

Procedure

Environmental Risk Assessment				
Management System:		Health, Safety and Environmental (HSE)	File Name:	HSE-Permit-INS-PNR - 005
Approver:		EPP Manager	Version No:	2,0
Reviewer:		Technical Director, Environmental Compliance Advisor, Frac Manager, Well Test Manager	Date of Issue:	October 2019
Author:		Permit Specialist	Proposed date of Review:	n/a
Version	Section	Revision Information	Date	Reviser
0.1	All	Draft for review	July 18	Permit Specialist
0.2	All	Review and updated	July 18	EPP Manager
0.3	All	Accepted changes and update	July 18	EPP Manager
1.0	All	Published	Dec 18	EPP Manager
2.0	Venting	Updated with N2 lift details and odour	October 19	EPP Manager
<i>Procedures are reviewed as per proposed review date, or sooner if a significant change to the operation has taken place, to ensure relevance to the systems and process that they define.</i>				

Environmental Risk Assessment for Preston New Road Exploration Pad

Phase: Drilling, hydraulic fracturing and initial/extended flow testing involving the generation of extractive waste and management of waste incineration.

Scope: The risk assessment examines the management of extractive waste throughout the drilling, hydraulic fracturing and flow testing of Preston New Road multi well exploration site in support of the permit application for a Mining Waste Directive Permit and Industrial Emissions Directive Permit known as the “Installation”. The format of this risk assessment follows the DEFRA Green Leaves III guidance on Environmental Risk Assessment and H1 Environment Agency guidance.

Risk Ratings

Likelihood: The likelihood accounts for the probability of an event occurring taking into account a potential pathway to a receptor.

Likelihood of Event	Score	Description
Highly Likely	5	The event will occur daily and there is a potential pollution linkage
Likely	4	The event might occur weekly and there is a potential linkage
Low Likelihood	3	The event might occur monthly/yearly etc. and there is a potential pollution linkage
Unlikely	2	The event could occur at some time but less than once per decade and there is a potential pollution linkage
Highly Unlikely	1	May only occur in exceptional circumstances and there is a potential pollution linkage

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Consequence: The consequence measures how the potential event interacts with a receptor (natural environment).

Consequence	Score	Description
Extreme	5	Irreversible environmental damage
Major	4	Environmental damage with significant effects which requires immediate and possibly long term management intervention to mitigate the damage and aid natural recovery
Moderate	3	Environmental damage with noticeable effects which requires immediate and possibly short term management intervention to preserve natural environment
Minor	2	Environmental damage is localised and easily managed
Insignificant	1	Very slight environmental damage with no measurable effect

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Likelihood	5 Highly Likely	5	10	15	20	25
	4 Likely	4	8	12	16	20
	3 Low Likelihood	3	6	9	12	15
	2 Unlikely	2	4	6	8	10
	1 Highly Unlikely	1	2	3	4	5
		1 Insignificant	2 Minor	3 Moderate	4 Major	5 Extreme
	Consequence					

After combining the likelihood and consequence, a risk category score is established e.g.

Likelihood = 5 (Highly Likely) and Consequence= 1 (Insignificant): Risk = 5 (Low)

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					Likelihood	Consequence	Risk	Risk Rating	What measures will Cuadrilla take to reduce the risk?					Likelihood	Consequence	Risk	Risk Rating	Is a RAMP required?	
									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments					Yes/ No	
Circulating drilling muds (Water Based Muds)	Returned drilling muds (waste)	Overfilling mud tanks or surface pipe leaks	Surface runoff and percolation into the ground	Surface soil, surface water	2	2	4	Low	✓		✓	✓	E	Use of non-hazardous muds during drilling of upper section of the well.	1	1	1	Low	No
													I	Mud tanks are situated on top of an impermeable membrane laid on the site.					
													C	Visual inspection of pipes and tanks during site daily HSE inspections. Visual monitoring by on site waste contractor. Pollution Incident Plan (PIP) in place on site with all staff briefed on the controls. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium. 24 hour manned operation. On site spill kits and access to 24 hour spill emergency contractor.					
Circulating drilling muds (Low Toxicity Oil Based Muds)	Returned drilling muds (waste)	Overfilling mud tanks or surface pipe leaks	Surface runoff and percolation into the ground water	Surface soil, surface water	2	2	4	Low		✓	✓	✓	R	Low Toxicity Oil Based Muds built from paraffinic base oils with very low aromatic content.	1	2	2	Low	No
													I	Mud tanks are situated on top of an impermeable membrane laid on the site.					
													C	Visual inspection of pipes and tanks during site daily HSE inspections. Visual monitoring by on site waste contractor. Pollution Incident Plan (PIP) in place on site with all staff briefed on the controls. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium. 24 hour manned operation.					



