MAJOR IMPEDIMENTS TO A FEASIBILITY STUDY IN THE CASE OF SMITH BAY DEVELOPMENT

By

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Alaska Oil Fields

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Abstract

The State of Alaska is one of the energy-producing states which rely on revenue from energy extraction, but faces several challenges, especially significant fluctuations in revenue generated by taxes. In the past, oil production from established oil fields on state land yielded sufficient tax revenue. For new sources of oil, oil company owners must make a decision about developing the prospects based on a feasibility study which produces preliminary design, cost estimates, project schedule, including many permits and other uncertainties, financing, and tax credits. When this study is done, the decision can be made to begin development. This paper considers the feasibility studies on main obstacles in the development path of Smith Bay. The evaluation of major tasks needed for a feasibility study, uncertainty and obstacles, combined with our estimation of the time period required for the oil fields to produce oil, led to an estimate of the time before tax money will be provided to the state.

Chapter-1

Introduction

Alaska is rich with natural resources and has huge untapped reserves that still need to be explored. The tax revenues generated from the oil and gas extraction constitute over 95% of the state budget. However, the state is caught between two inverse but critical parameters that do not depend on each other but affect the state significantly. First, the oil production and the oil flow through the Trans Alaska Pipeline System has been gradually decreasing in the last 10 years. Second, falling global oil prices have reduced the new investments in oil exploration by oil companies. These two factors combined together have largely impacted the total oil revenues.

The recent discovery of new oil fields by Caelus Energy at Smith Bay raised the curiosity of the author and thus initiated this project. Although the emphasis is on the example of Smith Bay other examples are included too. The statistical studies on oil production in Alaska and different states in the U.S. were carried out along with the statistical studies on revenue generation in Alaska.

Oil tax revenue has a significant effect on the state's ability to provide services to Alaskans. Any new oil discovery leads to one more avenue of revenue generation and stability for Alaska, but in order to reach to the stage of oil production and distribution, the oil companies must carry out feasibility study.

In this paper I have explored what goes into a feasibly study of oil exploration as I would like to estimate how long it will be before money gets to the state. Thus, this report covers the detailed step-by-step process required to reach the revenue generation from the oil fields, and examines uncertainties and impediments to that process, especially those that impact the first major step, the feasibility study. The process begins with the concept development which is the feasibility phase followed by environmental permitting requirements, stages of oil and gas exploration and production and whether the pipeline should be constructed in the ocean or on roads and the uncertainties and unknown. Oil reserves in other parts of US are studied. Examples of different exploration attempts are used as samples of uncertainties. Furthermore, the time taken and permitting requirement studies on mining developments in Alaska are reported subsequent to examples.

1.1.Overview

Alaska depends heavily on the petroleum industry. The State of Alaska depends on the oil revenues earned from the oil extraction. Though the quantity of oil flowing down the Trans Alaska pipeline has gone down from 1.2 million barrels a day to less than 500,000 barrels per day, the oil revenues still continue to be a major contributor to the state's wealth. The **Table-1.** shows the tax revenues over recent years. (AOGA, 2017)

Table-1: The Alaska tax revenues over recent years. (AOGA, 2017)

TOTAL OIL REVENUE TO STATE FY2011 - FY2015 ($ MILLIONS)

	OIL REVENUE	2015 PROJECTED	2014 ACTUAL (YTD FISCAL)	2013 ACTUAL	2012 ACTUAL	2011 ACTUAL
Unrestricted	Production Tax	1,746.3	2,408.5	4,042.5	6,136.7	4,543.2
	Royalties Net	1,616.4	1,696.3	1,748.4	2,022.8	1,921.3
	Petroleum Corporate Income Tax	463.7	463.8	434.6	568.8	542.1
	Property Tax	97.4	99.6	99.3	111.2	110.6
	Hazardous Release	8.1	8.6	7.8	9.4	9.7
	Royalties – Oil and Gas, Bonuses, Rents, Interest	14	21.1	19.4	8.9	22
Restricted	Royalties to Permanent Fund and School Fund	706.6	741.7	855.9	919.6	870.9
	Tax Settlements to Constitutional Budget Reserve Fund	20	20	176.6	102.1	167.3
	NPR-A Royalties, Rents and Bonuses	3.5	4	3.6	4.8	3
	Total Oil Revenue	**4,676**	**5,463.6**	**7,388.1**	**9,884.3**	**8,090.1**

In the state's 2013 fiscal year, oil and gas revenues represented 92 percent of Alaska's unrestricted revenue. Oil tax revenue has a substantial influence on the state's ability to provide services to Alaskans. The oil and gas production tax revenues have been cut in half in the last three years, from $4 billion in fiscal 2013 to $2.1 billion in 2014 and $1.7 billion in 2015. Petroleum revenues have fallen from 92% of the budget in 2013 to 82% in 2015. (AOGA, 2017)

The falling oil prices and reduced tax revenues paint a picture of despair, but there are signs of revival. In the past year, Exxon and Conoco both began pumping from new North Slope projects. In 2016, Apollo Global Management LLC, claimed to find oil in the shallow waters of Smith Bay, about 300 miles north of the Arctic Circle. (Gold, 2016) On Oct, 4, Caelus Energy LLC said it had discovered an additional 6 billion barrels of oil that could double the state's recoverable reserves.

In order to begin the process of oil extraction and reach to the stage of oil distribution, construction of road routes will be essential. Development of the new oil field at the Smith Bay would be very expensive based on its location. The cost estimated is around $8 billion to $10 billion to bring the Smith Bay field on line, (Bailey, 2016) and hence the feasibility of the field would need a constant oil price in the range of mid-$60s plus the future steadiness of Alaska's economic system. Funded by private investors, Caelus is a limited liability company (LLC). The CEO of Caelus, Mr. Musselman, points the effective finding of foremost oil resources at Smith Bay both to the state's latest oil production tax regime, commonly known as SB 21, and to the state's tax credits. "Fiscal stability going forward is critical for a project of this magnitude," Musselman said. "Without the state tax credit programs, none of this would've happened, and I'm not sure Caelus would've come to explore in Alaska. We're proof that the credit programs work." (Bailey, 2016)

Alaska has established a liable tax policy using important means like tax credit systems. Tax credits inspire investment that certainly influence production but at the same time decreases the risks taken by companies. The tax credit systems are directly related to revenue generation, therefore I have attempted to cover how the revenue generation is related to tax credit system.

Chapter-2

Alaska Tax Credit System (AS 43.55)

The idea of giving a tax break to companies developing new oil, particularly small fields facing tough economics, goes back to the 1970s with the Economic Limit Factor, or ELF. (Berman, 2006) This was a formula in the tax law that required an advanced degree in mathematics to comprehend. Tax credits are an important tool in Alaska's stable and predictable tax policy. (AOGA A. O., n.d.) Credits act to encourage investment that will positively impact production and reduce the perceived risk of expenditures by industry. The State of Alaska offers a variety of tax credits to incentivize investment across the state. Whether drilling a well, building a facility to gather new oil, or installing a pipe to transport new oil, tax credits help companies offset investment risks that companies make in Alaska. For example, one credit focuses investment on subsurface intangible-drilling expenditures- well activity, which is a direct investment in increasing oil and gas production. (AOGA A. O., n.d.) Another credit increases the likelihood of participation by new industry players who might otherwise have been deterred from coming to Alaska by presumptions of increased risks of higher-than-average costs and expenses. New contributors with new notions can toughen and improve the Alaska petroleum industry and help the state increase production. (AOGA A. O., n.d.) The State of Alaska needs tax money and producing developed oil fields on state land leads to this goal. (Roy & Hullavarad, 2015)

Alaska charges a yearly tax on oil and gas produced in the state. The tax is centered on the net value of oil and gas, the value at the time of production multiplied by the taxable volume, minus all lease expenses permissible under AS 43.55.165. For example oil and gas produced from the Cook Inlet tax rates are successfully capped at the rate that was levied on oil and gas produced from every lease or property. North Slope gas tax is capped at the rate of 17.7 cents per Mcf *. (Alaska, 2010) Returns on the tax can be viewed as follows; taxpayers need to report all values, volumes, transportation costs, expenditures, and credits used for calculating their projected monthly installment payments in the monthly report. (Alaska, 2010) The tax on oil and gas is collected on all but state and federal royalty production. Use of oil and gas on a lease or property for production, drilling, or re-pressuring is not taxed.

The State of Alaska as an independent taxing authority over the Department of Revenue (DOR) and as a landowner, the Department of Natural Resources (DNR) propose several motivations to inspire exploration and development of Alaska's oil and gas resources. (Financial Incentive Programs, n.d.) The existing tax rate was imposed by More Alaska Production Act or MAPA. Cook Inlet and North Slope Gas Prevailing Values are calculated quarterly by the tax division (1994 – present), statistical data is seen in the **Figure 1a and b**. (Statistical analysis report is attached as an **Appendix-1**) (Alaska, n.d.) (AK, 2017) [Prevailing value is the weighted average sales price of gas to publicly regulated utilities in the North Slope and Cook Inlet area. (Alaska, 2017)] A statistical analysis has been applied to oil data since 1980s and 1990s, when some new statistical methods were absorbed into petroleum risk analysis such as lognormal risk resources distribution, (Attanasi E D, 1985), and (2) Pareto distribution applied to petroleum field-size data in a play (A., 1995) A statistical study was conducted to understand the relation between annual royalty volume and value at North Slope and Cook Inlet area that is appended (**Appendix-2**)

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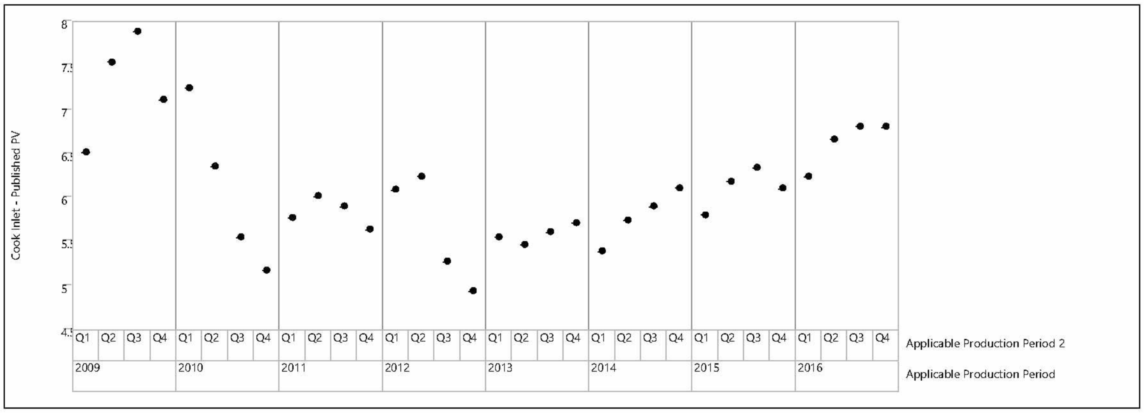
*($ per Mcf) - Mcf is an abbreviation denoting a thousand cubic feet of natural gas. A natural gas well that produces 400 Mcf of gas per day operates with a daily production rate of 400,000 cubic feet. A single Mcf is equal to approximately 1,000,000 Btu (British thermal units) of energy.



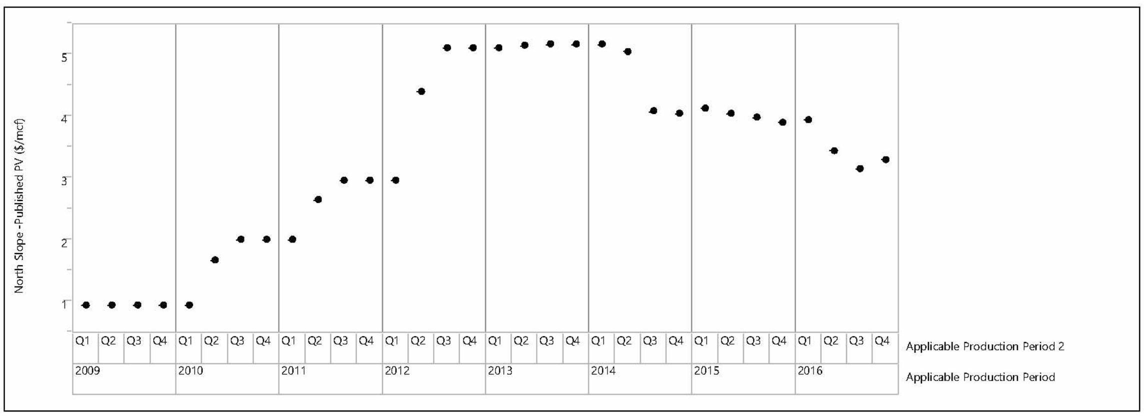


Figure 1 a & b. Statistical data of Cook Inlet Gas Prevailing Value calculated quarterly by the Division (1994 – present) (raw data obtained and graphs by the author: N. Hullavarad), (Alaska, 2017)

Table-2: History of Alaska's Oil and Gas Production Tax

The oil and gas production tax provides for various credit programs:

AS 43.55.019>	Oil or gas producer education credit
AS 43.55.023(a)	Qualified capital expenditure credit
AS 43.55.023(b)	Carried-forward annual loss credit
AS 43.55.023(l)	Well Lease Expenditures credit
AS 43.55.023(d)	Transferable tax credit certificate
AS 43.55.023(i)	Transitional investment expenditure credit
AS 43.55.024(a)	New area development credit
AS 43.55.024(c)	Small producer credit
AS 43.55.024(i)-(j)	Per-taxable-barrel credit
AS 43.55.025(a)(1)-(4)	Alternative Tax Credit for Exploration
AS 43.55.025(a)(5)	Cook Inlet jack-up rig credit
AS 43.55.025(a)(6)-(7)	Frontier basin credits
AS 43.55.028	Cash purchases of tax credit certificates

Under AS 43.55.201, the State collects a 1 cent per barrel conservation surcharge on taxable oil produced if there is less than $50 million in the Hazardous Release Fund. The State also collects an additional 4 cents per barrel conservation surcharge under AS 43.55.300.

History of Alaska's Oil and Gas Production Tax:

Senate Bill 21, aka the More Alaska Production Act (MAPA), was signed by Governor Sean Parnell on May 21, 2013.

Senate Bill 236, House Bill 280, and Senate Bill 309 signed in 2010, by Governor Sean Parnell, created new tax credits and amended some provisions of the tax.

House Bill 2001, aka Alaska's Clear and Equitable Share (ACES), was signed by Governor Sarah Palin on December 20, 2007.

House Bill 3001, aka Petroleum Production Tax (PPT), signed by Governor Frank Murkowski on August 19, 2006.

Production tax system using the Economic Limit Factor (ELF) was in place from

Prices for North Slope oil have drifted around $50 a barrel for almost two years. The Alaska state's epoch long price forecast published in the spring of 2016 have estimated prices below $70 a barrel through 2025. (DeMarban A. A., 2016). The method to determine the future oil production was given by Campbell and Laherrère (Laherrère, March 1998). Three vital numbers required to project future oil production are - the tally of how much oil has been extracted to date, a number known as cumulative production; second, an estimate of reserves, the amount that companies can pump out of known oil fields; finally, an educated guess at the quantity of conventional [The term "Conventional Oil" refer to the methods of extraction that produce the petroleum using drilling and wells] oil that has not yet been discovered and exploited.

Factors, Risks, That Might Affect Cost and Cost Estimates

1. Inaccurate reserve estimates
2. Volatile oil and gas prices
3. Natural disasters and extreme weather conditions
4. Operational hazards including blowouts, spills and personal injury
5. Environmental restrictions and regulations
6. Decrease in demand for oil or natural gas
7. General industry competition
8. Inadequate or unavailable insurance coverage
9. Reliance upon third party transportation and processing facilities
10. Ability to attract or retain key personnel
11. Competition from alternative energy sources
12. Impact of climate change and greenhouse gas legislation

Together they add up to final recovery, the total number of barrels that will be extracted before the production will die away many decades from now. The clear way to collect these numbers is from several publications. This approach works well for cumulative production statistics since companies' meter the oil as it flows from their wells.

