101-383) in 1990 by providing additional drawdown authorities to the President to allow for the use of the SPR for a limited period without having to declare the existence of a "severe energy supply interruption" or to meet IEA obligations. Additional authorities allowed for a limited drawdown should a circumstance emerge that "constitutes, *or is likely to become*, a domestic energy supply shortage of significant scope *or* duration" and where "action taken ... would assist directly and significantly in preventing or reducing the adverse impact of such a shortage." Among other items, that legislation also added test sale authority.
October 1992	The Energy Policy Act of 1992 (Public Law. 102-486) (1) added the "or international" clause to mitigate the impacts of a severe supply disruption that did not impact U.S. imports ; (2) allowed the enlargement of the Reserve to one billion barrels; (3) permitted the Secretary of Energy to make payment in advance for delivery of petroleum product either owned or not owned by the United States for storage in the SPR or non-SPR facilities; and (4) gave the President discretionary authority to acquire domestic stripper well oil at competitive prices to fill the Reserve.
1996	Three major pieces of legislation passed which directed the sale of SPR oil for budgetary purposes: (1) the Balanced Budget Down Payment Act (Public Law 104-99), enacted on January 26, 1996, required the sale of up to $100 million of Weeks Island oil to fund decommissioning activities; (2) The Omnibus Consolidated Rescissions and Appropriations Act of 1996 (Public Law 104-134), enacted on April 26, 1996, required the sale of $227 million of Weeks Island oil for deficit reduction; and (3) The Omnibus Consolidated Appropriations Act (Public Law 104-208), enacted on September 30, 1996, appropriated $220 million for the SPR in FY 1997 to be financed through the sale of Reserve oil.
November 1998	The President signed Pub L. 105-388, an act to extend energy conservation programs under EPCA and provided that, during a drawdown of the SPR, the State of Hawaii may submit a binding offer for SPR oil.
July 2000	President Clinton directed, and DOE established, a 2 MMbbl home heating oil component of the SPR in the Northeast.
November 2000	The EPCA Amendments of 2000 (Public Law 106-469): (1) added authority, which allowed the Secretary to purchase oil at $15/bbl from marginal wells when the price falls below $15/bbl, adjusted for inflation; and (2) provided clear authority for NEHHOR under Title I, Part D, Section 181, as follows: "Notwithstanding any other provision of this Act, the Secretary may establish, maintain, and operate in the Northeast a NEHHOR. A Reserve established under this part is not a component of the Strategic Petroleum Reserve established under Part B of this title."
2005	Congress directed a further physical expansion to the authorized size of one Bbbl (EPAct of 2005, Public Law 109-58, Section 301, Permanent Authority to Operate the Strategic Petroleum Reserve and Other Energy Programs).

Date	Legal Changes and/or Authorization Updates
2005	The expanded SPR authorities, which were initially subject to sunset provisions requiring episodic congressional reauthorization, were made permanent through additional amendments to EPCA (Public Law 109-58).
April 2011	Congress passed the DoD and Full Year Continuing Appropriations Act (Public Law 112-10) that rescinded all appropriations for the purpose of the expansion beyond 727 MMbbl and the fifth site.
December 2011	Congress passed the Consolidated Appropriations Act of 2012 (Public Law 112-74) which directed for FY2012 and beyond that NEHHOR contain no more than 1 MMbbl of petroleum distillate.
February 2012	NEHHOR was converted to ULSD and reduced to 1 MMbbl.
November 2015	Congress passes Bipartisan Budget Act of 2015 (Public Law 114-74). Section 403 of the bill requires the Secretary of Energy to drawdown and sell a total of 58 MMbbl of crude oil from the SPR over eight consecutive years commencing in FY 2018 and continuing through FY 2025. Section 404 of the bill authorizes the Secretary to sell up to $2 billion worth of crude oil between FY 2017 and FY 2020 to fund a modernization program for the SPR.
December 2015	Section 32204 of the FAST Act (Public Law 114-94) requires the Secretary to drawdown and sell a total of 66 MMbbl of crude oil from the SPR for three consecutive years commencing in FY 2023 and continuing through FY 2025. Congress passed the Consolidated Appropriations Act of 2016 (Public Law 114-113), which legalizes exports of crude oil from the United States

Table 30: Legal Changes and/or Authorization Updates

6.3 EPCA OVERVIEW

Key legislation related to the SPR and NEHHOR is found in Parts B, C, and D of Title I of EPCA.

