EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The Bureau of Safety and Environmental Enforcement (BSEE) and Bureau of Ocean Energy Management (BOEM) propose to allow the use of selected well stimulation treatments (WSTs) on the 43 current active leases and 23 operating platforms on the Southern California Outer Continental Shelf (OCS). Use of some WSTs may allow lessees to recover hydrocarbon resources (i.e., oil) that would otherwise not be recovered from the reservoirs in the lease areas that have been and continue to be accessed by existing wells as well as any new wells in the foreseeable future.

In accordance with the National Environmental Policy Act (NEPA) of 1969, BSEE and BOEM prepared this draft environmental assessment (EA) to evaluate the potential environmental impacts of the proposed approval of the use of WSTs on the 23 platforms currently in operation on the Southern California OCS Planning Area. This draft EA analyzes the potential environmental effects of WSTs under various alternative actions that would meet the purpose and need for the proposed action.

ES.2 PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose and need for the proposed action, to allow the use of certain WSTs (e.g., hydraulic fracturing) in support of oil production at platforms on the Pacific OCS, are to carry out BSEE and BOEM's responsibilities under the Outer Continental Shelf Lands Act (OCSLA) for effectively managing resources on the Federal OCS. Under the OCSLA, the Secretary of the Interior is required to establish policies and procedures that expedite exploration and development of the OCS for the production of resources (e.g., oil and natural gas) and to balance resource development with protection of the human, marine, and coastal environments, while simultaneously ensuring that the public receives an equitable return for these resources.

ES.3 PROPOSED ACTION AND ALTERNATIVES

The WSTs evaluated in this EA include fracturing and non-fracturing treatments which may be used for enhancing production from existing or new wells where formation permeability and decreasing reservoir pressure are limiting oil recovery. This EA adopts the definitions that are found in State of California Senate Bill No. 4 (SB-4) Oil and Gas: Well Stimulation. The SB-4 definitions are applied to WST activities that are occurring in State waters and accessing the same formations as those being accessed by offshore platforms on the 43 active Federal lease areas, as well as being widely used on land in California. Adopting the SB-4 definitions allows for straightforward comparisons of WST applications in Federal and State offshore operations and in the analysis of the cumulative effects of all offshore operations.

Under the SB-4 definitions, *Well Stimulation Treatment* means any treatment of a well designed to enhance oil and gas production or recovery by increasing the permeability of the formation. WSTs include, but are not limited to, hydraulic fracturing treatments and acid well stimulations. Routine well cleanout work, routine well maintenance, routine removal of formation damage due to drilling, bottom hole pressure surveys, and routine activities that do not affect the integrity of the well or the formation are not considered WSTs.

This EA distinguishes between "fracturing WSTs," in which WST fluids are injected at pressures required to fracture the formation (i.e., greater than the formation fracture pressure), and "non-fracturing WSTs," in which the WST fluid is injected at less than the pressure required to hydraulically fracture the formation. Diagnostic fracture injection tests (DFITs), hydraulic fracturing, and acid fracturing are the fracturing WSTs analyzed in this EA. Matrix acidizing is the only non-fracturing WST analyzed. The four WSTs analyzed in this EA are described as follows:

- **Diagnostic Fracture Injection Test (DFIT).** The DFIT is used to estimate key reservoir properties and parameters that are needed to optimize a main fracture job. It is a short duration procedure that involves the injection of typically less than 100 barrels of fracturing fluid at pressures high enough to initiate a fracture. Key parameters are estimated from the fluid volume injected and the pressure dissipation profile. The fluid used in a DFIT is typically the fluid that would be used in the main fracture treatment but with no proppant[1] added, thus allowing the fracture to close naturally as pressure is released.

- **Hydraulic Fracturing.** Hydraulic fracturing involves the injection of a fracturing fluid at a pressure (as typically determined by a DFIT) needed to induce fractures within the producing formation. The process generally proceeds in three sequential steps: (1) injection of a fracturing fluid without proppant to create fractures which extend out from the well; (2) injection of a slurry of fracturing fluid and proppant; and (3) injection of breakers, chemicals added to reduce the viscosity of the fracturing fluid. Upon release of pressure, the fracturing fluid is allowed to flow back (the flowback fluid) to the surface platform. Key fluid additives include polymer gels which increase the viscosity of the fluid and allow it to more easily carry proppant into the fractures, crosslinker compounds that help further increase the fluid viscosity, and breaker chemicals which break down the crosslinked polymers and allow them to return more readily to the surface after fracturing is completed. Other important additives may include pH buffers, clay control additives, microbial biocides, and surfactants to aid in fluid recovery. In offshore applications, the base fracturing fluid is filtered seawater.