"The record of production is not perfect (for example, the two billion barrels of Kuwaiti oil wastefully burned by Iraq in 1991 is usually not included in official statistics), but errors are relatively easy to spot and rectify. Most experts agree that the industry had removed just over 800 billion barrels of oil (Gbo) from the earth at the end of 1997" (Laherrère, March 1998).

The Anchorage Economic Development Corporation (AEDC) 2015 Resource Extraction Projects give 10-Year Projection Report. (AEDC, 2015) This projection started in 2004 to give a perception on the future of resource extraction projects in Alaska. These are based on the factual revenues generated in the previous years. **Figure 2** shows an overview of total spending on oil and gas projects and when that spending will take place. (AEDC, 2015) **Figure 3** shows Project Investments of oil and gas exploration (AEDC, 2015). [Note: these make a big deal out of LNG project – a lot of uncertainty there.]

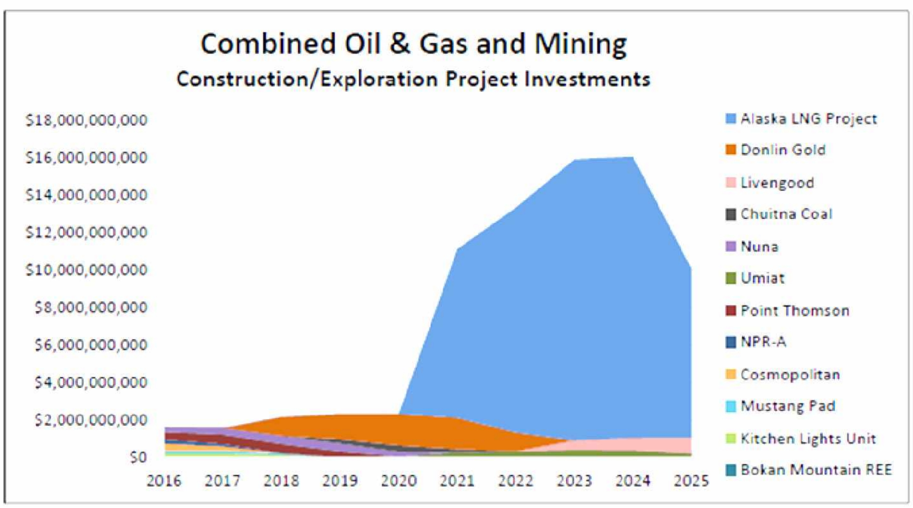


Figure 2. An overview of potential total spending on the oil and gas mining-construction/Exploration Projects. (AEDC, 2015)

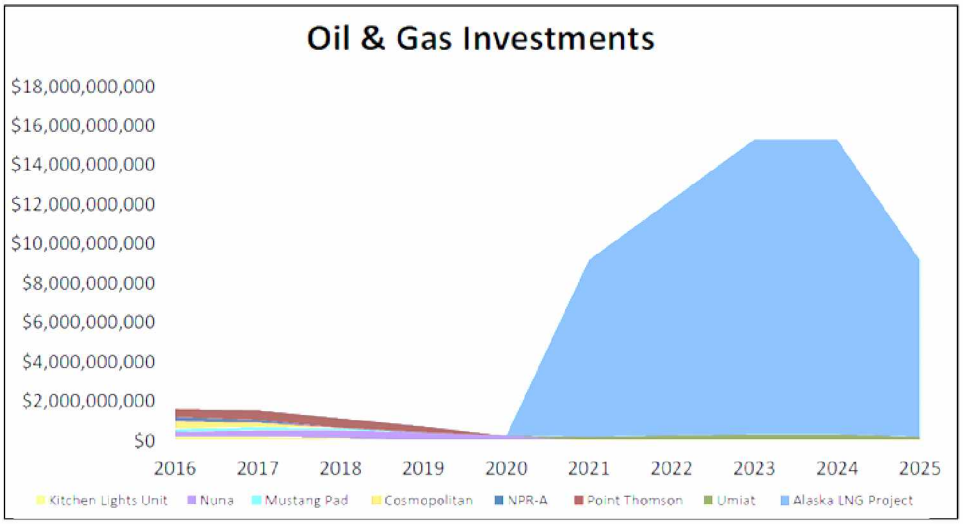


Figure 3. Project Investments of Oil and Gas Exploration. (AEDC, Resource Extraction Projects Projection, Report page - 10 Combined oil and gas mining-construction, 2015)

2.1. Revenues generation

Mr. Musselman, the CEO of Caelus energy said, "The cost of exploration at Smith Bay has totaled about $130 million, with state credits expected to help pay for about $75 million. The company holds certificates from the state for that $75 million and another $25 million for other work, but has not been paid roughly $100 million". The money was withheld as part of Governor Bill Walker's decision in June to address the state's budget deficit by deferring payment to oil companies of $430 million in credits. (DeMarban A. , 2016) The author discussed with Caelus Energy. As per Caelus, the governor's veto came at pretty interesting times when Caelus was ready to drill the third exploration well but due to the veto, had to halt and delay the process probably until 2022-23. This indicates how political volatility has a great influence on the large projects. Based on the interests and vision of the authority party, the project directions may change and influence the overall outcome that leads to a question whether new energy companies would want to invest in the new projects at the time of uncertainty? An elaborate discussion on uncertainties and unknowns is carried out later in this paper.

State's current revenue generation problems will not be fixed by Smith Bay. If developed rapidly by obtaining appropriate permits and leases, still the oil would not be flowing through the pipeline approximately for a decade as per Caelus's prediction. (EMPIRE, 2016) The Smith Bay field's production tax revenue and royalty oil would not fill the budget gap on its own; the state would be functioning at a noteworthy deficit even though the top-end estimation of oil production is about 200,000 barrels oil. (EMPIRE, 2016) Yet the Caelus discovery can be considered as an important one for the state's future. It could have a considerable direct positive effect on Alaska residents where, Under Gov. Bill Walker's permanent fund restructuring plan, dividend checks would move from being generated by returns from the permanent fund body to a distribution directly based on oil revenue. The Smith Bay oil, when developed, would provide a rise to that amount. (EMPIRE, 2016)

Offshore oil projects are much more complicated than onshore projects: a fact known to the investors in the petroleum industry. Usually the offshore projects are categorized by enormous investment and great uncertainties. A minute change in an indeterminate factor may cause a large fluctuation of total investment. One important uncertain factor that has a great influence on the investment is production uncertainty. (Cheng Cheng, 75 (2015))

Chapter-3

Concept development - onshore and offshore- Feasibility phase

A standard project usually has four major phases: initiation – conceptual phase, selection, planning, implementation, and closure (evaluation and termination). These phases collectively characterize the path taken by a project from the start to end and are generally referred to as the project's "life cycle." (**Figure 4**)

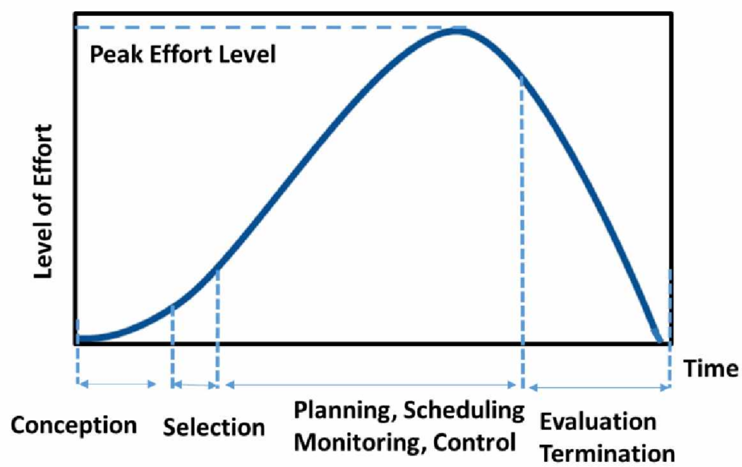


Figure 4. The project "life cycle" showing different phases during project development. (Jack R. Meredith, 2014)

During the initiation phase, the project requirement is recognized and conceptualized; it could be either a business problem or an opportunity. A feasibility study is conducted to examine whether each option discourses the project objective and a solution is determined. Feasibility issues (Is the project doable?) and justification (should the project be undertaken?), are addressed. During the next phase, i.e. the planning phase, the project solution is developed and the steps required to meet the objective of the project are planned. All the work to be performed, main tasks, resource requirements and the approach to be followed are identified. A project plan is constructed that outlines the activities, tasks, needs, and timeframes. The preparation of a project budget with the help of cost estimates for the labor, equipment, and materials is done. The focus of the budget is to monitor and control cost disbursements during project implementation. (Watt, n.d.) Details on the conceptual and planning phase relevant to this paper are discussed here.

Concept development studies are the core of project (that has many phases) development planning for both onshore and offshore developments. Understanding and estimating different development possibilities for offshore locations is vital in choosing the most cost effective solution to support oil company's investment decisions, and to take the subsequent project phases forward. (Unknown, Concept development - onshore and offshore, n.d.) **Figure 5** shows the offshore design branches

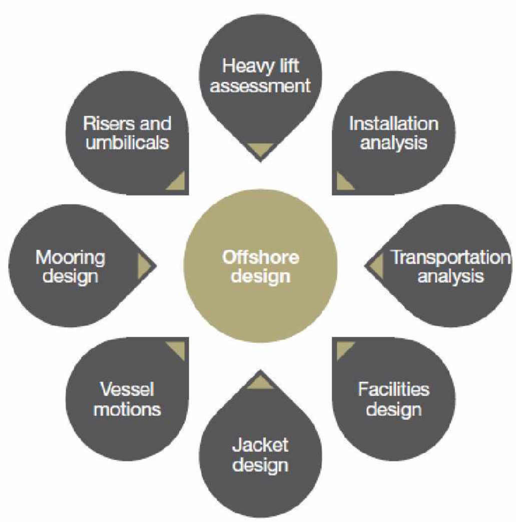


Figure 5. The offshore design branches. (Unknown, Concept development - onshore and offshore, n.d.)

During the concept development phase, both technical and economic viability are validated by developing specific solutions after considering issues like: plant location, conceptual plant layout-architecture of production gathering system, processing scheme, refinery configuration, hydrocarbon properties, impurities (e.g. H_2S, wax, sand, salt), export & storage of products (oil/ gas / NGL/ LPG/ LNG, gasoline, diesel, kerosene), power generation, utility systems integration and enhanced oil recovery methods, materials selection for plant and pipelines, process plant technology selection, process and safety studies, operability, control, overpressure protection, power generation/ supply, machinery selection, long lead item identification, environmental and disposal issues. The cost estimation considers market situations, construction approach and country specific infrastructure, and labor productivity, heavy lift assessment, installation analysis, transportation analysis, offshore design, facilities design and vessel motions. Thus, the feasibility of the concept is evaluated.

Project Life-Cycle Phases In Construction are;

(i) Planning, data gathering, and procedures

(ii) Studies and basic engineering

(iii) Major review

(iv) Detail engineering

(v) Detail engineering/ construction overlap

(vi) Construction and

(vii) Testing and commissioning

Chapter-4

Environmental Permitting

After the recognition of the project, the projects are evaluated to determine the type of permits required for the project. Three main types of projects are carried out on the North Slope; oil exploration, minor alterations, and growth projects. Individually each type of project needs a different set of permits based on the longevity of the project, while some permits are mutual to all projects. Oil exploration is permitted only during winter in order to safeguard the sensitive tundra from wear and tear that might be caused by the weight of heavy vehicles. For that reason, in order to drill an exploration well it is necessary to build an ice road to the drilling location and build an ice pad for the drilling rig to work from. Tundra has to be frozen up to 12 inches and accumulation of minimum of 6 inches of snow on the ground to construct the ice roads and pads as per current regulations. The drilling rig is then driven out to the pad location, the well is drilled, and the rig and associated equipment are taken back to the established oil fields after melting, when thawing starts. When the ice road and pad then melt away, little traces are left except for a "Christmas tree" (wellhead) in some cases. (Sally Rothwell, 2002) This kind of temporary exploration projects last a maximum of four months including construction of the ice road and therefore many permits are issued just for one year or a single winter season, and permits are not complex to prepare nor challenging to comply with compared to the permits required for longer-term development projects. (Caelus Energy Alaska Smith Bay, 2016)

Minor modification projects typically comprise of equipment upgrades or extensions. Such projects exist in current permitted oil fields that already have permits in place. These minor modification projects may require simply a notification to the agencies about the activity to be taking place, or possibly amendments or revisions to existing permits. Whereas, ‘development projects’ consist of construction of gravel roads and pads, pipelines and power lines, fiber optic communications lines, and waste disposal facilities. It also includes different fuel emissions equipment that are normally estimated to survive for more than 20 or 30 years. These “semi-permanent” facilities influence the local environment largely because they exist all year round for many years. Additional permits are required to regulate such impacts of these long-term development projects. Access to the project site defines the type of permits required by any project. For example, the only road system existing on the North Slope is in the established oil fields therefore, new projects require a new access route. It also depends on if it will have a gravel road, seasonal ice road, helicopter-pad or an airstrip. If the oil company decides to have an airstrip, determination of whether the airstrip be sufficient enough for 15-passenger planes in service in the oilfields (an Otter or a Casa) or larger to carry a C130 cargo plane. The type of access selected for a project decides which agencies regulate the access and which permits are required. Defining the project scope and time wisely is vital for deciding on permits required. **Figure 6** shows the Work breakdown structure (WBS) for the exploratory well and **Figure** 7 shows the WBS for the typical permitting schedule for a new field development project.