Part B (Sections 151– 169) is focused solely on the SPR. A summary of the key sections of Part B and the relevant authorities for those sections are as follows:

- Section 159: Provides the authority for the development, operation, and maintenance of the SPR.
- Section 160: Provides the authority for the types of petroleum products that may be acquired, placed in storage, transported, or exchanged, as well as guidance for the acquisition of petroleum products.
- Section 161: Provides the authority for the drawdown and sale of petroleum products from the SPR, including the conditions and limitations associated with the different types of drawdown and sales.
- Section 167: Provides the authority for the establishment of the SPR Petroleum Account, and for the uses of the funds in the account.

Part C (Sections 171–174) is focused on the authority to contract for storage of petroleum product either owned or not owned by the United States:

- Section 171: Provides the authority for contracting for petroleum products and facilities, to include conditions, charge for storage, contract duration, and authorized funding.

Part D (Sections 181–185) is focused solely on the NEHHOR. A summary of the key sections of Part D and the relevant authorities for those sections are as follows:

- Section 181: Provides the authority to establish, maintain, and operate a NEHHOR of no more than 2 MMbbl of petroleum distillate in the Northeast.[49]

- Section 182: Provides the authority for the storage, acquisition, and disposition of petroleum distillate in the NEHHOR.

- Section 183: Provides the authority for the release of petroleum distillate from the NEHHOR, including the conditions and limitations associated with such a release.

- Section 184: Provides the authority for the establishment of the NEHHOR Account, and for the uses of the funds in the account.

6.4 SPR AND NEHHOR RELEASE AUTHORITIES

The SPR and NEHHOR can be considered a "national insurance policy" that is available to address U.S. energy and economic security issues. These reserves are not meant to be used as a "price maintenance" mechanism for addressing rising petroleum prices resulting from existing economic conditions that fundamentally occur as a result of normal supply-demand imbalances in the petroleum market. Instead, both the SPR and the NEHHOR are meant to address interruptions in petroleum supply of a significant scope and/or duration that are likely to cause a major impact on the national economy or create a regional supply shortage, and by taking action to release reserves, would assist directly and significantly in preventing or reducing the adverse impact of a shortage.

There is specific statutory language in EPCA that provides the authority, requirements, and conditions for petroleum products to be released from the SPR and NEHHOR. These authorities are described in detail in the following subsections of this report, given the impact of these authorities on the ability of the OPR to carry out its mission and functional responsibilities.

6.4.1 SPR Release Authorities

The circumstances that might require the use of the SPR are defined in EPCA and the FAST Act. Following the Exxon Valdez oil spill in 1989, which interrupted Alaskan oil shipments and thereby triggered spot shortages and price increases, Congress amended EPCA in 1990 (Public Law 101-383) to provide additional drawdown authorities to the President. The revised authorities in the 1990 legislation allowed for a drawdown from the SPR for a limited (60-day) period if the President finds a

[49] The Consolidated Appropriations Act of 2012, enacted on December 23, 2011 limits the amount of petroleum distillate that can be stored in the NEHHOR to no more than 1 MMbbl, notwithstanding Section 181 of EPCA.

circumstance that constitutes or is likely to become a domestic energy supply shortage of significant scope or duration without having to declare the existence of a "severe energy supply interruption" or to meet IEA obligations. Additional authorities allowed for a limited drawdown should a circumstance emerge that "constitutes, or is likely to become, a domestic *or international* [emphasis added] energy supply shortage of significant scope or duration" and where "action taken … would assist directly and significantly in preventing or reducing the adverse impact of such a shortage." The addition of the "or international" clause (added when EPCA was once again amended in 1992)[50] empowered the President to mitigate the severe adverse economic impacts of a supply disruption by providing supply to the global market, even if U.S. imports were not directly impacted, while the amendments more broadly allowed the President to leverage the SPR in anticipation of, rather than simply in reaction to, global supply interruptions. The expanded SPR authorities, which were subject to sunset provisions[51] requiring episodic congressional reauthorization, were made permanent through additional amendments to EPCA in 2005.[52]

EPCA provides for four distinct authorities that govern the release of petroleum products from the SPR. The key parts of these authorities are as follows:

Section 161(d): Authority to Conduct a Full Drawdown of the SPR

A drawdown and sale of petroleum products from the SPR may not be made unless the President has found the drawdown and sale are required by a severe energy supply interruption or by obligations of the United States under the IEP. EPCA defines a "severe energy supply interruption" as a national energy supply shortage that the President determines:

- Is, or is likely to be, of significant scope and duration, and of an emergency nature;
- May cause major adverse impact on national safety or the national economy; and
- Results, or is likely to result from an interruption in the supply of imported petroleum products; an interruption in the supply of domestic petroleum products, or sabotage, terrorism, or an act of God.