[1] A proppant is a solid material, typically sand, treated sand, or man-made ceramic materials, designed to keep an induced fracture open during or following a fracture treatment.

- **Acid Fracturing.** Acid fracturing is similar to hydraulic fracturing except that instead of using a proppant to keep fractures open, an acid solution is used to etch channels in the rock walls of the fractures, thereby creating pathways for oil and gas to flow to the well. As with a hydraulic fracturing WST, a pad fluid is first injected to induce fractures in the formation. Next, the acid fracturing fluid is injected at pressures above the formation fracture pressure and allowed to etch the fracture walls. The acid fracturing fluid is typically gelled, cross-linked, or emulsified to maintain full contact with the fracture walls. Fifteen percent hydrochloric acid (15% HCl) solutions are typically used in carbonate formations such as limestone and dolomite, while hydrofluoric acid (HF) solutions and HCl/HF mixtures are used in sandstone and Monterey shale formations and in other more heterogeneous geologic formations, typically at levels of 12% and 3%, respectively. The fracturing fluid typically also includes a variety of additives at a combined concentration on the order of 1% or less, such as inhibitors to prevent corrosion of the steel well casing, and sequestering agents to prevent formation of gels or iron precipitation which may clog the pores.

- **Matrix Acidizing.** In matrix acidizing, a non-fracturing treatment, an acid solution, is injected into a formation where it penetrates pores in the rock to dissolve sediments and muds. By dissolving these materials, existing channels or pathways are opened and new ones are created, allowing formation fluids (oil, gas, and water) to move more freely to the well. Matrix acidizing also removes formation damage around a wellbore, which also aids oil flow into the well. The acid solution is injected at pressures below the formation fracture pressure and is thus a non-fracturing treatment. Three distinct fluids are commonly used sequentially: (1) an HCl acid preflush fluid; (2) a main acidizing fluid generated from mixing HCL and ammonium bifluoride to produce an HCl/HF mud acid at typically 12% and 3%, respectively (some operations use mud acid, for example sandstone and Monterrey shale while some operations primarily use 15% HCl); and (3) an ammonium chloride overflush fluid. The acidizing fluid also includes a variety of additives at a combined concentration of on the order of 1% or less, similar to those used in acid fracturing.

This EA analyzes the following alternatives that meet the purpose and need of the proposed action:

- **Alternative 1: Proposed Action—Allow Use of WSTs.** Under this alternative, BSEE technical staff and subject matter experts will continue to review applications for permit to drill (APDs) and applications for permit to modify (APMs), and, if deemed compliant with performance standards identified in BSEE regulations at Title 30, *Code of Federal Regulations,* Part 250, subpart D (30 CFR Part 250, subpart D), will approve the use of fracturing and non-fracturing WSTs at the 22 production platforms located on the 43 active leases on the Southern California OCS.

- **Alternative 2: Allow Use of WSTs with Subsurface Seafloor Depth Stipulations.** Under this alternative, no use of fracturing WSTs would be approved at depths less than 2,000 ft (610 m) below the seafloor surface. This alternative is intended to reduce the likelihood that a fracturing WST would produce fractures that could intersect an existing fault, fracture, or well and potentially create a pathway to the seafloor surface and result in a hydrocarbon release to the ocean.

- **Alternative 3: Allow Use of WSTs but No Open Water Discharge of WST Waste Fluids.** Under this alternative, no WSTs would be approved that use open ocean disposal of any WST-related waste fluids (such as the flowback) or of produced water comingled with WST waste fluids. This alternative is intended to eliminate any potential effects of discharges of WST-related chemicals on the marine environment. Currently permitted open water discharge of produced water could continue when produced water does not contain WST-related chemicals. When WST-related chemicals are present, produced water would need to be disposed by alternative means such as through injection. Additional injection wells could be needed at one or more of the platforms where disposal currently occurs only via permitted open water discharge.