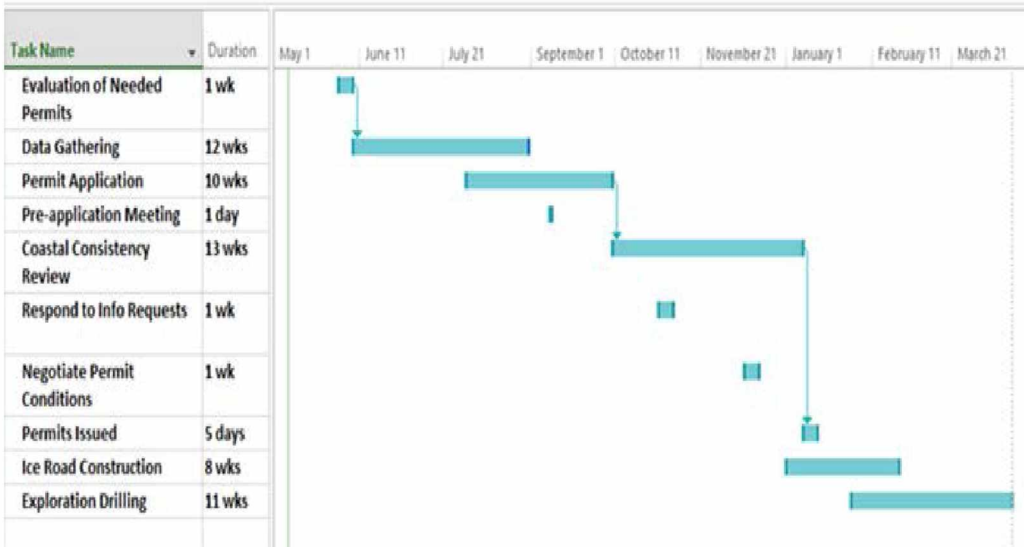


Figure 6. The Work breakdown structure (WBS) for the exploratory well (Sally Rothwell, 2002)

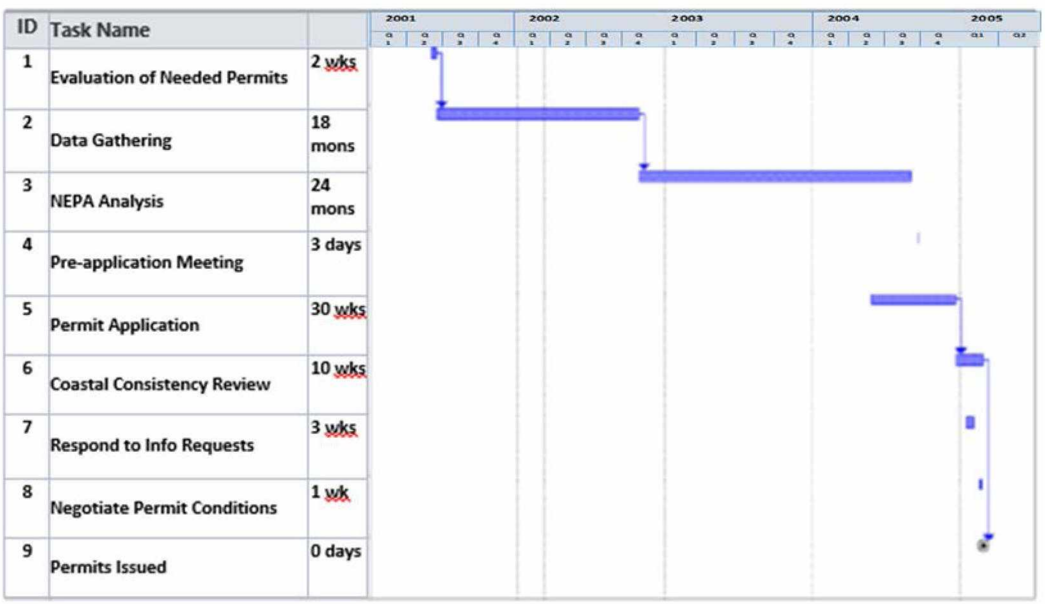


Figure 7. The WBS for the typical permitting schedule for a new field development project. (Sally Rothwell, 2002)

Certain activities that would take place at the same location in a single project may be combined together for efficiency purposes. However, if one of the activities in the "project" is contentious and its approval is uncertain because of public or agency protest, then it may hinder the project activities. This type of situation can confirm that separate permits are required. On the other hand, certain activities that would need a new permit can be carried out within an existing oil field because the field's permits allow those activities. Building an exploration ice road outside of the project unit location entails several new permits. Numerous governing agencies have jurisdictions based on land proprietorship. The North Slope region is currently active for oil and gas exploration and development, consists of a mixture of land possessed by the State of Alaska, the Bureau of Land Management (BLM), Native Corporations, and private citizens (Native allotments). Some state agency's permits are a must (e.g. air permits), irrespective of ownership and some are applicable only to projects on State of Alaska land (land use permits). The Bureau of Land Management (BLM), issues permits for projects on BLM land only. The North Slope Borough (NSB) issues permits for projects on State, BLM and Native Corporation lands but does not permit activities on Native allotments.

4.1. Stages of Oil and Gas Exploration and Production

Exploration involves the search for rock formations associated with oil or natural gas deposits, and involves geophysical prospecting and/or exploratory drilling. Well development occurs after exploration has located an economically recoverable field, and involves the construction of one or more wells from the beginning (called "spudding") to either abandonment if no hydrocarbons are found, or to well completion if hydrocarbons are found in sufficient quantities. Production is the process of extracting the hydrocarbons and separating the mixture of liquid hydrocarbons, gas, water, and solids, removing the constituents that are non-saleable, and selling the liquid hydrocarbons and gas. Production sites often handle crude oil from more than one well. Natural gas may be processed to remove impurities either in the field or at a natural gas processing plant.

The oil and gas exploration can be classified into four main processes:

(1) Exploration,

(2) Well Development,

(3) Production, and

(4) Site Abandonment.

Finally, site abandonment involves plugging the well(s) and restoring the site when a recently-drilled well lacks the potential to produce economic quantities of oil or gas, or when a production well is no longer economically viable.

4.2. Environmental Management Involved with Oil Exploration and Production

Two categories of environmental permits are available for seismic exploration. Non-Exclusive seismic permit (one type) and Exclusive geophysical agreements (three types) available for use on state-owned lands and water bottoms. With properly completed application, Non-Exclusive seismic permits are usually issued within 15 days (for one year term). "The Exclusive Geophysical Agreement (EGA) issuing process usually takes 3 to 4 months. The EGA's have a term of 18 months with an optional 6 month extension. Under an EGA, the permitee may obtain exclusive rights to acquire seismic data, nominate acreage for lease, and select acreage to be leased following seismic acquisition in the area of the EGA." (DNR, n.d.)

- Different densities of liquids
- Source Rocks, Reservoirs and Seals
- Seismic Surveys
- Echoes
- Drilling Techniques

Although there are several methods of locating oil and gas reservoirs, like surveys based on the earth's gravitational pull, magnetic field or electrical resistance; but the most significant method of locating oil and gas reservoirs is by seismic surveys. (Bowman, 2008) In this section, the discussion is carried out on seismic survey that is used to find out the location of oil and gas. One of the definite methods to discover hydrocarbons is by drilling through thousands of meters of rock and check whether oil or gas can be found. But since drilling an oil well costs tens of millions of dollars, energy companies need to use new techniques to identify where oil or gas can be found before they start drilling. Hydrocarbons are generally found in sedimentary basins that may be on land, or below the ocean. Here we use an example from Australia to illustrate the oil exploration with respect to uncertainty. Example; there are lots of sedimentary basins both onshore and offshore Australia, like the Perth basin in the southwest corner of Western Australia. Although the location of these basins are known, not all of them contain oil or gas. In order to start drilling it is required to know for sure if oil or gas might be trapped within a basin. A source rock, migration path, seal, trap and reservoir rock form a petroleum system. In modern era, the most important scientific techniques used to locate oil and gas fields are geophysical surveys, like seismic surveys along with gravity and magnetic surveys, seismic surveys and conventional geology, remote sensing techniques like aerial photography or satellite imagery from outer space to locate rock formations. For more than hundred years oil companies have been exploring oil and gas in every corner of the world, in spite of the fact that the conventional techniques cannot be used for exploring oil that is deep below the seabed. In the past, oil wells were drilled wherever some oil leaks were found. Frequently, huge folds of rocks, called ‘anticlines’ that are found on the earth’s surface, were drilled in the hope that oil or gas may be trapped in the folds down below. Nevertheless, seismic surveys are the utmost essential modern technique for detecting new oil and gas fields. The sound waves are generated by specially built trucks that thump and vibrate the ground, or ships towing ‘guns’ motorized by compressed air and are created just below the land surface or near the surface of the sea. Those waves travel

It is vital to answer questions such as:

- Is there any oil or gas present?
- In what kind of rock is the oil or gas trapped?
- How deep is the oil or gas?
- How thick is the oil or gas reservoir, and so, how much is there?
- At what pressure is the oil or gas?

through layers of rocks and bounce back in echoes and are recorded by means of arrays of special microphones, called ‘geophones’ on land, and ‘hydrophones’ at sea. A precise picture of what is under the ground or seabed is computed by geologists and geophysicists, to find out the location of oil and gas **(Figure 8)**. (Bowman, 2008)

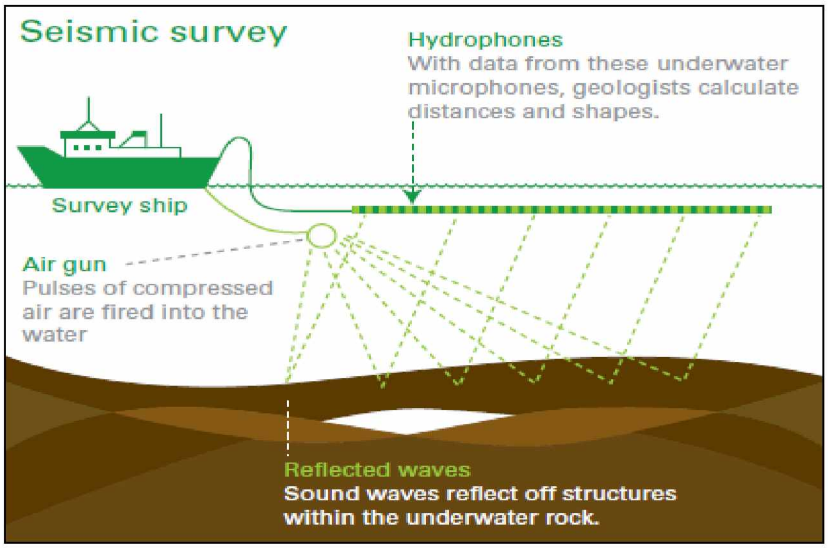


Figure 8. Seismic Survey- what is under the ground or seabed computed to find out the location of oil and gas. (Bowman, 2008)

In the next step, an exploration well is drilled to review if the area comprises any oil or gas and whether it is worth the exploration (Smith Bay is at this stage). Once confirmed, detailed seismic surveys are carried out and more wells are drilled to design the oil platforms and pipelines vital for extraction and transportation of the oil and gas to be processed.

A lot of special equipment is needed for drilling (e.g. drill pipe with drill bit at the end), designed to make drilling easier, faster and safer, and some of it is designed to take scientific measurements collecting data from in and around the hole, deep under the ground, so that the geoscientists and engineers can answer the questions listed above. Special electronic measuring devices are attached to the drill pipe or metal cables to collect physical measurements of the rock that has been drilled through, and of the oil and gas that has been found. This type of measurement is known as "logging" and the measuring devices are called "logging tools". Wrecked chips of rocks known as "cuttings" are collected at the surface when they come up the hole to the surface. Solid rock "cores" are produced by using special down-hole cutting equipment. Measurement equipment is mounted on a floating vessel while drilling at sea. Drilling ships are used in the ocean water that has depth greater than 1500m. Special water thrusters and GPS technology are used to make sure the ship stays relatively motionless while drilling. "Exploration wells" are drilled for exploring the new locations of oil and gas. Once oil has been discovered, additional wells called "appraisal wells" are drilled to collect more data on the properties of the field. Finally, if production of hydrocarbons from the field is undertaken, then "production wells" are drilled. Perforations or meshes are constructed using special tools at the bottom of such wells, letting the oil and gas out of the rocks and up the well bore to the surface. (Bowman, 2008) Well drilling, construction and completion includes a number of divergent project functions, (petroleumonline, n.d.) where each function may be carried out by a different company. Extracted oil is then transported to the

Distinctive Steps for Completion of Oil Well

- Well Planning
- Well Design
- Drilling Operations
- Formation Evaluation and Testing
- Well Completion

refinery or gas plant for processing. (Bowman, 2008) Transporting the extracted oil to the refinery or gas plant for processing and further for distribution requires proper transportation mode. In order to establish convenient transportation mode, the State of Alaska has come up with a program called **Alaska's Roads to Resources (R2R)** to improve roads to resource centers. (Longan, 2014) R2R can provide a "ground transportation" element to currently existing transportation methods. In collaboration with the state agencies, resource developers, and other interested parties, including local governments, and native corporations, R2R program designs and builds projects that support development of natural resources in the oil and gas, alternative energy, agriculture, timber, fisheries, and mining industries. R2R functions on two funding approaches, one is traditionally-funded public projects, secondly, Public-Private Partnerships (P3) to fund projects that will make enough revenue to pay off costs of planning and construction. Key program efforts identify resource development projects that need building of transportation access focus on the road access, marine, rail, and aviation related transportation improvements. R2R program works with the Department of Natural Resources in evaluating, designing, and permitting transportation improvements necessary for commercial feasibility in developing a resource. R2R program assist National Environmental Policy Act (NEPA) permitting process as either an applicant or provides a technical assistance to the permit applicant. (Longan, 2014)

4.3.Pipeline on ocean or roads?

Only one gravel road connects the North Slope to the permanent road system. There is a possibility of constructing two road routes from the Dalton Highway to Smith Bay. One route could be the state's planned "road to resources" route on the north foothills of the Brooks-range, but will require some method to connect that road and Smith Bay. The advantage is that it could further be linked directly to the Trans Alaska Pipeline.

The second alternative would be a road connecting the Kuparuk oil field to Smith Bay. The Kuparuk field connects to Prudhoe Bay by road and pipeline, and consequently, to the trans-Alaska Pipeline (**Figure 9).** Apparently, the same route could be followed by the pipeline connecting Kuparuk field and Smith Bay. **Figure 10** shows map indicating Caelus' plan to position the pipeline in water.

Pipelines carry and distribute enormous amounts of oil and gas across the world every day. Because of their very few failures, pipelines are considered as the safest means of transporting oil and gas.

Figure 9. Trans Alaska Pipeline (Gold, 2016)

The third possibility would be positioning the pipeline in water and probably, not building a road, as seen in the **Figure 10**. (Gold, 2016) In such a case transporting into the site need to be carried out via large vessels during summer and ice pads/roads during winter.

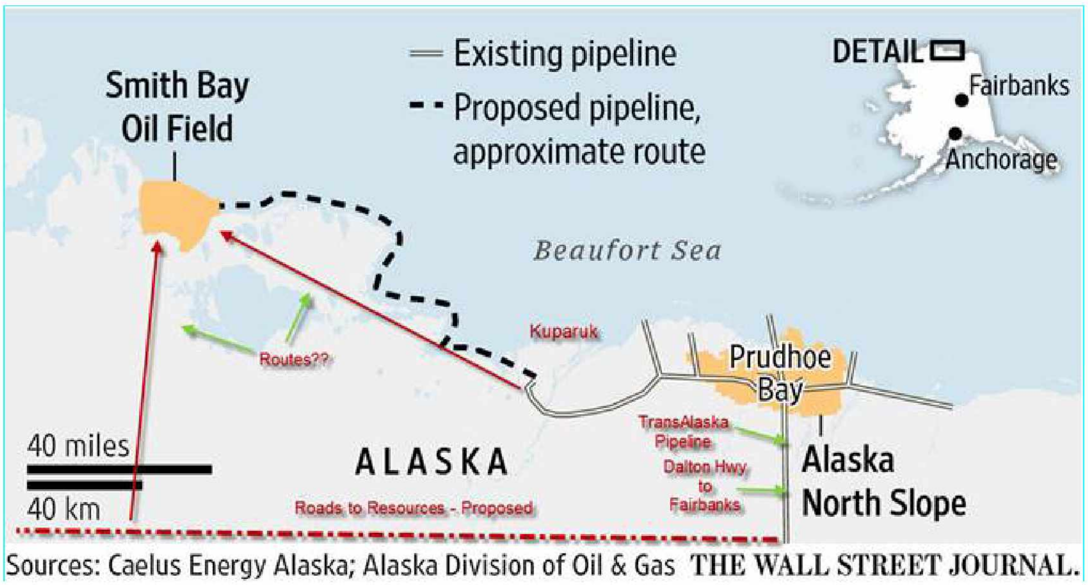


Figure 10. Map showing Caelus' plan to position the pipeline in water. (Gold, 2016) [Note: the original figure has been modified with certain additions]

Chapter-5

Smith Bay

Caelus owns 75 percent of the leases at Smith Bay. NordAq Energy Inc. holds 17.5 percent and L71 Resources holds 7.5 percent. Because the leases are in state waters, the state gets the royalty and tax benefits, and the royalty to the state for the Smith Bay leases is set at 12.5 percent. (DeMarban A. A., 2016)

Exploration Licenses - The Division of Oil and Gas issues exploration licenses to stimulate exploration of oil and gas in remote areas of the state. Each April applicants may submit proposals for licenses. At any time the Commissioner may solicit license proposals for a specific area. A license, with a term of up to 10 years, will be awarded to the applicant who has committed the most dollars to an exploration program. The license area must be between 10,000 and 500,000 acres. During its term any portion of the licensed area may be converted to oil and gas leases. (DNR S. o., 2015)