In addition to the circumstances defining a "severe energy supply interruption," a severe energy supply interruption shall be deemed to exist if the President determines that:

- An emergency situation exists and there is a significant reduction in supply that is of significant scope and duration;

[50] Congress amended EPCA on October 25, 1992. Public Law 102-486.
[51] The sunset provisions were introduced by Public Law 99-58, enacted July 2, 1985.
[52] U.S. Library of Congress, Congressional Research Service. (2009). *The Strategic Petroleum Reserve: History, Perspectives, and Issues*, Bamberger, Robert. R33341, p. 3. http://research.policyarchive.org/2790.pdf.

- A severe increase in the price of petroleum products has resulted from such an emergency situation; and

- Such a price increase is likely to cause a major adverse impact on the national economy.

Section 161(h): Authority to Conduct a Limited Drawdown of the SPR
If the President finds that:

- A circumstance, other than those described for a full drawdown exists that constitutes, or is likely to become, a domestic or international energy supply shortage of significant scope or duration;

- Action taken would assist directly and significantly in preventing or reducing the adverse impact of such a shortage; and

- The Secretary of Defense has found that action taken will not impair national security;

Then the Secretary may, subject to the below limitations, drawdown and sell petroleum products from the SPR, although in no case:

- In excess of an aggregate of 30 MMbbl with respect to each shortage;

- For more than 60 days with respect to each shortage;

- If there are fewer than 500 MMbbl of petroleum product stored in the Reserve; or

- Below the level of an aggregate 500 MMbbl of petroleum product stored in the Reserve.

Section 161(g): Authority to Conduct a Test Drawdown and Sale or Exchange of the SPR
The Secretary shall conduct a continuing evaluation of the drawdown and sales procedures. In the conduct of an evaluation of the drawdown and sales procedures, the Secretary is authorized to carry out a test drawdown and sale or exchange of petroleum products from the Reserve. Such a test drawdown and sale or exchange may not exceed 5 MMbbl of petroleum products.

Section 159(f): Authority to Acquire Petroleum Products for the SPR by Exchange
In order to develop, operate, and maintain the SPR, the Secretary may acquire, subject to the provisions of Section 160, by purchase, exchange, or otherwise, petroleum products for storage in the SPR. Therefore, releases from the reserves may be made for the purposes of exchanges.

6.4.2 NEHHOR and NGSR Release Authorities

Northeast Home Heating Oil Reserve
Section 183(a): Authority to Sell Products from the NEHHOR
The Secretary may sell products from the NEHHOR only upon a finding by the President that there is a severe energy supply interruption. Such a finding may be made if the President determines that:

- A dislocation in the heating oil market has resulted from such interruption; or

- A circumstance, other than a dislocation in the heating oil market, exists that constitutes a regional supply shortage of significant scope and duration, and that action taken would assist directly and significantly in reducing the adverse impact of such a shortage.

The law deems a *dislocation* to have occurred only when:

1. "The price differential between crude oil … and No. 2 heating oil … increases by more than 60% over its five year rolling average for the months of mid-October through March (considered as a heating season average), and continues for seven consecutive days; and

2. The price differential continues to increase during the most recent week for which price information is available."

Northeast Gasoline Supply Reserve
The authority to lease storage space for the NGSR derived from EPCA Section 171, which expressly states that petroleum products stored pursuant to that section are part of the Reserve. Therefore, to sell gasoline from the NGSR would require use of one of the SPR release authorities described in Section 6.4.1 above.