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What are the operational activities?	What has the potential to cause harm? (H1 Risk)	Where is it coming from?	How can the hazard get to the receptor?	What is at risk? What do I wish to protect?															
Circulating muds (Water Based Muds)	Drilling muds (fugitive emission)	Drilling muds left in situ through any losses to surrounding underground rock whilst drilling the well	Geological matrix	Groundwater	2	1	2	Low	✓	✓		✓	E	Use of non-hazardous drilling muds in upper section of the well in line with the Groundwater Directive 2006.	1	1	1	Low	No
													R	Drilling fluid composition mixed by competent contractors. Typical filtrate penetration during drilling is 10-50cms from the wellbore.					
													C	Monitoring Pit Volume Totaliser to detect and prevent any losses to formation during drilling. Non Hazardous Additives incorporated (if needed) into muds to control any loss of mud to the surrounding underground formation. QC/QA by independent third parties.					
Circulating muds (Low Toxicity Oil Based Muds)	Drilling muds (fugitive emission)	Drilling muds left in situ through any losses to surrounding underground rock whilst drilling the well	Geological matrix	Groundwater	3	1	3	Low		✓	✓	✓	R	Use of Low Toxicity Oil Based Muds in lower section of the well. These formations have very low permeability and as such losses to formation are very unlikely with poor quality groundwater receptor. Low Toxicity Oil Based Muds and or mineral oil based built from paraffinic base oils with very low aromatic content.	1	1	1	Low	No
													I	Typical filtrate penetration 3 to 5 times lower than water based muds.					
													C	Monitoring Pit Volume Totaliser to detect and prevent any losses to formation during drilling					



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Activity/ Event	Hazard <i>What has the potential to cause harm? (H1 Risk)</i>	Source <i>Where is it coming from?</i>	Pathway <i>How can the hazard get to the receptor?</i>	Receptor <i>What is at risk? What do I wish to protect?</i>	Unmitigated Risk				Mitigation Measures						Residual Risk				RAMP (Risk Assessment Management Plan)			
					Likelihood	Consequence	Risk	Risk Rating	What measures will Cuadrilla take to reduce the risk?						Likelihood	Consequence	Risk	Risk Rating	Is a RAMP required?			
									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments						Yes/ No			
Cementing (mud displacement back to surface)	Drilling muds (fugitive emission)	Incomplete mud displacement from wellbore	Geological matrix	Groundwater	2	1	2	Low	✓	✓		✓	R	QC/QA by independent third parties. Use of spacer fluid to wash out drilling muds.	1	1	1	Low	No			
													C	Competent contractors. Monitoring QC/QA pumped in and pumped out of the well. Cement Bond Log (CBL) on production string. Formation Integrity Testing (FIT) on casing shoes.								
Spacer fluid & cement returns	Cement & spacer fluid (accident)	Spillage of spacer fluid & cement at surface with residue of extractive waste (waste)	Surface runoff and percolation into the ground water	Surface water, soil, groundwater	2	1	2	Low			✓	✓	I	Returns are stored in waste containers situated on top of a pad wide impermeable membrane.	1	1	1	Low	No			
													C	On site spill kits and access to 24 hour spill emergency contractor. Visual inspection by on site waste contractor during waste accumulation.								
Transfer connection	Waste fluids, flowback, drilling muds (accident)	Leakage from road tanker hose connection to waste containers	Surface runoff and percolation into the ground water	Surface water, soil, groundwater	2	2	4	Low			✓	✓	I	Road tanker and transfer conducted on top of pad wide impermeable membrane. Use of drip trays underneath connection points. Shut off valve to stop further leakage if any occurs.	1	2	2	Low	No			
													C	On site spill kits and access to 24 hour spill emergency contractor. Manned operation during transfer of fluids. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium.								
Returning flowback fluid	Flowback water (accident)	Pipe assembly leakage	Surface runoff and percolation	Surface water, soil, groundwater	2	2	4	Low		✓	✓	✓	R	Hydro test of flowback tanks prior to receiving flowback water during commissioning of well testing equipment.	1	2	2	Low	No			