- **Alternative 4: No Action—Allow No Use of WSTs.** Under this alternative, none of the four WSTs identified for the proposed action would be approved for use in any current or future wells on the 23 platforms associated with active lease areas on the Southern California OCS. This alternative would eliminate all effects of the use of WSTs. Production at some wells may be expected to decline sooner than under the proposed action, as reservoir pressures continue to decline with primary production. Routine well maintenance activities (e.g., wellbore cleanup) and enhanced oil recovery techniques (e.g., water flooding) that fall outside of the SB-4 definitions of WSTs would continue (as they would under any of the other three alternatives). For example, well maintenance conducted with the well tree installed, which may not require specific BSEE approval, would continue, including (1) acid wash (a form of acid treatment), (2) solvent wash (a chemical method of cutting paraffin), (3) casing scrape/surge (a method of scale or corrosion treatment and swabbing), and (4) pressure/jet wash (a method of bailing sand and a scale or corrosion treatment). In addition, well maintenance operations that require removal of the tree, which are not considered routine and need an approved APM, would also continue.

ES.4 AFFECTED ENVIRONMENT

The 43 lease areas where WSTs may be carried out represent the project area for the proposed action. Figure ES-1 shows the project area and the platforms in Federal and State waters. The geographic scope of the affected environment includes the project area and the