6.5 LEGISLATIVE ISSUES

Since its enactment in 1975, including various amendments over the ensuing years, EPCA's statutory authorities have guided the management and operation of both the SPR and NEHHOR, and have provided a solid legal framework for addressing numerous complex and challenging issues that have transpired over time. However, it is appropriate to periodically conduct a detailed review of existing law to determine whether changes are warranted that would result in improvements and efficiencies to programmatic management and operating authorities. As required by Section 402 of the Bipartisan Budget Act of 2015, the following subsections discuss two legislative issues.

6.5.1 EPCA Release Authority "Trigger" for a Full Drawdown of the SPR

Existing Authority: EPCA Section 161(d)

Issue: A full drawdown of the SPR cannot be ordered until a supply interruption *has resulted* in a severe increase in the price of petroleum products.

Discussion: Under existing authorities in Section 161(d), a full drawdown of the SPR cannot be made unless the President determines that "a severe energy supply interruption" exists or a drawdown is required by U.S. obligations under the IEP. A severe energy supply interruption is deemed to exist if the President determines that: "(A) an emergency situation exists and there is a significant reduction in supply which is of significant scope and duration; (B) a severe increase in the price of petroleum products *has* resulted from such an emergency situation; and (C) such a price increase is likely to cause a major adverse impact on the national economy."[53] As a result of these conditions, the President cannot issue a Presidential Finding ordering a full drawdown of the SPR until *after* a supply disruption has already caused a severe increase in the price of petroleum products, with a corresponding adverse impact on the national economy. The President has the authority under Section 161(h) to drawdown the SPR *before* a supply disruption has impacted the economy, but this authority is limited to a drawdown of 30 MMbbl for a period of no more than 60 days[54] (i.e., an average drawdown rate of 0.5 MMbbl/d for two months).

One of the recommendations contained in the 2015 QER was that SPR drawdown authorities be updated in EPCA to clarify that "(1) the definition of a severe energy supply interruption includes an interruption of the supply of oil that is *likely* to cause a severe increase in the price of domestic petroleum products, and (2) the requirement that a severe increase in the price of petroleum products *has resulted* from such an emergency situation is changed to a requirement that a severe price increase *will likely result* from such an emergency situation."[55]

6.5.2 Align Release Authorities for Regional Product Reserves

Issue: The NEHHOR and NGSR operate under different release authorities.

Existing Authority: For NEHHOR – EPCA Section 183(a); for NGSR – EPCA Section 161(d)

Discussion: The purpose of a regional product reserve is different from the purpose of the SPR. As the name implies, a *regional* product reserve is meant to address *regional* supply shortages, whereas the SPR is meant to address severe energy supply interruptions that have a *national* impact. As stated in EPCA Section 183(a), the release authority for NEHHOR is focused on a *regional* supply shortage. On the other hand, a release from the NGSR, which was established as a part of the SPR, must meet the same requirements and conditions for a release that apply to the SPR (Section 161 of EPCA). In practice, this means that the release threshold for a release from the NGSR would have to have a national impact, when, in fact, the purpose of the NGSR is to address regional supply shortages that can stem from localized natural disasters, such as severe winter weather or hurricanes impacting the Northeast, or from other incidents that may impact regional fuel supplies.

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[53] Energy Policy and Conservation Act, Section 161(d).
[54] Energy Policy and Conservation Act, Section 161(h).
[55] Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure, April 2015, pp. 4–9.

One of the recommendations contained in the 2015 QER was to integrate the authorities of the President to release products from regional petroleum product reserves into a single, unified authority. Specifically, "Congress should amend the trigger for release of fuel from the Northeast Home Heating Oil Reserve and from the Northeast Gasoline Supply Reserve so that they are aligned and properly suited to the purpose of a product reserve, as opposed to a crude oil reserve."[56]

[56] Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure, April 2015, pp. 2-42.

CHAPTER 7 – CONCLUSIONS

The purpose of this SPR Long-Term Strategic Review is to assess the ability of the Reserve to carry out its energy security mission in the context of changing North American and Global oil markets and to address challenges and critical decisions that the program will face in the coming years. The review is driven by multiple factors, including changes in U.S. crude oil production and infrastructure utilization, which has reduced imports and constrained normal distribution pathways for SPR crude oil; surface and subsurface infrastructure challenges that will fundamentally impact the ability of the SPR to carry out its mission in the coming decades; questions about the appropriate inventory level for the SPR in light of projected U.S. oil production; and the need to review the SPR's legal authorities within the EPCA for the effective management and operation of the SPR.