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments					Yes/ No	
			into the ground water																
Returning flowback fluid	Flowback water (accident)	Overfilling flowback tank	Surface runoff and percolation into the ground water	Surface water, soil	2	2	4	Low		✓	✓	✓	R	Non-hazardous waste stream.	1	2	2	Low	No
													I	Site built on an impermeable membrane with surface flows going into controlled site rainwater containment area. Ability to shut in the operations to prevent further overflowing of flowback.					
													C	Transferring of flowback water is a manned operation by competent personnel. On site spill kits and access to 24 hour spill emergency contractor. Pollution Incident Plan (PIP) in place on site with all staff briefed on the controls. 24 hour manned operation. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium.					



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments	Yes/ No					
Returning flowback fluid	Flowback water (accident)	Integrity failure of storage containers	Surface runoff and percolation into the ground water	Surface water, soil, groundwater	1	2	2	Low		✓	✓	✓	R	Hydro test of flowback tanks prior to receiving flowback water during commissioning of well testing equipment. Walkthrough check of pipework configuration/valve operation prior to commencing well test operation Well test spread configuration drawings. Equipment pre load out checks.	1	2	2	Low	No
													I	Flow back tanks located on site impermeable membrane.					
													C	Daily visual inspection of flowback tanks for integrity. On site spill kits and access to 24 hour spill emergency contractor. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium.					
													C	Visual inspection of tanks during site daily HSE inspections. Visual monitoring by on site waste contractor. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium.					
Flow testing & Flowback between Hydraulic Fracturing	Waste gas (fugitive emission)	Ineffective separation of water and gas at surface	Venting to atmosphere of methane	Atmosphere (venting)	2	3	6	Medium		✓	✓	✓	R	Adherence to well flowback emission control procedure (HSE- CORP-HSE-PLA-011) Trained well test engineer listening for acoustic changes in flowback with entrained gas at the Choke.	2	2	4	Low	No



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments					Yes/ No	
Flaring of waste natural gas	Natural gas (global warming)	Inefficient burning from the flare	Airborne contaminant (VOC's, methane)	Atmosphere	3	2	6	Medium		✓	✓	✓	R	24 supervision of pipes and flare during flow testing. Surface equipment subject to mobile monitoring of fugitive methane emissions.	1	2	2	Low	No
													I	Flare designed for complete combustion at temperatures of up to 1000°C with compliant residences time and temperature.					
													C	Ability to shut in the well in the unlikely event of an inefficient burn. 24 hour supervision of flare. Temperature monitoring using thermocouples at the base and tip of the flare. Continuous monitoring of temperature. Ambient air quality monitoring at 4 locations surrounding the site including monitoring of BTEX (Benzene, Toluene, Ethylbenzene, Xylene). Environment Statement models impact Benzene as an air quality determinant as an insignificant impact. ADMS modelling shows flaring from site is below the 1% significance threshold.					
Flaring of waste natural gas	Noise from the flare (noise)	Flaring natural gas	Sound waves	Local community	3	2	6	Medium		✓	✓	✓	R	Fully enclosed flare to reduce noise levels.	1	2	2	Low	No
													C	Modelling of noise as per Environmental Impact Assessment along with monitoring at the nearest residential location.					
Flaring of waste gas	Light from the flare (light)	Flaring natural gas	Light	Local community and wildlife	2	2	4	Low		✓		✓	R	Fully enclosed flare to reduce light pollution.	1	2	2	Low	No
													C	Modelling of light impact as per Environmental Impact Assessment (EIA).					
Venting of waste gas (during nitrogen lifting)	Natural gas (global warming)	Flares (non-combusted)	Airborne Contaminant	Atmosphere	3	2	6	Medium		✓		✓	R	Only utilise nitrogen lifting if required. Reduce nitrogen usage duration to shortest possible time Core samples have not detected H2S or high sulphurous compounds.	3	1	3	Low	No