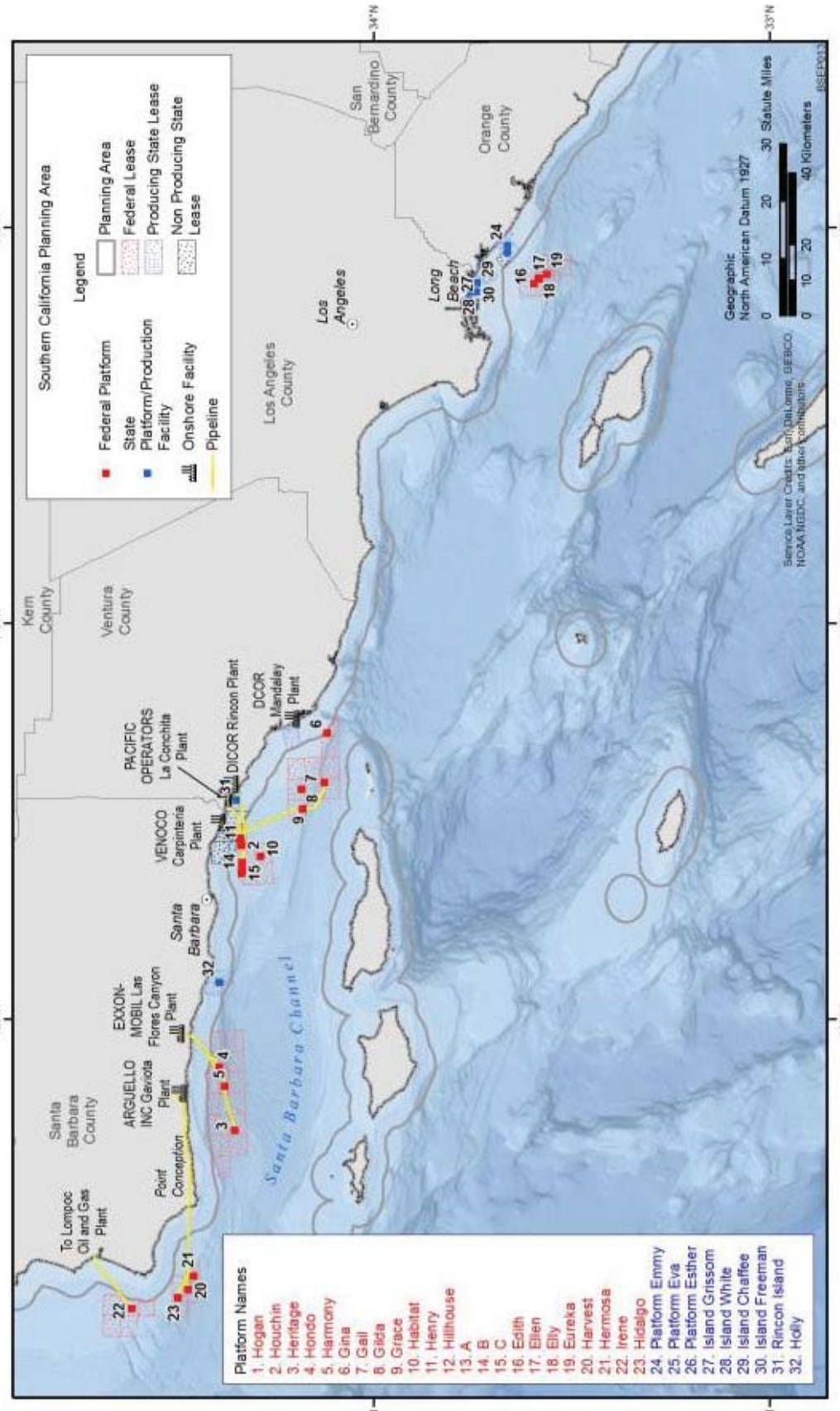

FIGURE ES-1 Locations of Current Lease Areas and Platforms Operating on the Southern California OCS Planning Area (Also shown are platforms and production facilities in offshore State waters adjacent to the Federal OCS.)

surrounding area, to the extent that potential effects from the proposed action could extend beyond the project area.

The following potential effects on resources of WST activities carried out in the project area were evaluated:

- *Air quality*: Potential impacts due to contributions to elevated photochemical ozone from ozone precursor emissions from diesel pumps and support vessels; contributions to visibility degradation from emissions of particulate matter; and contributions of greenhouse gas emissions associated with routine WST activities; temporary effects on air quality from releases of WST fluids and hydrocarbons under potential accidents; and from potential emissions during drilling of new injection wells which may be needed under Alternative 3.

- *Water quality*: Potential impacts of routine WST operations on water quality and marine life within the 100-m radius mixing zone defined under the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) general permit from WST waste fluids in permitted discharges to the ocean; compliance with the provisions of the permit would prevent effects outside the mixing zone; potential impacts on water quality from the release of WST fluids or hydrocarbons from potential accidents. Temporary and localized decreases in water quality that may occur as a result of bottom-disturbing activities that may occur under Alternative 3.

- *Geologic resources/seismicity*: Small potential that WSTs may stimulate seismic activity in seismically active areas such as the Santa Barbara Channel, and thus result in an increase in seismic hazard in the vicinity of the wells where fracturing WSTs are being implemented.

- *Benthic resources (including special status species)*: Potential lethal, sublethal, or displacement impacts on benthic communities following ocean disposal of WST waste fluids or the accidental release of WST fluids or hydrocarbons from potential accidents; and contamination of Endangered Species Act (ESA)-designated critical habitat with hydrocarbons and WST fluids following an accidental release. Benthic resources may also be affected by bottom-disturbing activities under Alternative 3.

- *Marine and coastal fish (including special status species) and essential fish habitat*: Potential lethal, sublethal, or displacement impacts on fish following ocean disposal of WST waste fluids or the release of WST fluids or hydrocarbons from potential accidents; contamination of Essential Fish Habitat (EFH) and ESA-designated critical habitat with hydrocarbons and WST fluids following an accidental release. Marine and coastal fish may also be affected by bottom-disturbing activities that may occur under Alternative 3.

- *Marine and coastal birds (including special status species)*: Potential lethal or sublethal effects following ocean disposal of WST waste fluids or the accidental release of WST fluids or hydrocarbons from potential accidents.

- *Marine mammals (including special status species)*: Potential lethal or sublethal effects following ocean disposal of WST waste fluids or release of WST fluids and hydrocarbons from potential accidents; vessel strikes. Marine mammals may also be affected by noise from bottom-disturbing activities that may occur under Alternative 3.

- *Sea turtles*: Potential lethal or sublethal effects following ocean disposal of WST waste fluids or release of WST fluids or hydrocarbons from potential accidents; and vessel strikes, noise, and other disturbances associated with WST operations. Sea turtles may also be affected by bottom-disturbing activities that may occur under Alternative 3.

- *Commercial and recreational fisheries*: Potential impacts due to preclusion from fishing areas due to interference with vessels transporting WST materials and equipment; localized closure of fisheries due to accidental release of WST fluids or hydrocarbons; and reduced abundance of fishing resources due to exposure to accidental release of WST fluids or hydrocarbons or to routine disposal of WST waste fluids.

- *Areas of Special Concern*: Potential impacts if water quality is affected; some biological resources potentially affected as identified above.