Caelus Energy Alaska made an official announcement in late 2016 that the two wells drilled by the company for exploration purpose in the Smith Bay in early 2016, when combined with the previous results of seismic surveying, have shown the existence of a substantial reserve of light oil. The oil fields in the Smith Bay are more towards the western end of the North Slope and in general, existing oil areas are roughly in the middle of the North Slope. The company has predicted the existence of 6 billion barrels of oil in its Smith Bay leases with the likelihood of 10 billion barrels or more across the complete Smith Bay area. 200,000 barrels per day of light crude oil could be delivered to the trans-Alaska pipeline system. (Bailey, 2016) If the predictions are correct, then the production level would make the new oil field more productive than ConocoPhillips' Alpine unit, which began production in 2000 and reached a production peak of 139,000 barrels in 2007. (DeMarban A. A., 2016) According to Caelus CEO Mr. Musselman in an Oct. 4 2016 statement specified, “This discovery could be really exciting for the State of Alaska. It has the size and scale to play a meaningful role in sustaining the Alaskan oil business over the next three or four decades.” (Bailey, 2016) The project chief for the U.S. Geological Survey's Energy Resources Program for Alaska, David Houseknecht, who is one of the region's leading geologists, said that “Caelus' announcement comes in a little-explored rock formation with potential to support large oil deposits.” (DeMarban A. A., 2016) The studies indicate that the field characterized by Caelus would have approximately comparable scale to the Kuparuk River field, together with the Prudhoe Bay field, has been a necessity of North Slope oil production. Caelus has also been interpreting 3-D seismic data in its 350,000-acre lease position to the east of Prudhoe Bay, and has recognized some promising oil existence predictions. Probably 500 million to 750 million barrels of oil could be extracted from that region (Bailey, 2016). Smith Bay is approximately 150 miles west of Prudhoe Bay and is well recognized for its broad hydrocarbon potential. (**Figure 11**)

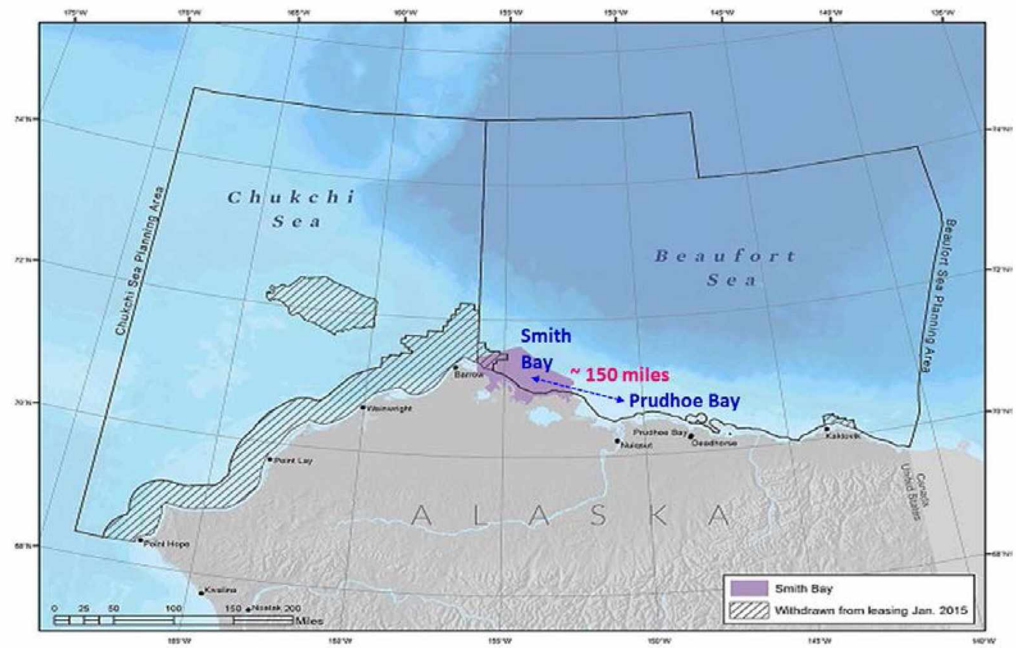


Figure 11. Distance between Smith Bay and Prudhoe Bay (MarEx, 2016) [Note: the original figure has been modified with certain additions]

A short conversation with Caelus was conducted to understand Caelus's stand point about governor's veto. According to Caelus, governor's veto of the tax credits came at the time when two wells were drilled already and Caelus was getting ready to drill an additional well. The investors hesitate to invest due to uncertainty, and there is a big ambiguity in whole planning! There are two things Caelus is focusing on currently; continued low prices of oil, and since the government is considering some more changes to the tax bills, Caelus is waiting on refunds on tax credits. Which makes it really hard for Caelus to make a decision on whether they would go back to Smith Bay right away and spend another ~$150 million! Political volatility usually puts some speedbumps in the path of oil companies. Smith bay project is currently an exploration project, at the stage of ice and snow pads. A lot of upfront capital is invested in the predevelopment work. Caelus's goal is 100% to get back to Smith Bay and drill additional well or two. Understanding commercial viability of the project takes certain efforts.

Maintaining good relations with local Alaska native corporations and different stakeholder groups is vital to oil companies.

5.1. Uncertainties and unknowns

Numerous challenges are faced by oil companies while pursuing oil and natural gas exploration. First, major oil spills cause a great environmental impact. Second, iceberg movements (for offshore drilling) need to be tracked for the safety of oil drilling process, but due to insufficient geological maps, patchy communication systems and polar icecap melting, it may become uncertain and unpredictable to forecast the location. Third, shortage of transportation infrastructure to transfer oil from drilling sites to processing plants becomes challenging. (Roy & Hullavarad, 2015) Finally, extreme climatic conditions and long distances put forth challenges in various areas.

The Smith Bay oil field was discovered in an ancient undersea fan structure with an area more than 300 square miles in Smith Bay area. Apparently the discovery sits at a subsurface depth of some 5,000 feet in the Torok, a rock formation that lies below the Nanushuk formation in the Brookian sequence, the youngest and shallowest rock sequence within the Arctic Alaska petroleum systems. The Nanushuk is the focus of a major oil discovery being pursued by Armstrong Energy and Repsol in the Pikka unit, on the east side of the Colville River delta.

(Bailey, 2016) The uncertainty in the state tax system due to the low oil prices made Caelus change their decision of drilling the third well and to drill a horizontal lateral from that well to frack and flow test the oil during winter of 2016-17. (Bailey, 2016) According to Caelus officials, an extension of pipeline from the field would need to be more than 125 miles before it could be tied into existing oil field set-up, and a processing center to be built in the Smith Bay area to prepare crude oil for delivery. If the project is developed, it could take up to 5 to 10 years before oil flow begins, with permitting requirements, restricted seasonal work and other challenges. (DeMarban A. A., 2016)

Royal Dutch Shell decided to abandon efforts to drill in the Chukchi Sea, off the coast of Alaska because Shell's earlier efforts to drill in the Chukchi Sea ended critically, due to damaged vessels, malfunctioning safety equipment, and an on-board fire**.** Particularly, in January 2013 Shell lost control of its drilling rig while towing it from Alaska to Seattle for maintenance. The rig was stranded on a primeval island in the Gulf of Alaska. (Global, 2015) Due to these reasons, in 2015, the US Department of the Interior declared that two planned Arctic offshore lease sales will be canceled, that were under the US government's current five-year plan for 2012-2017. This decision was made due to Shell's failed Arctic operation and current market conditions, which left the last Gulf of Mexico lease sale a commercial disappointment. (Leon, 2015)

In 1990, ARCO Alaska – predecessor of ConocoPhillips –announced a 1 billion barrel oil discovery called Kuvlum, offshore from the Arctic National Wildlife Refuge. That was never developed because when they drilled two more wells, they did not find the reservoir what it was expected to be, based on the first well. (DeMarban A. A., 2016)

Another important factor to be considered is a fact that crude oil affects the world economy, and oil price fluctuations have enormous effects on development, and economic growth throughout the world. Volatility of oil prices affects the overall world economy. International Energy Agency (IEA) provides the annual time series database on crude oil. **Figure 12** shows the total annual average crude oil imports from 1976 to 2016.

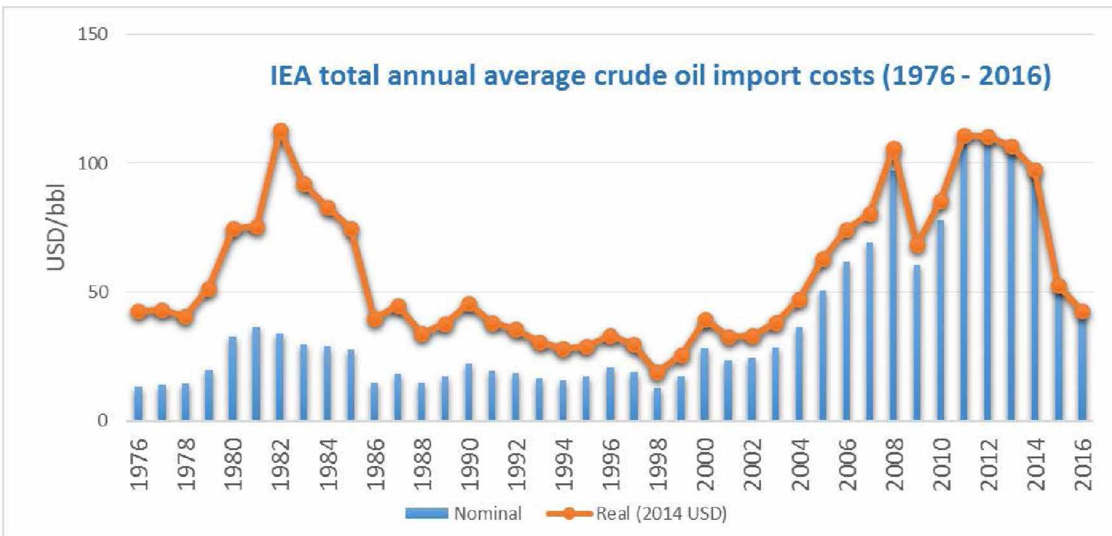


Figure 12. Long-term IEA total annual average crude oil import costs (IEA, 2017)

The graph indicates that costs of oil fell by nearly 60% in nominal terms between 2014 and 2016, a drop of around $65 per barrel. After a sharp drop of $48 between 2014 and 2015, import costs reduced their descent between 2015 and 2016. (IEA, 2017) Fluctuation in oil prices occur because of changes in supply and demand, but investors face the challenges of multiple interconnected factors. These include climatic conditions, interruptions in oil supply due to worker strikes or spills, or larger demands for instance the development of renewable energy. Geopolitical risks, such as potential acceleration of conflict in the Middle East or even election results of oil exporting countries can affect the oil prices. (Equities, 2017)

Many uncertainties faced by the mining projects will be discussed in the next chapter.

Chapter-6

Mine Projects in Alaska

In this chapter the uncertainties and unknowns related to mining are discussed with relevant examples. The exploration Incentive Credit Program was established in the State of Alaska to encourage new mineral exploration activities. Permitted expenses from certain mineral exploration activities serve as credits which can be applied against future state mining license tax, corporate income tax and state production royalty owed from mine production resulting from exploration efforts. The program is authorized under AS 27.30.010-27.30.99. ((Hoffbeck, 2015) A map of Mining activity in Alaska (Enos, 2015) is seen in **Figure 13.**

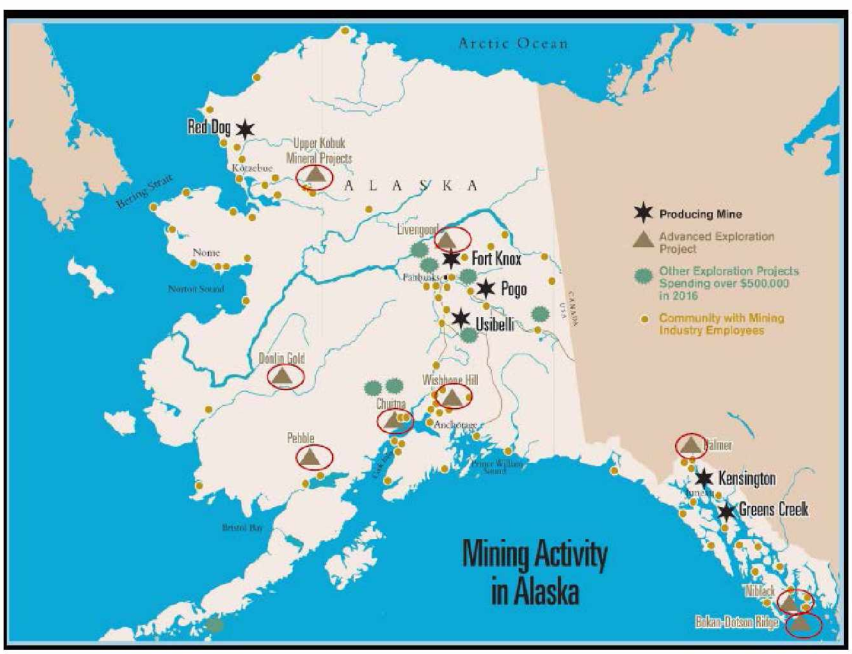


Figure 13. Mining activity in Alaska (Enos, 2015)

Economic impact on the mining process include unforeseen delays in permitting process reduce a typical mining project's value by more than one-third. The higher costs and increased risk occurring due to lengthy permitting process can cut the anticipated value of a mine in half before the production begins. The combined impact of unforeseen, and open-ended, delays and higher costs and risks can lead to mining projects becoming financially unrealistic. (Enos, 2015) (Agency, September 2003)

TABLE 7 AVERAGE TIMEFRAME FOR NEPA PROCESS FOR PLANS OF OPERATIONS IN THE U.S.

Stage	Time Frame
Data collection and analysis	
Project development and prefeasibility screening	Multiple years
EIS pre-scoping	
State/Federal consultation	6-8 months
EIS scoping documents	
Public notice and review	2-3 months
Final scoping decision	45 days
EIS preparation notice	
Draft EIS presentation	12-24 months
Draft EIS public notice and review	45-90 days
Draft EIS revisions	8-12 months
Final EIS public notice and review	30 days
Final EIS and RoD	
State permits can be issued	
Federal permits can be issued	
30 days	
30-60 days	

In the U.S., multiple permits are required from numerous agencies, and the involvement of other stakeholders, including local indigenous groups, the general public and nongovernmental organizations. As a result of the country's disorganized permitting system, it takes on average 7 to 10 years (Fellows, n.d.) to secure the permits required to initiate operations in the U.S. The average permitting period is two years for Canada and Australia, countries that have similar strict environmental regulations. There is a clearly outlined timeline for the government to respond in these countries. Mining projects usually have a lifetime of several decades from exploration to closure and site remediation. Economic factors determine whether the project continues or not, although geology and topography predict a location of deposit and how it is mined. Sometimes even a large high-grade deposit may stay unmined based on the revenue-cost balance and timetable being disadvantageous. (Fellows, n.d.) The permitting process can become extremely long or unpredictable, and can lead to unpredicted incremental costs, causing a serious impact on the economic feasibility of a project. A flowchart of mining project is seen in **Figure 14**. (Fellows, n.d.) Whereas, development Timeline of Mining Projects in Alaska is seen in **Figure 15**, (Enos, 2015) and Timeline - Completion of Mining Projects in Alaska (Enos, 2015) is seen in **Figure 16**.