This report consolidated the findings of numerous projects completed by outside experts for DOE and analyzed their findings in concert. The consolidated results of these efforts and this report can be distilled to the following critical takeaways:

1. *The SPR's aging surface infrastructure will begin to fundamentally compromise the Reserve's capabilities. Investing in a second Life Extension project is essential for ensuring the long-term integrity of SPR assets and the ability of the program to carry out its mission.*

   Most of the critical infrastructure for moving crude oil within the SPR has exceeded its serviceable life, increasing maintenance costs and decreasing system reliability. This issue has been exacerbated by a building backlog of major maintenance. The Reserve continues to experience increases in the frequency and severity of equipment failures, which will only worsen as physical assets age and as the upcoming mandated oil sales and authorized SPR Modernization sales place a heavy burden on SPR systems. These issues directly impact the ability of the SPR to carry out its energy security mission. The investment in SPR surface infrastructure covered by the proposed Life Extension II project, to be funded through crude oil inventory sales as part of the SPR modernization program, is fundamentally justified.

2. *Expanding North American oil production and the resulting shifts in U.S. midstream infrastructure have reduced the SPR's ability to add incremental barrels of oil to the market under certain scenarios in the event of an oil supply crisis. The addition of dedicated marine terminals will significantly enhance the Reserve's effective distribution capability.*

   Increases in United States and Canadian crude oil production have fundamentally changed crude oil flow patterns, which have resulted in pipelines being reversed to bring crude south and east into the Gulf Coast market. Midstream congestion caused by these flow reversals, along with high utilization of crude oil pipelines and marine terminals along the Gulf Coast, has compromised the SPR's effective distribution capability in certain scenarios. This means that while the SPR remains connected to physical assets which could bring oil to the market, in many cases, forcing SPR oil into the distribution system would result in an offsetting reduction in domestic commercial crude flow.

This disjuncture between the SPR's physical distribution capability and its effective distribution capability poses a major challenge for the program moving forward.

A DOE-sponsored barrel-by-barrel analysis of various disruption scenarios indicates that the effective distribution capacity of the SPR could be more than 2 MMbbl below the design drawdown rate of 4.415 MMbbl/d in certain supply outages. Given the current congestion in the United States Gulf Coast oil infrastructure, the United States could, depending on the specific disruption being addressed, fail to meet its IEA obligation in the event of a major collective action release to address an oil supply crisis. Without effective participation from the United States, an IEA collective action would not effectively supply world oil markets. Given that an unmitigated oil price shock would pose significant risks for the United States economy, substantial investments to address this problem are warranted.

The Marine Terminal Distribution Capability Enhancements project would increase effective distribution capacity through the addition of dedicated marine terminals. This project, funded by crude oil sales, would ensure that the Reserve is able to expeditiously deliver sufficient volumes of oil to the world market in the event of a crisis. This investment is economically justified based on an assessment of risks to the world oil market and the need to significantly increase the effective distribution capability of the SPR.

3. *The SPR is projected to provide substantial benefits to the national economy over the next 25 years and inventory reductions beyond those mandated in Section 403 of the Bipartisan Budget Act of 2015 and Section 32204 of the FAST Act and those authorized in Section 404 of the Bipartisan Budget Act of 2015 will compromise its ability to do so. Determining whether such further reductions are appropriate would require a fuller analysis of costs and benefits.*

While the reduction in crude oil imports in recent years has reduced U.S. exposure to physical supply shortages, crude oil is a globally traded commodity and disruptions anywhere in the world result in price spikes that harm the American economy. The results of a DOE-sponsored expert elicitation on world oil market risk suggest that the potential for major global oil supply disruptions remains high.

An economic simulation model developed by ORNL quantified the economic benefits of various SPR sizes and configurations in terms of avoided GDP loss and import costs. Assuming that the SPR's inventory is determined by the upcoming mandated and authorized crude oil sales, the Reserve is projected to avert approximately $350 billion in economic losses in the *AEO2015* Reference case and approximately $450 billion in the *AEO2015* world Low Oil Price case. Scenario analysis of different SPR sizes and configurations yields three key takeaways:

- The benefits of modernizing the SPR's distribution infrastructure significantly outweigh the costs of adding dedicated marine terminals.