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)					Mitigation Comments	Yes/ No	
	What has the potential to cause harm? (H1 Risk)	Where is it coming from?	How can the hazard get to the receptor?	What is at risk? What do I wish to protect?															
Flow testing	Natural gas (global warming)	Leaks from pipe connections	Airborne Contaminant	Atmosphere	2	2	4	Low		✓	✓	✓	R	PNR2 initial data corresponds with air quality assessment for venting. Detection of odour or TVOC which could cause pollution outside boundary of the site will result in suspension of well test/ clean up associated with operations. Attempt flare ignition and supported combustion at regular methane concentration set points. Continuous methane monitoring with alerts to detect changes to background methane concentration. TVOC and odour to monitor Benzene/ nuisance smells as per EMMP PO2 and associated notifications. Hydro test of pipework and joints before use. Connection and operation of equipment in line with manufacturer's standards. Surface equipment subject to mobile monitoring of fugitive methane emissions. Ambient air quality monitoring at 4 locations surrounding the site including monitoring of BTEX (Benzene, Toluene, Ethylbenzene, Xylene). Visual inspection of site joints and connections as per HSE site tours.	2	1	2	Low	No
Multi stage Hydraulic Fracturing	Hydraulic fracturing fluid	Hydraulic fracture	Fracture	Millstone Grit Groundwater	2	1	2	Low	✓	✓	✓	✓	E	Very poor quality saline groundwater unit at depth ~1300m below ground level (Millstone Grit). Water or gel based hydraulic fracturing fluid utilising non-hazardous to groundwater hydraulic fracturing fluid additives. Low permeability of target formation preventing fluids flow from the target formation. Groundwater monitoring post abandonment in line with Mining Waste Permit site closure plan.	1	1	1	Low	No



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)					Mitigation Comments	Yes/ No	
Disposal of retained fracturing fluid in the target reservoir	Retained non-hazardous hydraulic fracturing fluid (waste)	Fugitive migration of retained fracturing fluids from the target reservoir	Vertical migration via the well bore	Upper Groundwater bearing units	2	2	4	Low	✓	✓	✓	✓	E	Absent vertical pressure gradient to force flow back fluid upwards.	1	1	1	Low	No
													R	Waster or gel based hydraulic fracturing fluid utilising non-hazardous to groundwater hydraulic fracturing fluid additives.					
													I	Multiple cement sheaths pressure tested in combination with cement or mechanical plugs to isolate the well. Low permeability of target formation preventing fluids flow from the target formation.					
													C	Plugging and abandonment design and constructed in line with HSE regulations Offshore Installations and Wells (Design and Construction Etc) Regulations 1996 (DCR) regulation 15 and UK Oil and Gas Standards. Groundwater monitoring post abandonment in line with Mining Waste Permit site closure plan. Hydraulic fracturing plan to design the location of the fractures. Downhole micro Seismic array to allow monitoring of fracturing propagation.					
Disposal of retained fracturing fluid in the target reservoir	Retained non-hazardous hydraulic fracturing fluid (waste)	Fugitive migration of retained fracturing fluids from the target reservoir	Vertical migration via induced or natural fractures	Upper Groundwater bearing units	2	2	4	Low	✓	✓		✓	E	Composite layering effect restricting the possibility of upward migration of fluid and fractures Presence of impermeable Manchester Marl formation above the target formation preventing fluid migration. Target formation over 2000m deep.	1	1	1	Low	No