> "As a consequence of the country's inefficient permitting system, it takes on average seven to 10 years to secure the permits needed to commence operations in the U.S." (Enos, 2015)

The Pebble Mine has become a profoundly argumentative issue in Alaska, chiefly due to the environmentally destructive potential of the project (Valentine, 2014). The project is located on state land in the Bristol Bay Region of southwest Alaska, approximately 17 miles northwest of the community of Iliamna. The mine is projected for a copper, gold, and molybdenum sulfide deposit, which would be one of the biggest in the world, located on Alaska's Bristol Bay. But the region is well-known for its wild salmon populations: "Bristol Bay is home to the world's largest sockeye salmon fishery, and chum silver and king salmon also run through the area." Due to this reason, the Environmental Protection Agency has opted to protect Bristol Bay, instead of allowing mining to take place there. (Valentine, 2014) **Figure 17** shows the map of choosing

Salmon over Gold. (Warrick, 2015) The project is currently on hold as the Pebble Limited Partnership (PLP) reviews its options for advancing the project further. (State of Alaska, 2017)

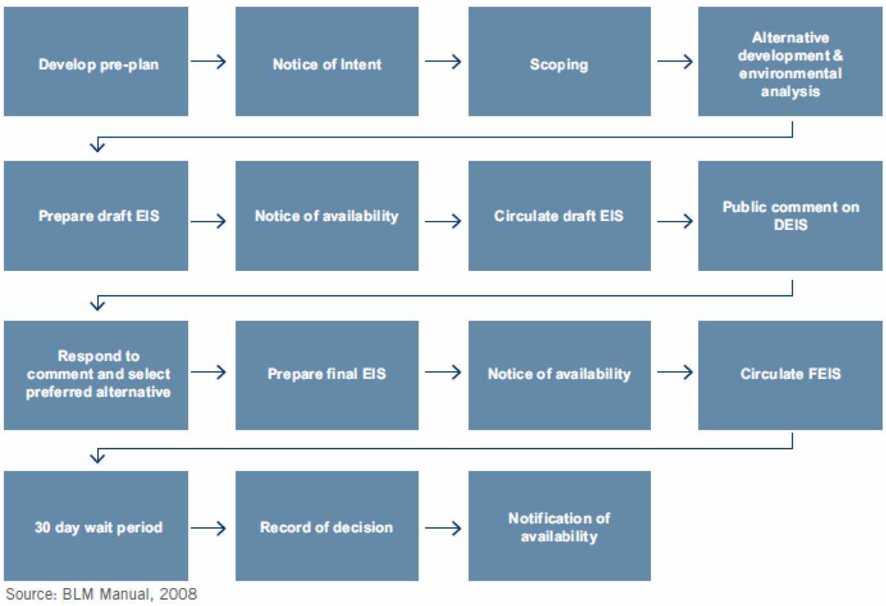


Figure 14. Flowchart of mining project (Fellows, n.d.)

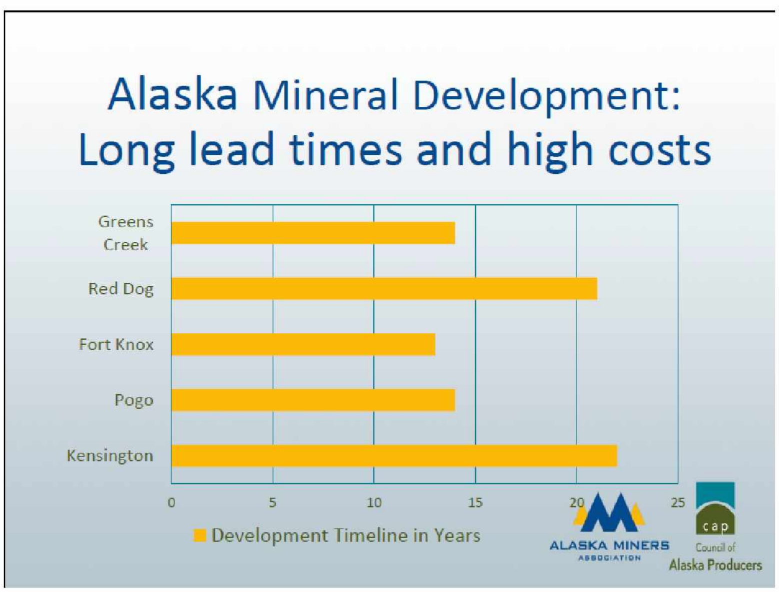


Figure 15. Development Timeline of Mining Projects in Alaska (Enos, 2015)

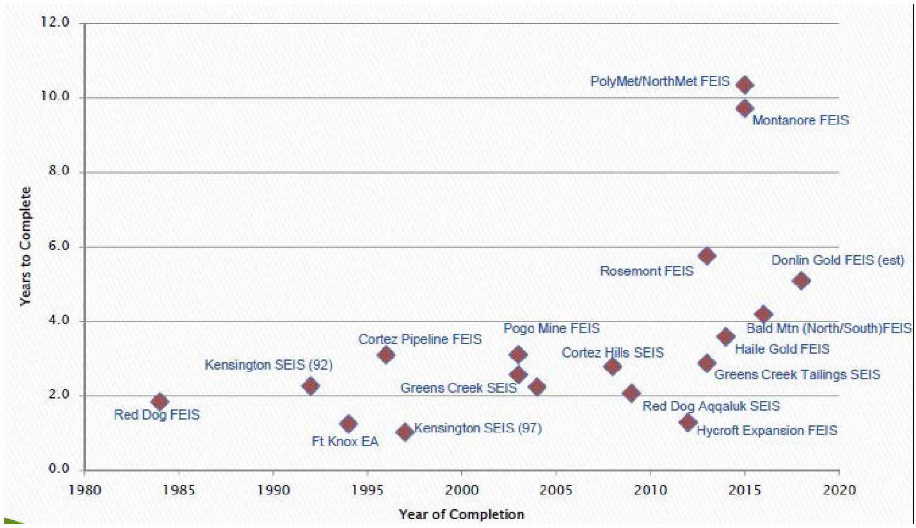


Figure 16. Timeline - Completion of Mining Projects in Alaska (Enos, 2015)

Figure 17. Choosing Salmon over Gold (Warrick, 2015)

Conclusions

Alaska has a wealth of natural resources that are unexplored. Although this report has focused on the uncertainties and impediments related to a feasibility study of oil exploration and the significant impact on the state oil revenues, there is a scope for further studies on different oil companies. The background to estimate how long it will be before money gets to the state and examined uncertainties and impediments that affect the oil companies to reach from discovery to distribution of oil. The State of Alaska has established a reliable tax credit systems over the years that attract oil companies to Alaska. The revenue generation is directly related to tax credit systems. Tax credits are vital for Alaska's stable and predictable tax policy that encourages investment which positively impacts production. Oil prices fluctuate because of changes in supply and demand. Investors face challenges of overcoming multiple interconnected factors. Certain climatic conditions like disruptions in oil supply related to worker strikes or spills, and geopolitical risks affect the oil prices.

The unforeseen impediments/uncertainties like political volatility, oppositions by environmental agencies, climatic conditions, and lack of existence of oil at the desired location and so on, either challenge the oil companies to reconsider their decisions on explorations and drilling, or delay the project. The uncertainty in the state tax system due to the low oil prices made Caelus change their decision of drilling the third well and halt it for a few years. According to Caelus, they are hopeful to get back to the project in next five years. Various environmental permits required including those for seismic exploration were discussed. After understanding the concept development during the feasibility phase, different environmental permitting requirements, stages of oil-gas exploration and the uncertainties & unknown, we have reached a conclusion that the average time taken to secure the (required) permits to initiate oil and gas operations in the United States is about 5-10 years. Thus, a new oil field development project does not start generating revenue for more than a decade.

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APPENDIX-1

Statistical Studies of the U.S. Oil Fields' Exploration

1. Introduction

Here, studies were carried out on oil fields data throughout the US and Alaska. Data is taken from two different sources. The discrete variable data for Offshore Federal Digital Well Log, North Slope Well Log, and other Digital Well Log are taken from the Alaska Oil and Gas Conservation Commission website. The Alaska Oil and Gas Conservation Commission is an independent, quasi-judicial agency of the State of Alaska that oversees oil and gas drilling, development and production, reservoir depletion and metering operations on all lands. The available information is mainly from pre-1986 exploratory wells along with selected younger exploratory wells. (Alaska Oil and Gas Conservation Commission, 2014)

Whereas, the continuous data for US tight Oil production data is taken From the U.S. Energy Information Administration that provides free and open data by making it available through an Application Programming Interface (API) and open data tools. (EIA, n.d.) It is an estimated monthly production derived from state administrative data which is a retrospective study that uses samples of the historical process data from January 1st, 2000 to January 1st 2017. This data is selected to cover all possible states through U.S., states of interest for our studies. We have selected total of seven categories of oil fields data. The remaining overlapping data from the same state is not considered since we are trying to generate an overview of oil distribution and not a focus on any specific state.

Sample size of three discrete observational sample specimens; Offshore Federal Digital Well Log consisting of 48 data points, North Slope Well Log consisting of 51 data points, and other Digital Well Log consisting of 65 data points are selected. Seven random sample out of 15 continuous specimens with 205 data points are selected for this study. The data is an observational study because it is observing the process during a certain period, hence, it cannot be considered as a random sample. The continuous data can be considered as an enumerative study because there is a known population of data from which the sample was drawn. (Montgomery)

A full factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factors. Since this data does not have many factors associated with it, we cannot call it as a factorial experiment design.

The North Slope Digital Well Log Files – Start Depth and Stop Depth are selected and considered as the discrete variable data to construct a dot diagram. A dot diagram of Start Depth of oil wells at the North Slope are seen in Figure 2a.1. Dot diagram gives us the information on the location or the middle, and the scatter or variability. We see two outliers, i.e. Observations that differ considerably from the main body of the data and a few clusters (observed as- opaque, and non-clusters as transparent). Mean is at 993.41176 and variance at 5912080.6.
A dot diagram of Stop Depth of oil wells at the North Slope are seen in Figure 2a.2. Dot diagram gives us the information on the location or the middle, and the scatter or variability. We see two outliers, i.e. Observations that differ considerably from the main body of the data, and a few clusters (observed as –opaque, or non-clusters as transparent). Mean is at 6859.902 and variance at 17041422.

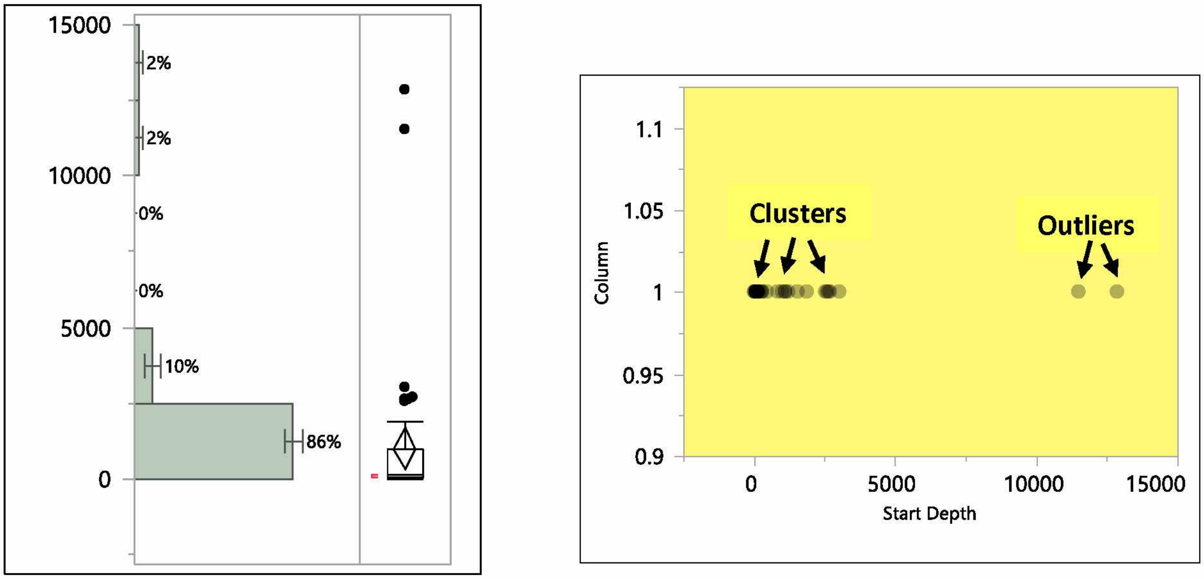


Figure 2a.1. The North Slope Digital Well Log Files

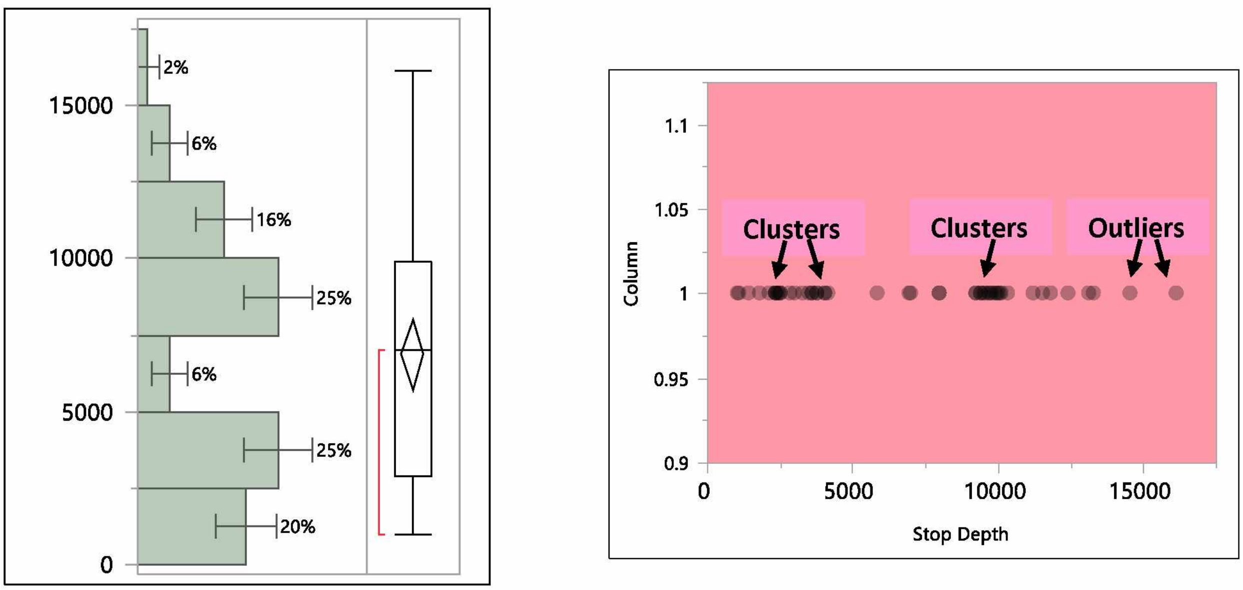
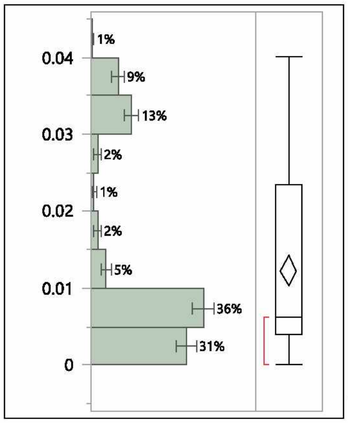


Figure 2a.2. - Bivariate Fit of Column 3 By Stop Depth

Stem and Leaf diagram gives an informative visual display of Marcellus (PA,WV,OH &NY) for constructing Stem and Leaf diagram with N = 184 and missing values = 21 out of 205 as seen in Figure 2b.1

Figure 2b.1 Distributions
Marcellus (PA,WV,OH &NY) **Stem and Leaf**

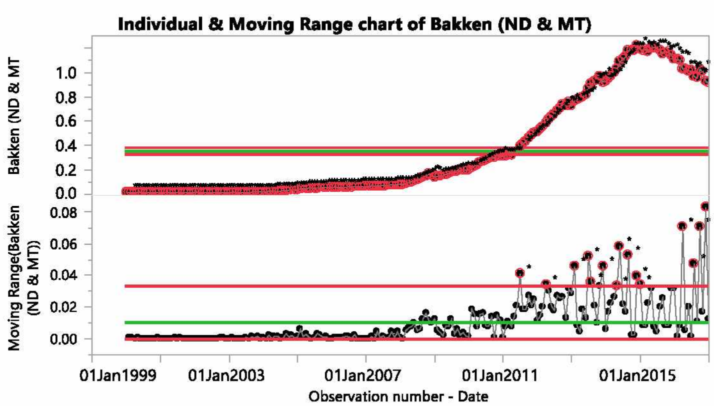


Stem	Leaf	Count
4	0	1
3	5555566666677899999	19
3	001111111223334444444	21
2	7899	4
2	34	2
1	7889	4
1	00001111224	11
0	555555555555555555555555566666666666666777777777777777778888899999999	69
0	00000000000000000000000000000000000000334444444444444	53

0|0 represents 0.000

The Graph shows Control chart of Bakken (ND & MT) A control chart (Figure 2c.1) is an irreplaceable method to examine the variability in time-oriented data. The center line on the control chart is just the average of the US oil production data mmbbl per day at Bakken (that exists in two states ND & MT). The upper control limit UCL = 0.383829 and lower control limit = 0.329435 are a pair of statistically derived limits that reflect the inherent, or natural, variability in the process.