- *Recreation and Tourism*: Potential impacts if water quality is affected and use of recreational areas is affected.

- *Environmental Justice*: Reduced use of coastal and offshore areas by minority and low-income populations following accidental release of WST fluids and waste fluids.

- *Archaeological Resources*: The proposed action would not affect archaeological resources, except potential from bottom-disturbing activities that may occur under Alternative 3.

ES.5 ENVIRONMENTAL CONSEQUENCES

ES.5.1 WST Operations

Each of the four WSTs included in the proposed action have been used in Federal and State waters off of southern California. Of the more than 1,450 exploration and development wells that have been drilled in Federal waters on the southern California OCS between 1982 and

2014, there have been only 21 hydraulically fractured completions, and these were conducted on only 4 of the 23 platforms in Federal waters on the OCS. Three of these were in the Santa Barbara Channel, and the fourth was in the Santa Maria Basin. Only three matrix acidizing treatments, as defined as WSTs under SB-4, occurring in OCS waters during a similar time frame (between 1985 and 2011) have been identified in records, and these were conducted on only 2 of the 23 platforms.

The application of any of the WSTs included in the proposed action follows three basic steps: (1) the delivery of WST materials (i.e., WST chemical additives and proppant [typically sand]) to a platform; (2) the injection of WST fluids into the well undergoing treatment; and (3) the collection, handling, and disposal of WST-related waste fluids. Implementation of any of the WSTs included in the proposed action would largely use existing infrastructure, would require no construction of new infrastructure (e.g., no new pipelines, no new platforms), and would not result in bottom-disturbing activities (e.g., trenching), except potentially the drilling of new injection wells under Alternative 3. Some minor equipment changes may occur that would not entail any seafloor disturbance (e.g., replacement of existing platform injection pumps or fluid storage tanks with higher capacity equipment).

Materials for WSTs would be delivered to platforms via platform service vessels (PSVs) which routinely bring materials, supplies, and personnel to and from the platforms. Additional PSV trips may be needed to bring WST-related materials to a platform, which would represent a short-term, localized, and minor increase in PSV traffic. All WST-related materials would be transported in shipping containers designed and certified for marine and offshore transport. Bulk liquids could be transported in 350-gal or 500-gal stainless-steel totes, and non-liquid materials (e.g., proppant) could be transported in appropriate steel transport pods, all designed for marine transport and in compliance with all applicable shipping and safety requirements.

During a WST, chemical additives and proppant, if required, are mixed into a base injection fluid, filtered seawater, which is sourced at each platform. WST fluid components are mixed as they are injected. WSTs are conducted under the conditions, for example, of pressure and volume, specified in the APD or APM for a particular WST. Pumping time will vary by the type of WST being conducted and the number of stages needed for completion. Pumping time may be as little as 10 minutes for a DFIT, and up to 4 hours per stage for a hydraulic fracturing treatment.

WST operations produce waste fluids containing WST-related chemicals recovered during production, and air emissions associated with the operation of WST-related equipment (e.g., injection pumps, blending units) and with the transport of WST materials and supplies to and from platforms (e.g., PSV traffic). Following completion of a WST, waste fluids containing WST-related chemicals are recovered, typically comingled with formation water, referred to as produced water, and recovered oil. This comingled fluid is collected, and the oil phase is separated from the water phase for later refining and sale. A fraction of the injected WST chemical additives is typically recovered and becomes part of the produced water waste stream following separation. Chemical additives are largely consumed during treatment or retained in the formation. The water phase is treated and disposed of in the same manner as that used for

produced water during routine (non-WST) oil and gas production, via NPDES-permitted open water discharge, or by reinjection.

ES.5.2 Potential Releases from WST-Related Accidents

The three categories of accidents considered and analyzed in this EA were accidents occurring during (1) the transport of WST chemicals and fluids to platforms; (2) WST fluid injection; and (3) the handling, transport, treatment, and disposal of WST-related waste fluids. Some accident scenarios may be applicable to each of the four WSTs included in the proposed action, while other scenarios are applicable to only some of the WSTs.