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									Eliminate (E)	Reduce (R)	Isolate (I)	Control (C)	Mitigation Comments					Yes/ No					
Transportation of waste materials / liquids	Accident resulting in spillage from transport (accident)	Road tanker	Surface run off into drains or soft ground	Surface water and soils	2	3	6	Medium		✓	✓	✓	R	Lack of vertical pressure gradient to force flow back fluid upwards. Waster based hydraulic fracturing fluid utilising non-hazardous to groundwater hydraulic fracturing fluid additives. Groundwater monitoring post abandonment in line with Mining Waste Permit site closure plan. Hydraulic fracturing plan to design the location of the fractures. Downhole micro Seismic array to allow monitoring of fracturing propagation.									
													R	Flowback fluid classified as non-hazardous waste stream.	1	2	2	Low	No				
													I	Competent, licensed and experienced waste carriers will be employed to undertake this service. Support from 24 hour emergency contractor and spill response which includes off site locations to isolate spills.									
													C	Use of Environment Agency authorised haulage/ delivery companies with waste carrier's licences. Utilisation of a travel plan. MSDS sheets to accompany movement of liquids. Pollution Incident Plan (PIP) in place on site with all staff briefed on the controls. Spill kits available on each delivery carrying liquids/ fuels.									
Waste road tankers reversing	Noise (noise)	Reversing alarm	Sound waves	Local community	3	2	6	Medium		✓		✓	R	Movement of vehicles will be restricted during night time operations.	2	1	2	Low	No				



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Movement of road tankers	Mud from road tankers (mud)	Wheels of road tanker	Vibration	Road	3	1	3	Low	✓			✓	E	Site pad and is constructed of stone. Drillings muds are transported in enclosed road tankers.	2	1	2	Low	No		
													C	Monitoring of access and egress track on a daily basis. Utilise road sweeper in the event of mud on the road.							
Tear in impermeable membrane	Waste spill (fugitive emission)	Tear in the impermeable membrane	Surface runoff and percolation into the ground towards the south of site down gradient	Surface soils, groundwater	2	4	8	Medium	✓	✓	✓	✓	E	Installation is tested with a guarantee from contractor of no tears.	1	2	2	Low	No		
													R	Protective matting and felt to prevent tears during operations.							
													I	Textured HDPE impermeable membrane to prevent movement of surface protective matting.							
													C	Ability to isolate and repair any tears. Groundwater quality monitoring by independent environmental consultancy, GGS. Local surface water quality sampling at minimum 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium. No excavation on site once the impermeable membrane and stone pad are constructed.							
Plugging and Abandonment; accumulation and storage of liquid waste fluid	Liquid waste fluid (waste)	Spillage	Overland flow	Surface water, groundwater and soil	2	2	4	Low			✓	✓	I	Pad wide impermeable membrane with surface flows going into controlled site rainwater containment area.	1	2	2	Low	No		



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	What has the potential to cause harm? (H1 Risk)	Where is it coming from?	How can the hazard get to the receptor?	What is at risk? What do I wish to protect?															
Plugged and abandoned well	Fugitive methane (Fugitive emission)	Leaks	Vertical Migration	Groundwater Atmosphere	2	2	4	Low	✓		✓	✓	E	On site spill kits and access to 24 hour spill emergency contractor. Pollution Incident Plan (PIP) in place on site with all staff briefed on the controls. Manned operation by competent personnel. Local surface water quality sampling at 5 locations. Determinants to represent chemicals/diesel/oils on site e.g. heavy metals, TPH, BTEX, chlorides, sodium. Steel skips checked for integrity. Groundwater monitoring post abandonment in line with Mining Waste Permit site closure plan.	1	2	2	Low	No
													I	Multiple cement sheaths pressure tested in combination with cement or mechanical plugs to isolate the well.					
													C	Plugging and abandonment design and constructed in line with HSE regulations Offshore Installations and Wells (Design and Construction Etc) Regulations 1996 (DCR) regulation 15 and UK oil and gas standards. Fugitive methane emissions monitoring post abandonment. Groundwater monitoring post abandonment in line with Mining Waste Permit site closure plan.					
Discharge from site to Carr Bridge Brook	Contaminants from site	Site drainage ditch collection point	Pipeline	Carr Bridge Brook	2	3	6	Medium	✓	✓	✓	✓	E	Isolation valve is closed during operations and only opened when permitted.	1	3	3	Low	No