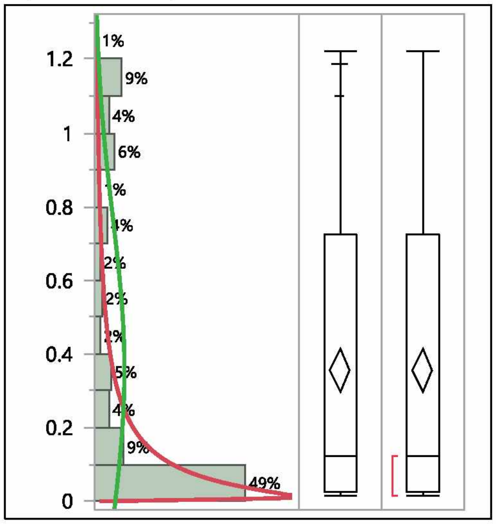
Figure 2c.1 Control Chart



Bakken (ND & MT) Limit Summaries

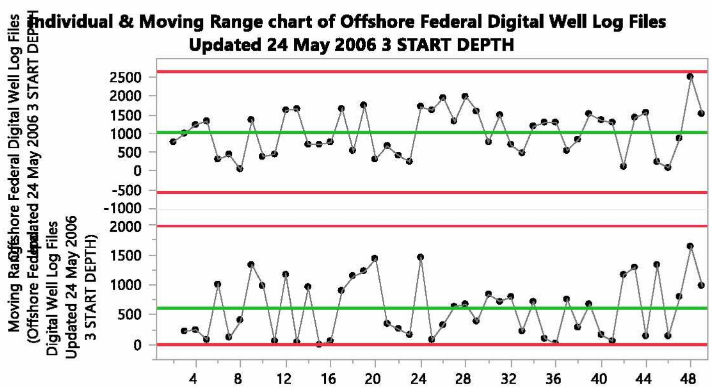
Points plotted	LCL	Avg	UCL	Limits Sigma	Sample Size
Individual	0.329435	0.356632	0.383829	Moving Rang	1
Moving Rang	0	0.01023	0.033415	Moving Rang	1

Bakken (ND & MT)

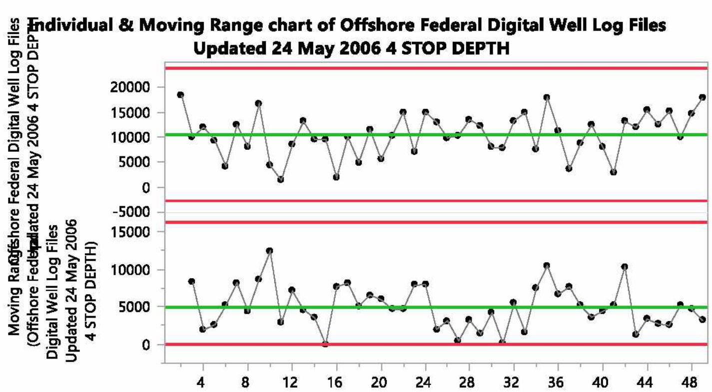


Bakken (ND & MT) shows skewed data. In order to check the difference compared to normally distributed data, control charts were constructed for the discrete variable data of Offshore WellLogs Digital Start Depth and Stop Depth data, Figure 2c.1

Figure 2c.1 Control Charts for discrete variable



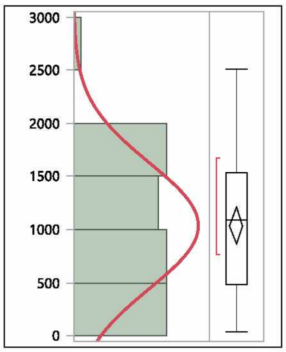
Offshore Federal Digital Well Log Files Updated 24 May 2006 3 START DEPTH Limit Summaries					
Points plotted	LCL	Avg	UCL	Limits Sigma	Sample Size
Individual	-574.545	1037.125	2648.795	Moving Rang	.
Moving Rang	0	606.1915	1980.144	Moving Rang	.



Offshore Federal Digital Well Log Files Updated 24 May 2006 4 STOP DEPTH Limit Summaries					
Points plotted	LCL	Avg	UCL	Limits Sigma	Sample Size
Individual	-2748.87	10506.13	23761.12	Moving Rang	.
Moving Rang	0	4985.553	16285.47	Moving Rang	.

Distributions

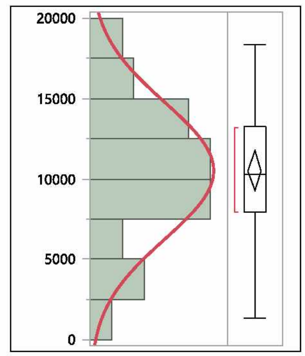
Offshore Federal Digital Well Log Files Updated 24 May 2006 3 START DEPTH



Quantiles

100%	maximum	2514
75%	quartile	1533.75
50%	median	1093
25%	quartile	489.25
0%	minimum	34

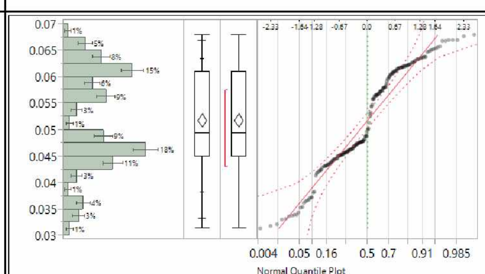
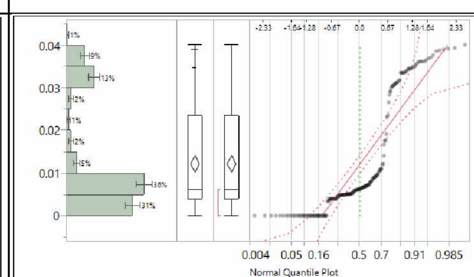
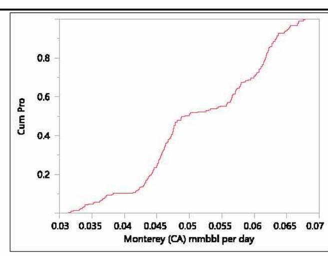
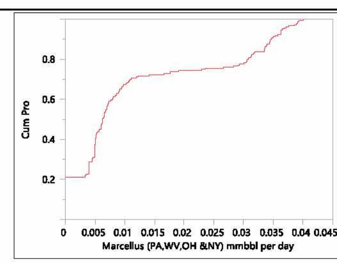
Offshore Federal Digital Well Log Files Updated 24 May 2006 4 STOP DEPTH



Quantiles

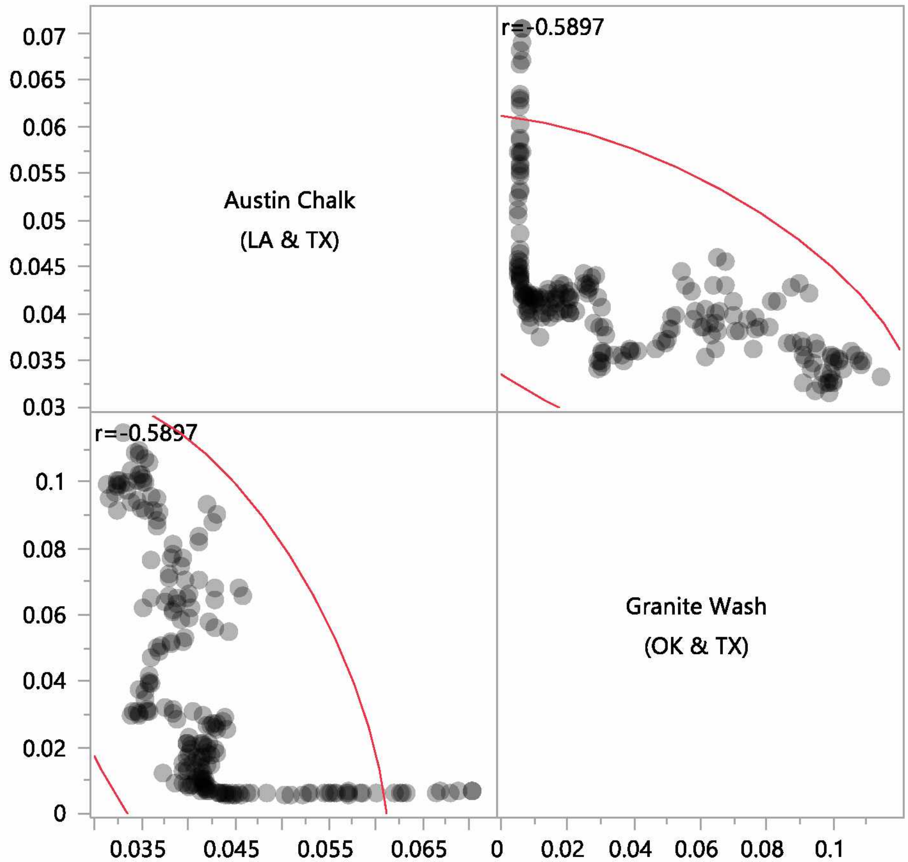
100%	maximum	18354
75%	quartile	13243.3
50%	median	10291.5
25%	quartile	7943
0%	minimum	1375

Two continuous variables selected here are Monterey (CA) and Marcellus (PA,WV,OH &NY).

#	Variables - → Parameters	Monterey (CA)	Marcellus (PA,WV,OH &NY)
i.	Minimum	0.03139	1e-6
ii.	Maximum	0.06784	0.04003
iii.	Number of observations and	205	184
	missing values	0	21
iv.	Mean	0.0517784	0.0123007
v.	Variance	0.0000899	0.0001725
vi.	First, second, and third quartiles with a corresponding box and whisker plot	75% quartile 0.061 50% median 0.04927 25% quartile 0.04505	75% quartile 0.02349 50% median 0.00627 25% quartile 0.004
vii.	Probability density function plot		
viii.	Continuous distribution function plot		

My hypothesis is that the oil data from same state will probably show positive correlation. Two variables that I expected to have a correlation are the continuous data from the state of Texas; Austin Chalk (LA, TX) and Granite Wash (OK, TX) that might have some overlap. Scatter diagram with box plots is as seen below.

In general, the strength of a linear relationship between two variables, y and x can be described by the sample correlation coefficient *r*. Positive relationship (*r* is near +1) is seen if large values of y occur together with large values of x and small values of y occur with small values of x. Negative relationship (*r* is near -1) is seen if large values of y occur together with small values of x and small values of y occur with large values of x.

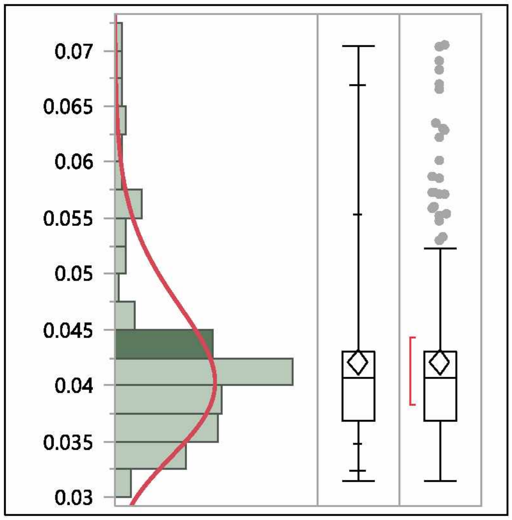


Multivariate Correlations		
	Austin Chalk (LA & TX)	**Granite Wash (OK & TX)**
Austin Chalk (LA & TX)	1.0000	-0.5897
Granite Wash (OK & TX)	-0.5897	1.0000

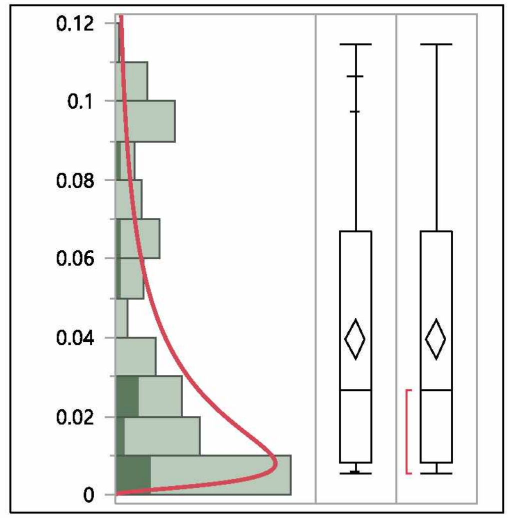
The correlation coefficient does not support my hypothesis about positive correlation. The correlation coefficient observed shows the Negative relationship, r = - 0.5897 (i.e. *r* is near -1) (which is seen if large values of y occur together with small values of x and small values of y occur with large values of x).

The correlation between two variables Granite Wash (OK & TX) and Austin Chalk (LA & TX), r = -0.5897 is MODERATE because it does not satisfy the conditions for STRONG (when $0.8 \leq r \leq 1$) or WEAK (when $0 \leq r \leq 0.5$) correlation.

Austin Chalk (LA & TX)



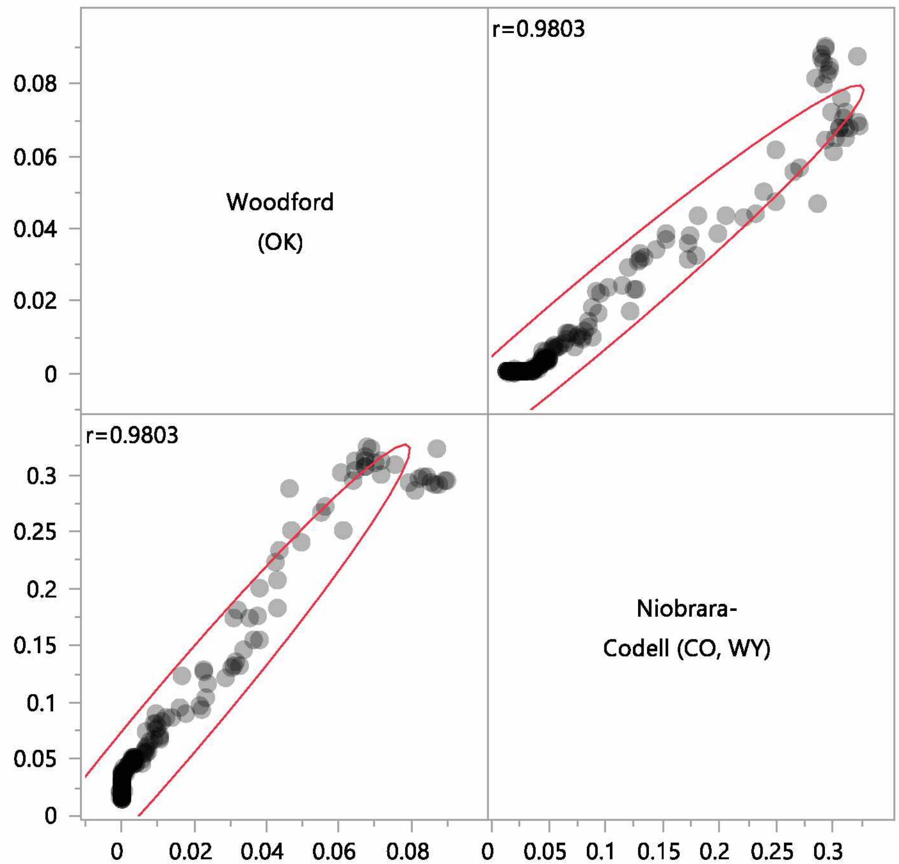
Granite Wash (OK & TX)



My hypothesis in this case is that the oil data from two different states will not have any kind of correlation.