- Reducing the inventory below 530 MMbbl, which would reduce the President's authority to address smaller supply disruptions, would significantly reduce the SPR's benefits.

- The benefits of a larger SPR inventory level off above 600 MMbbl due to the fact that most potential disruptions could be addressed with a smaller inventory.

These results highlight the importance of investing in the SPR's effective distribution capability and illustrate modest incremental benefits associated with additional inventory.

4. *The SPR's continually shrinking storage capacity will be able to accommodate the inventory levels mandated and authorized by the upcoming crude oil sales, but significant inventory additions would require the development of new storage.*

   The storage capacity required to maintain a given level of SPR crude oil inventory for an extended period is considerably larger than the volume of petroleum held. The Reserve should have at least a 10% cushion of storage space above its inventory for operational purposes. In addition, "cavern creep" caused by geological forces and cavern maintenance work reduces the space available for oil storage in the SPR's caverns by more than 2 MMbbl each year. Capacity requirements over the next 25 years should be determined based on these factors, keeping in mind the risk that additional caverns could be removed from service. Were it not for the upcoming crude oil sales, these factors would present a major challenge for the program. As it stands, the current cavern storage capacity will be able to accommodate all of the potential inventory levels dictated by current policy.

   If a decision is made to rebuild the SPR's inventory to more than 598 MMbbl after the mandated sales are carried out, and caverns were used for incremental storage, new storage caverns would need to be developed at a cost of $120 million−$140 million per cavern. If the Reserve draws down its single-cycle drawdown caverns, this capacity threshold would decrease due to the fact that emptying these caverns permanently removes them from service, lowering the total storage capacity of the Reserve. This issue is critical, as current decisions about which caverns are drawn down now will have lasting implications for the ability of the SPR inventory to be rebuilt.

5. *Operational requirements dictate that the SPR maintain its current four-site configuration.*

   The upcoming inventory reductions resulting from the mandated and authorized sales raise the question of whether it is necessary for the SPR to maintain four storage sites. Given the capacity challenges discussed above, the only SPR site that could potentially be closed is Bayou Choctaw. If Bayou Choctaw were closed, this would lead to an unacceptably low capacity cushion under all but one of the sales scenarios. Because five of the site's six caverns are single-cycle drawdown, closing this site would also constitute a permanent reduction in SPR capacity, barring investment in new caverns.

   Closing Bayou Choctaw would also reduce the design drawdown capability and effective distribution capability of the SPR, decrementing the Reserve's capability to defend the national economy from oil shocks. It would also remove the only site in the SPR where the entire volume of oil inventory has been available for drawdown over a multi-year timeframe. More importantly, the operational flexibility conferred by four storage locations will be critical in the coming decade as the SPR program concurrently conducts the mandated and authorized oil sales and executes the Life Extension II SPR Modernization project. The redundancy provided by four sites will be critical to ensuring that the SPR can carry out these two tasks and maintain operational readiness to address an oil supply emergency.

6. *Amending limited, discrete sections of EPCA would result in improvements and efficiencies to management and operating authorities governing the SPR and regional product reserves.*

   A detailed review of existing authorities under EPCA was conducted to identify changes that would improve the efficiency of program management and operating authorities. The two issues identified pertain to recommendations in the QER and directly impact the ability to respond to an emergency supply interruption in a timely and effective manner:

   The EPCA release authority “Trigger” for a full drawdown of the SPR under Section 161(d): The SPR’s ability to prevent damage to the national economy could be improved by expanding the President’s drawdown authorities in Section 161(d) to include the authority to order a full drawdown in anticipation of an economy-damaging price increase as a result of a severe energy supply interruption.

   The alignment of release authorities for the NGSR and NEHHOR regional product reserves under Sections 161(d) and 183(a): The current differences could be resolved by consolidating all refined product activities under a single set of unified refined petroleum product authorities that would encompass both of the existing regional product reserves, as well as any potential future regional product reserves that may be established. This would align all of the authorities for regional product reserves and allow for faster response times during supply interruptions involving refined petroleum products.