An accidental release of WST chemicals could occur with any of the four WST types during the delivery of required materials and their subsequent offloading to a platform. Required WST chemicals would be delivered to a platform via a PSV and transported in sealed steel containers designed for marine transport and in compliance with applicable packaging and shipping requirements. Release of the contents of such containers would require the loss of control of the container and a breach of container integrity. Such a release during PSV transport under the expected infrequent use of WSTs on the Pacific OCS is considered to be very unlikely for the foreseeable future. A release of small quantities of WST chemical additives from a container during crane transfer from a PSV to platform storage is considered unlikely, but reasonably foreseeable.

During WST fluid injection, the accidental release of WST-related chemicals could occur as a result of equipment malfunction on the platform during fluid blending and injection. Malfunctions of blending units, injection pumps, manifolds, and other platform equipment could release small quantities of WST chemicals and result in a surface spill of WST chemical additives. Any such malfunctions would tend to be quickly detected and WST activities halted, and any releases would be quickly addressed through implementation of existing spill containment and cleanup measures. Thus, although such accidental releases may occur, they would likely result in the release of only small quantities of WST chemicals that may or may not reach the open ocean. This accident scenario is considered to have a low probability of occurrence but is still reasonably foreseeable.

For the fracturing WSTs, accidental releases of WST chemicals and formation hydrocarbons may occur as a result of well casing failure during injection after repeated pressurization and depressurization events, thus providing a pathway for well fluids to pass along the outside of the well casing, migrate upward, and be released from the seafloor. Such an accident scenario, while possible, is considered to have a very low probability of occurrence and is not reasonably foreseeable.

An accidental release of WST chemicals may also occur during a fracturing WST if a new fracture contacts an existing pathway (e.g., an existing fault or other well) to the seafloor. Such an occurrence could result in the accidental release of WST chemicals, hydrocarbons, and produced water via a seafloor surface expression. Given BSEE requirements that all APDs and APMs include information on known fractures, faults, and wells in the vicinity of the proposed

WST, and requirements for continuous monitoring of injection pressures during a fracturing, the injection of fracturing fluids would be halted if a pathway to the seafloor was suspected, thus greatly reducing the potential of a seafloor surface expression to the ocean. This accident scenario, referred to as a surface expression, is considered to have a very low probability of occurrence and is not reasonably foreseeable.

Finally, an accidental release of any recovered WST-related chemicals in waste fluids may occur if a break occurs in a pipeline that is carrying such waste fluids as part of the produced water or the crude oil/produced water mixture (before separation) and these fluids are released to the ocean. Given the expected low frequency of WST use on the southern California OCS and required regular inspection of pipelines, such an accident has a very low probability of occurrence and is considered not reasonably foreseeable.

ES.5.3 Summary of Impacts on Resources

Evaluations of potential effects on resources characterize such effects with regard to how widespread any impacts might be (e.g., localized around platforms or affecting a much larger portion of the southern California OCS), the magnitude of any potential effect (e.g., small or large increase in air pollutants, individual biota or populations affected), and the duration of any potential effects (e.g., short-term [days or weeks] or long-term [months or longer]).

Alternatives 1 through 3 include all four WST types analyzed; thus the nature of any potential WST-related impacts will be relatively similar among these alternatives in most respects. Alternative 3, which would prohibit ocean discharge, has additional potential impacts from drilling new injection wells, while any potential effects from ocean discharge of WST-related chemicals would be eliminated. Alternative 2 includes a minimum depth requirement that may reduce, in comparison to Alternatives 1 and 3, the likelihood of an accidental surface expression occurring. Alternative 4, No Action, would eliminate all impacts of WSTs. Because impacts from routine operations and the risk of accidents are low for Alternative 1, there is only a marginal decrease in risk and potential impacts under Alternatives 2 through 4.

Table ES-1 presents a comparison of impacts on resources under the alternatives from routine operations. Table ES-2 presents a comparison of the likelihood of various accidents under the alternatives.

ES.6 CUMULATIVE IMPACTS

Given the consistently small estimated potential impacts of future WST activities on resources in the Pacific OCS off southern California, incremental contributions to impacts from the proposed action are not expected to result in any noticeable or material cumulative effects on resources potentially impacted by the proposed action when added to past, current, and foreseeable future impacts on these resources from other sources.