Two variables that I selected for this study are the continuous data from the state of Oklahoma; Woodford (OK) and data that falls in two states of Colorado and Wyoming; Niobrara Codell (CO & WY). Scatter diagram with box plots is as seen below.

In general, the strength of a linear relationship between two variables, y and x can be described by the sample correlation coefficient *r*. Positive relationship (*r* is near +1) is seen if large values of y occur together with large values of x and small values of y occur with small values of x. Negative relationship (*r* is near -1) is seen if large values of y occur together with small values of x and small values of y occur with large values of x.



Multivariate Correlations

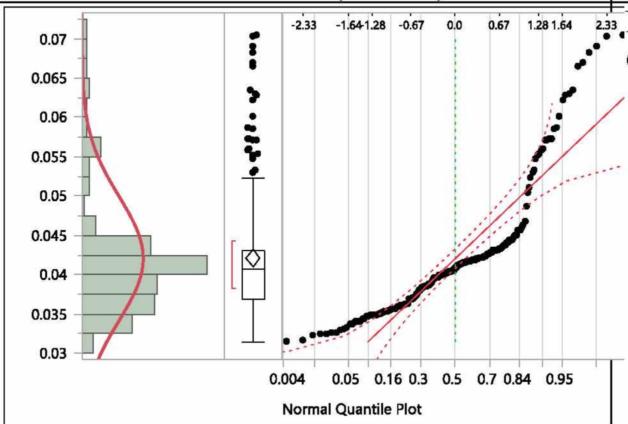
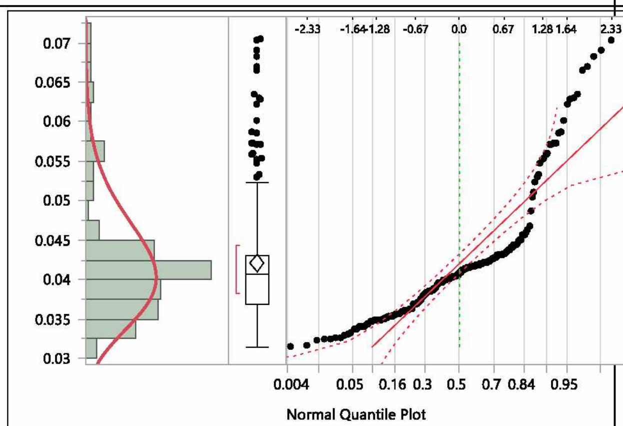
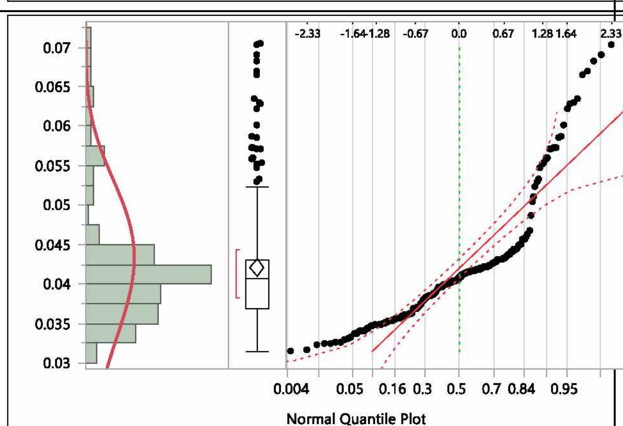
	Woodford (OK)	Niobrara-Codell (CO, WY)
Woodford (OK)	1.0000	0.9803
Niobrara-Codell (CO, WY)	0.9803	1.0000

The correlation coefficient does not support my hypothesis that is the oil data from two different states will not have any kind of correlation.

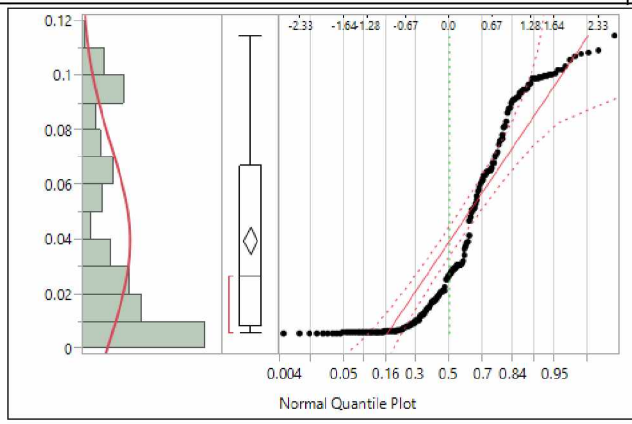
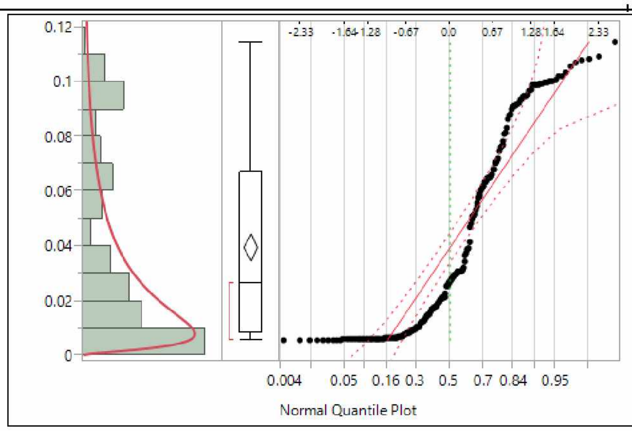
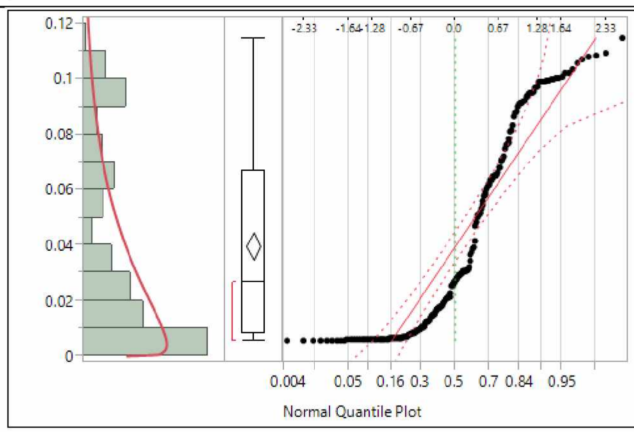
The correlation coefficient observed shows the positive relationship r = 0.9803 (i.e. *r* is near +1) (which is seen if large values of y occur together with large values of x and small values of y occur with small values of x.)

The correlation between two variables Woodford (OK) and Niobrara Codell (CO & WY). r= 0.9803 shows that the correlation between two variables is STRONG because the correlation between two variables is STRONG when $0.8 \leq r \leq 1$.

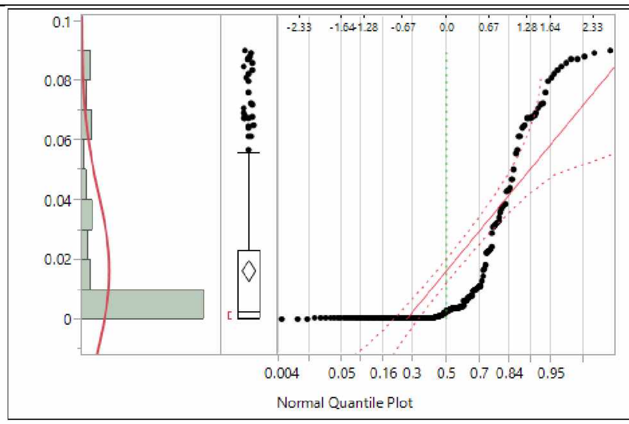
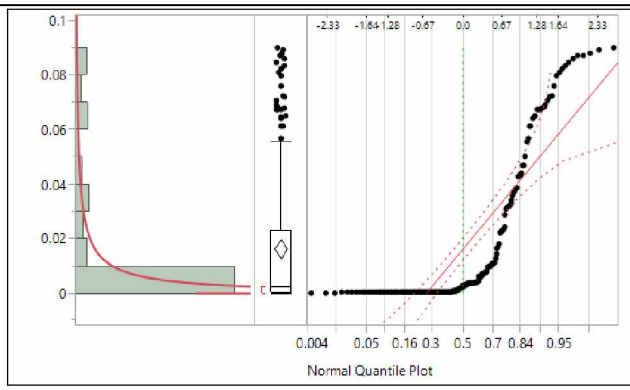
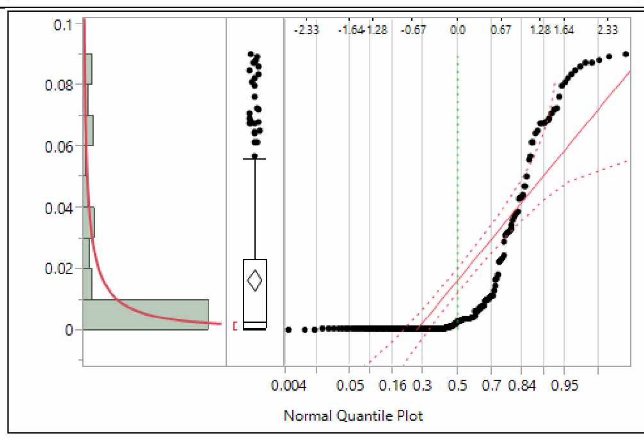
A normal quantile plot for the four variables

Probability plot	Austin chalk (la & tx)		
Normal		Normal(0.0420 6,0.00788)	-2log(likelihood) = -1404.7842737 7257
Lognormal		Lognormal(-3.1837,0.16764)	-2log(likelihood) = -1455.7832421 2279
Weibull		Weibull(0.0454 5,4.84054)	-2log(likelihood) = -1358.3102848 4916

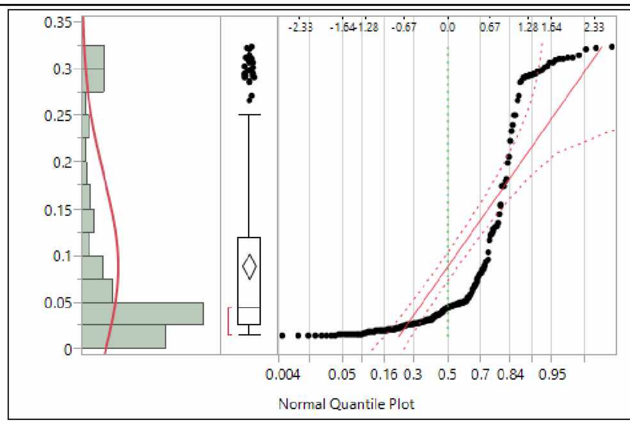
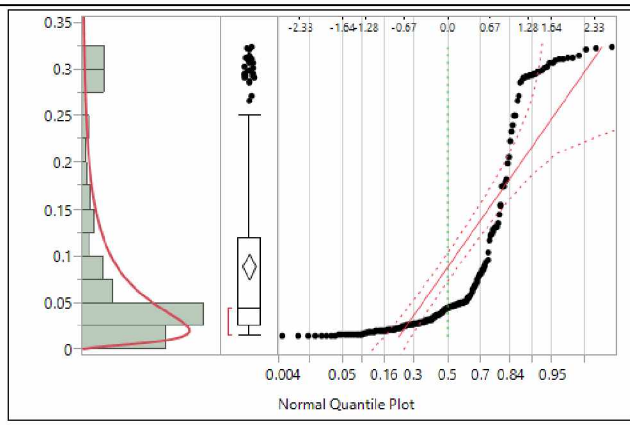
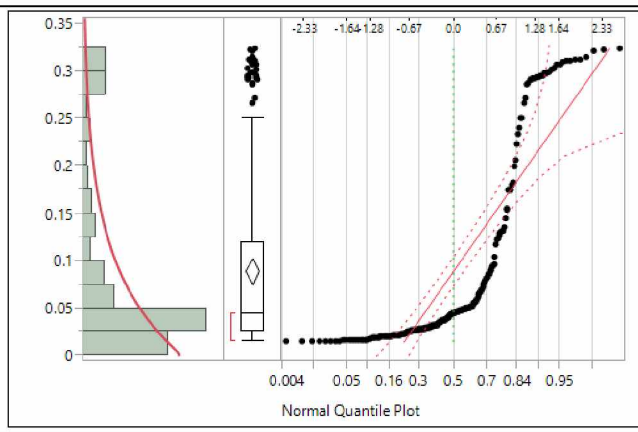
Three probability density model – normal, lognormal, or Weibull –were used, the most suitable fit to the data is seen to be lognormal compared to normal and Weibull, giving the best suitable fit. Austin Chalk (LA & TX), the continuous variable, is likely to follow Lognormal distribution as observed from the fitted plots.

Probability Plot	Granite Wash (OK & TX)		
Normal		Normal(0.03955,0.03468)	-2log(likelihood) = -797.462988552849
Lognormal		Lognormal(-3.7173,1.0548)	-2log(likelihood) = -920.455078981226
Weibull		Weibull(0.04092,1.09157)	-2log(likelihood) = -916.779046508646

Three probability density model – normal, lognormal, or Weibull –were used, the most suitable fit to the data is seen to be lognormal compared to normal and Weibull, giving the best suitable fit. Granite Wash (OK & TX), the continuous variable, is likely to follow Lognormal distribution as observed from the fitted plots.

Probability plot	Woodford (ok)		
Normal		Normal(0.01634,0.02586)	-2log(likelihood) = -917.823387996596
Lognormal		Lognormal(-5.8639,2.07099)	-2log(likelihood) = -1523.93916217642
Weibull		Weibull(0.00822,0.50552)	--2log(likelihood) = -1494.32979512741

Three probability density model – normal, lognormal, or Weibull –were used, the most suitable fit to the data is seen to be lognormal compared to normal and Weibull, giving the best suitable fit. Woodford (OK), the continuous variable, is likely to follow Lognormal distribution as observed from the fitted plots.

Probability Plot	Niobrara-Codell (CO, WY)		
Normal		Normal(0.08881,0.09717)	-2log(Likelihood) = -375.080853714017
Lognormal		Lognormal(-2.9298,0.97066)	-2log(Likelihood) = -631.665291485468
Weibull		Weibull(0.08894,1.00297)	-2log(Likelihood) = -582.730976605623

Three probability density model – normal, lognormal, or Weibull –were used, the most suitable fit to the data is seen to be lognormal compared to normal and Weibull, giving the best suitable fit. Niobrara-Codell (CO, WY) the continuous variable, is likely to follow Lognormal distribution as observed from the fitted plots.

7. Conclusions

The study conducted in this report consists of the discrete variable data for Offshore Federal Digital Well Log, North Slope Well Log, and other Digital Well Log that are taken from the Alaska Oil and Gas Conservation Commission website and the continuous data for US tight Oil production data is taken From the U.S. Energy Information Administration.

The North Slope Digital Well Log Files – Start Depth and Stop Depth are selected and considered as the discrete variable data to construct a dot diagram. The data selected for constructing Stem and Leaf diagram is a continuous variable Marcellus (PA,WV,OH &NY). The variable selected for constructing control chart is a continuous variable Bakken (ND & MT).