LIST OF ACRONYMS

Acronym	Description
AEO	Annual Energy Outlook
AFFF	Aqueous film-forming foam
API	American Petroleum Institute
ASEAN	Association of Southeast Asia Nations
ASTM	American Society for Testing and Materials
ATB	Articulated tug and barge
bbl	Barrels
bbl/d	Barrels per day
bbl/h	Barrels per hour
Bbbl	Billion barrels
BC	Bayou Choctaw
BH	Bill Hill
BM	Bryan Mound
BMS	Building Management Systems
BP	British Petroleum
CA	Capline
CAPP	Canadian Association of Petroleum Producers
CD	Critical Decision
CERM	Coordinated Emergency Response Mechanism
CP	ConocoPhillips
CT	Citgo
DC	District of Columbia
DCS	Distributed control system
DE	Department of Energy pipeline
DK	Delek
DLA	Defense Logistics Agency
DO	Dissolved Oxygen
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
ECHO	Enterprise Crude Houston
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EM	ExxonMobil
EMF	Energy Modeling Forum
EP	Enterprise
EPA	Environmental Protection Agency
EPAct	Energy Policy Act of 2005
EPCA	Energy Policy and Conservation Act
EPSA	Energy Policy and Systems Analysis
ESIM	Energy Security and Infrastructure Modernization
ESR	Early storage reserve
EU	European Union

Acronym	Description
FAST	Fixing America's Surface Transportation
FE	Office of Fossil Energy
FEA	Federal Energy Administration
FEMA	Federal Emergency Management Agency
FIMS	Facilities Information Management System
FOIDS	Fiber Optic Intelligence and Detection System
FT	Feet
FY	Fiscal Year
GAL	Gallon
GAO	Government Accountability Office
GDP	Gross domestic product
gpm	Gallons per minute
GS	Genesis
H	Hour
HEX	Heat exchangers
Ho-Ho	Houston to Houma
HP	Horsepower
HSI	Hurricane Severity Index
I/O	Input/output
IEA	International Energy Agency
IEP	International Energy Program
IPIDS	Intrusion Prevention and Intrusion Detection System
kV	Kilovolt
kVA	Kilovolt ampere
kW	Kilowatt
kWA	Kilowatt ampere
LC	Locap
LCC	Lifecycle cost
LCMS	Lake Charles Meter Station
LE	Life Extension
LEP	Life Extension Program
LLC	Limited Liability Corporation
LP	Loop
LTSR	Long-Term Strategic Review
M&A	Management and Administration
M&O	Management and Operating
MA	Marathon
Mbbl	Thousand barrels
Mbbl/d	Thousand barrels per day
MG	Magellan
MI	Mile
MMbbl	Million barrels
MMbbl/d	Million barrels per day
MV	Mid-Valley
MVA	Megavolt ampere

Acronym	Description
N/A	Not applicable
NEHHOR	Northeast Home Heating Oil Reserve
NEPA	National Environmental Policy Act
NGSR	Northeast Gasoline Supply Reserve
NO	Number
NOAA	National Oceanic and Atmospheric Administration
NPR	Naval Petroleum Reserve
NPV	Net present value
O&M	Operations and Maintenance
O&R	Operations and Readiness
OAPEC	Organization of Arab Petroleum Exporting Countries
OCS	Outer Continental Shelf
OECD	Organization for Economic Cooperation and Development
OK	Oklahoma
OPEC	Organization of Petroleum Exporting Countries
OPR	Office of Petroleum Reserves
ORNL	Oak Ridge National Laboratory
PADD	Petroleum Administration for Defense District
PDD	Presidential Decision Directives
PL	Plains
PMO	Project Management Office
PPS	Physical Protection System
psi	Pounds per square inch
PTZ	Pan-Tilt-Zoom
PV	Present value
Q	Quarter
QER	Quadrennial Energy Review
RBOB	Reformulated blendstock for oxygenate blending
RPPR	Regional Petroleum Product Reserve
RVP	Reid vapor pressure
SG	SemGroup
SH	Shell
SOTS	Site Operations Training Simulator
SPR	Strategic Petroleum Reserve
SU	Sun
SW	Seaway
SWCA	Site-Wide Card Access
TC	TransCanada
TCEQ	Texas Commission on Environmental Quality
TL	Total
TOC	Total Organic Carbon
TX	Texas
ULSD	Ultra-low sulfur distillate
ULSHO	Ultra-low sulfur heating oil
U.S.	United States

Acronym	Description
USA	United States of America
USGS	United States Geological Survey
V	Volts
VA	Valero
WTG	West Texas Gulf
WTI	West Texas Intermediate