TABLE ES-1 Comparison of Potential Effects among Alternatives from Routine Use of WSTs

Resource	Alternative 1 Proposed Action – Allow Use of WSTs	Alternative 2 – Allow Use of WSTs with Depth Stipulation	Alternative 3 – Allow Use of WSTs with No Open Water Discharge of WST Fluids	Alternative 4 – No WST Use on Existing OCS Leases
Air quality	No noticeable WST-related impacts on regional air quality expected. Negligible emissions of greenhouse gases.	Same as Alternative 1.	Same as Alternative 1. Additional air emissions if new injection well drilling and pipeline trenching occur.	No WST-related impacts.
Water quality	No WST-related impacts expected; although slight localized reduction in water quality at surface water discharge location.	Same as Alternative 1.	Similar to Alternative 1, but no reductions in water quality from WST chemicals in discharges to surface water. Temporary and localized reduction in water quality if new injection well drilling and/or pipeline trenching occur.	No WST-related impacts.
Induced seismicity	Low potential for induced seismicity.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Benthic resources	No WST-related impacts expected.	Same as Alternative 1.	Same as Alternative 1. Localized and temporary benthic habitat disturbance likely if new injection well and/or pipeline trenching occur.	No WST-related impacts.
Marine and coastal fish; sea turtles, marine and coastal birds, marine mammals	No WST-related impacts expected; potential for subtle toxic effects in some species from some WST chemicals occurring within the NPDES discharge mixing zone from discharges of WST waste fluids to surface water.	Same as Alternative 1.	Similar to Alternative 1 but with no potential for exposure to WST chemicals in discharges to surface water. Localized and temporary habitat disturbance and/or displacement of individuals likely if new injection well and/or pipeline trenching occur.	No WST-related impacts.
Commercial and recreational fisheries	No WST-related impacts expected.	Same as Alternative 1.	Same as Alternative 1. Localized and temporary habitat disturbance and/or displacement of individuals likely if new injection well and/or pipeline trenching occur.	No WST-related impacts.

TABLE ES-1 (Cont.)

Resource	Alternative 1 Proposed Action – Allow Use of WSTs	Alternative 2 – Allow Use of WSTs with Depth Stipulation	Alternative 3 – Allow Use of WSTs with No Open Water Discharge of WST Fluids	Alternative 4 – No WST Use on Existing OCS Leases
Areas of special concern, recreation and tourism, archaeological resources, environmental justice	No WST-related impacts expected.	Same as Alternative 1	Same as Alternative 1. Localized and temporary habitat disturbance and/or displacement of individuals likely if new injection well construction occurs.	No WST-related impacts.
Socioeconomics	No WST-related impacts or benefits expected.	Same as Alternative 1	Same as Alternative 1. Platform operators may incur additional costs if new injection wells or disposal pipelines are needed.	No WST-related impacts. Decommissioning costs may be incurred at some wells that become unproductive in the absence of WST use.

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TABLE ES-2 Comparison of Likelihood of Occurrence of WST-Related Accidents among Alternatives

Accident	Likelihood			
	Alternative 1 Proposed Action – Allow Use of WSTs	Alternative 2 – Allow Use of WSTs with Depth Stipulation	Alternative 3 – Allow Use of WSTs with No Open Water Discharge of WST Fluids	Alternative 4 – No WST Use on Existing OCS Leases
WST chemical release during transport following loss of transport container integrity	Applicable to all four WST types. Very low probability and not reasonably foreseeable.	Same as Alternative 1.	Same as Alternative 1.	Will not occur.
WST chemical release during crane transfer	Applicable to all four WST types. Low probability and reasonably foreseeable.	Same as Alternative 1.	Same as Alternative 1	Will not occur.
WST chemical release during injection from platform equipment malfunction	Applicable to all four WST types. Low probability and reasonably foreseeable.	Same as Alternative 1.	Same as Alternative 1.	Will not occur.
Seafloor expression of WST chemicals due to well casing failure	Applicable only to fracturing WSTs. Very low probability and not reasonably foreseeable.	Same as Alternative 1.	Same as Alternative 1.	Will not occur.
Seafloor expression of WST chemicals due to fracture intercept with existing surface pathway	Applicable only to fracturing WSTs. Very low probability and not reasonably foreseeable.	Reduced probability compared to Alternative 1.	Same as Alternative 1.	Will not occur.
Release of WST chemicals due to rupture of pipeline conveying produced water containing WST chemicals	Applicable to all WSTs. Very low probability and not reasonably foreseeable.	Same as Alternative 1.	Same as Alternative 1.	Will not occur.

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