Continuous Variable Analysis was carried out on Monterey (CA) and Marcellus (PA,WV,OH &NY) and Discrete Variable Analysis on Offshore Federal Digital Well Log Files and Other Digital Well Log Files. Multivariate Analysis on two variables that I expected to have a correlation (+ or -) Austin Chalk (LA, TX) and Granite Wash (OK, TX) showed MODERATE correlation with $r = -0.5897$ because it does not satisfy the conditions for STRONG (when $0.8 \leq r \leq 1$) or WEAK (when $0 \leq r \leq 0.5$) correlation. Two variables that I did not expect to have any correlation Woodford (OK) and Niobrara-Codell (CO, WY) with $r= 0.9803$ shows that the correlation between two variables is STRONG because the correlation between two variables is STRONG when $0.8 \leq r \leq 1$.

Finally, the continuous data for US tight Oil data production taken From the U.S. Energy Information Administration is selected as a valid data and 10% randomly selected data was used for hypothesis testing.

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Statistical Studies on Alaska Oil & Gas Revenue

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04/25/2017

UNIVERSITY OF ALASKA FAIRBANKS

Index

Part A

Paired difference comparison between mean Prevailing Values (PV) for North Slope and Cook Inlet -Gas data

PV Data obtained from the Alaska Department of Revenue, State of Alaska website

Part B

Correlation between different data

1] ANOVA - Analysis of Variance

Total Royalty Value ($) by Year for North Slope and Cook Inlet - Oil data

2] Regression Model

Total Royalty Value ($) by Volume (bbl) for North Slope and Cook Inlet - Oil data

Total Royalty data obtained from the Alaska Department of Natural Resources website

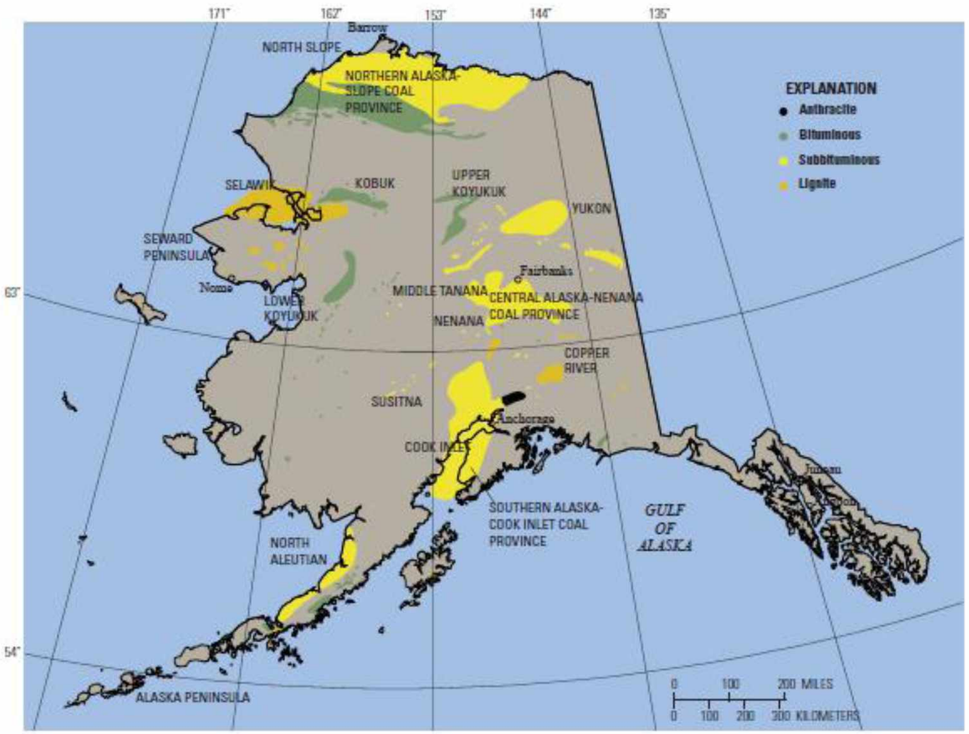
Part A

Paired differences comparison between mean Prevailing Values (PV) for North Slope and Cook Inlet -Gas data

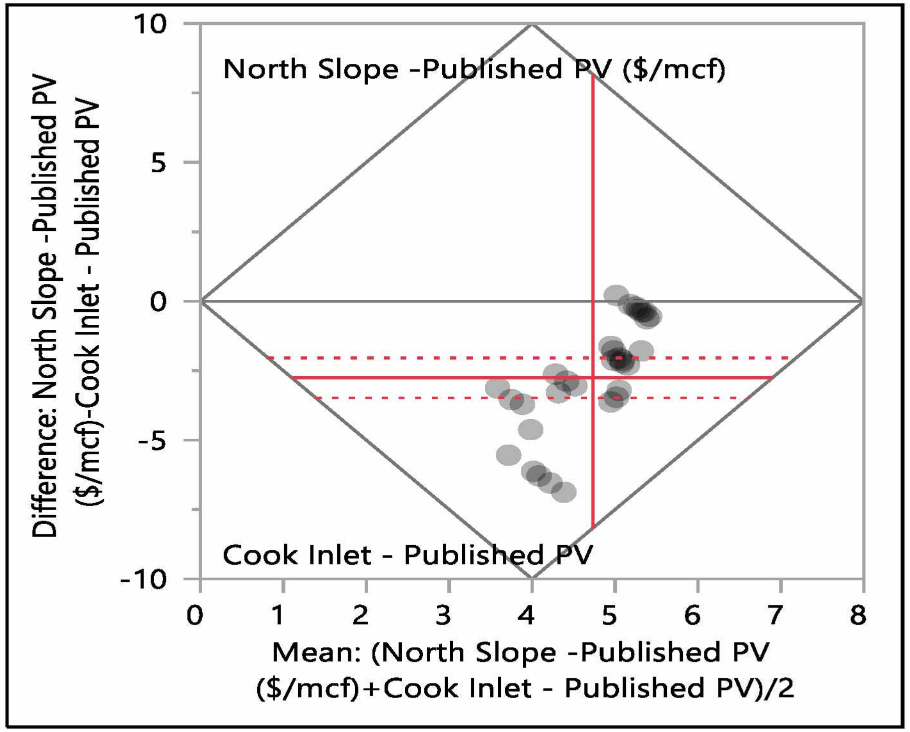
Hypothesis

Null - Mean PV for North Slope and Cook Inlet - Gas data are **equal**

Alternate - Mean PV for North Slope and Cook Inlet - Gas data are **different**



Results



Test Statistics

$t_0 = 7.8044$ and $t_{0.025, 31} = 2.042$

the *P*-value, $P = 0.0001 < \alpha = 0.05$

Reject H_0

Conclusion

The difference in mean PV between North Slope and Cook Inlet -Gas data is not equal to zero

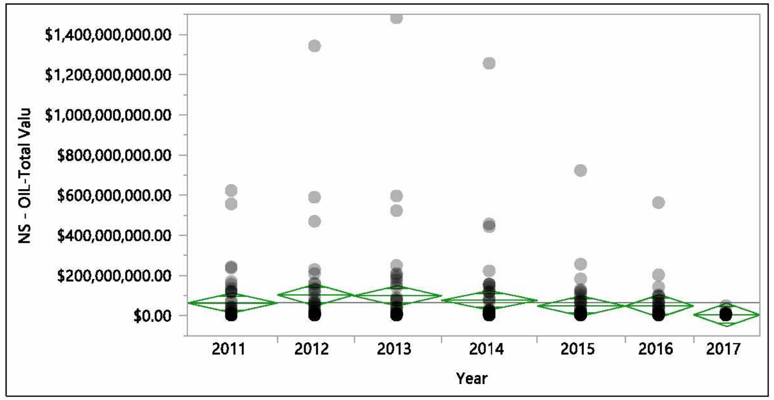
North Slope mean (μ_1) and Cook Inlet mean (μ_2) PV are not equal.

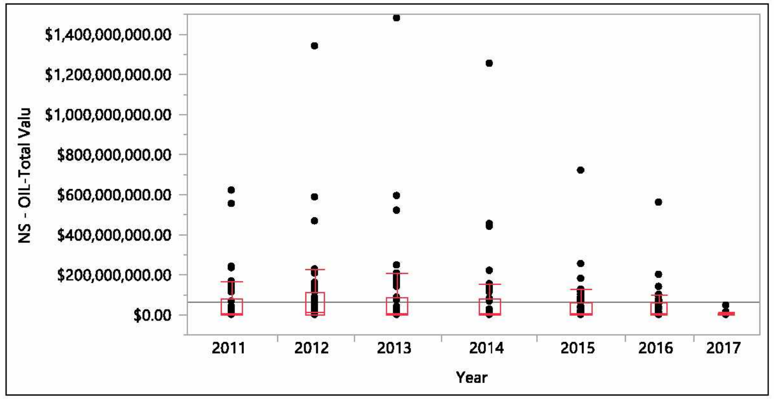
Part B

Correlation between different data

1] Analysis of Variance (ANOVA) - Total Royalty Value ($) by Year for North Slope - Oil data

Oneway Analysis of NS - OIL-Total Value By Year





Null – Total Royalty Values ($) obtained every year are **equal**

Alternate - Total Royalty Values ($) obtained every year are **different**

F Ratio	Prob > F
1.4903	0.1813

At the 95% confidence level

the P-value P = 0.1813 is larger than $\alpha = 0.05$

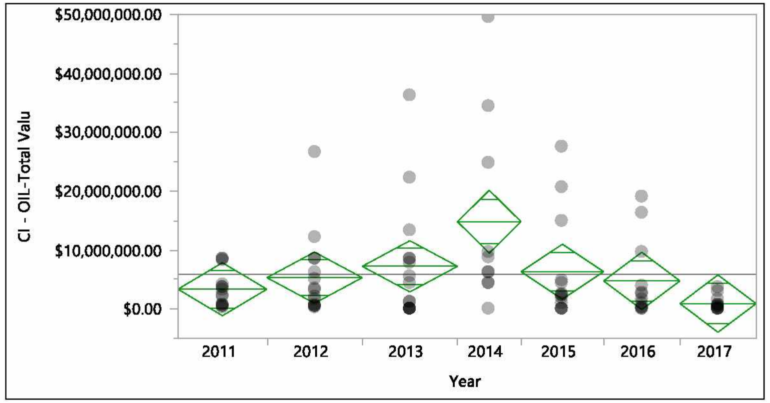
Fail to reject H_0

Conclude - Not enough evidence to strongly state that Total Royalty Value ($) is affected by the Year in which data is obtained for North Slope - Oil data

Part B

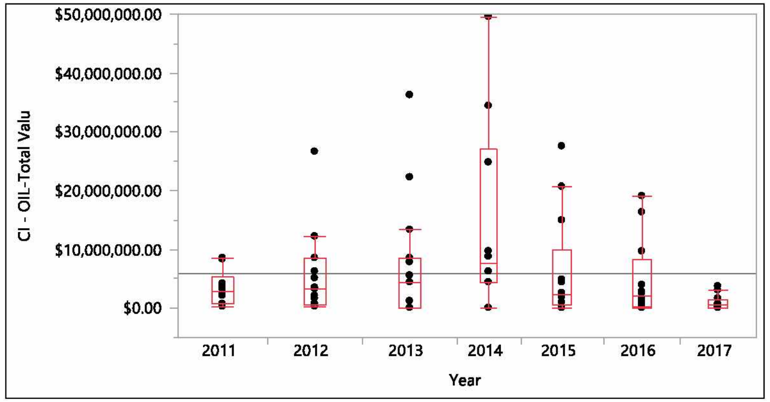
1] ANOVA - Total Royalty Value ($) by Year for Cook Inlet - Oil data

Oneway Analysis of CI - OIL-Total Value By Year



Null – Total Royalty Values ($) obtained year are **equal**
Alternate - Total Royalty Values ($) obtained every year are **different**

F Ratio	Prob > F
2.8711	0.0136*



At the 95% confidence level

the P-value P = 0.0136 is **less than** α = 0.05

Reject H_0

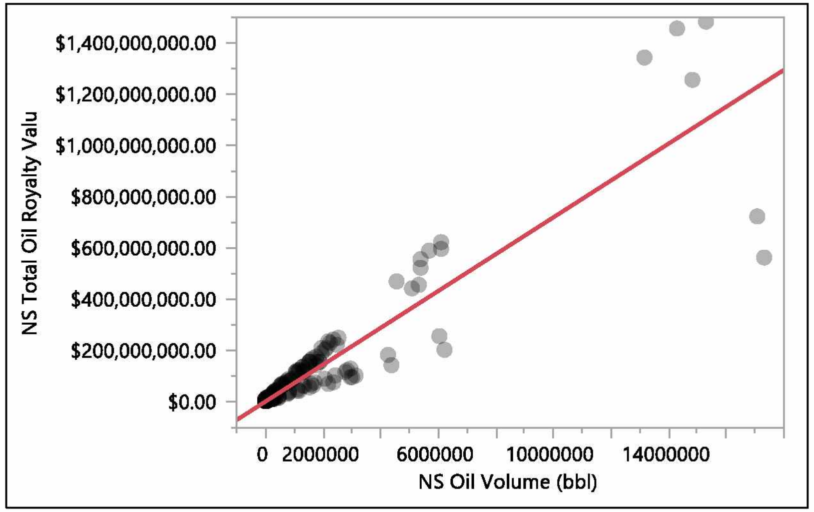
Conclude - Total Royalty Value ($) is affected by the Year in which data is obtained for Cook Inlet - Oil data

Part B

2] Regression Model

Total Royalty Value ($) by Volume (bbl) for North Slope - Oil data

North Slope Total Royalty Value By Volume (bbl)



t Ratio	Prob>|t|
0.35	0.7294
38.79	<.0001*

F Ratio
1504.973
Prob > F
<.0001*

Practical Interpretation:

P-value = 0.0001 **for Slope is less than** α = 0.05

P-value = 0.7294 **for the intercept is greater than** α = 0.05

The slope and intercept are different than zero

Reject the Null

Conclude - The Regression Is Significant

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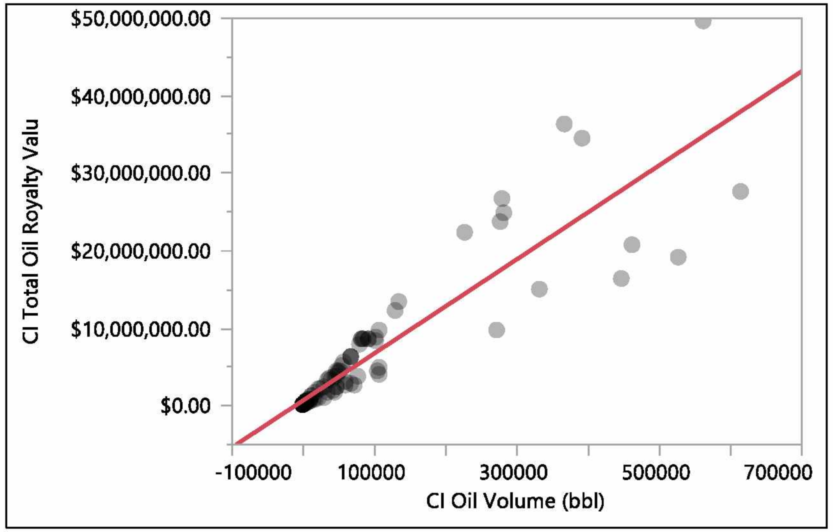
Part B

2] Regression Model

Total Royalty Value ($) by Volume (bbl) for Cook Inlet- Oil data

Cook Inlet Total Royalty Value By Volume (bbl)



t Ratio	Prob>|t|
1.43	0.1559
19.34	<.0001*

F Ratio
374.1329
Prob > F
<.0001*

Practical Interpretation:

P-value = 0.0001 **for Slope is less than** α = 0.05

P-value = 0.1559 **for the intercept is greater than** α = 0.05

The slope and intercept are different than zero

Reject the Null

Conclude - The Regression Is Significant

References

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Thank You