ExxonMobil

Point Thomson
Gas Cycling Project

Pipeline Design Modifications to Address Subsistence Hunting and Caribou Issues

March 26, 2003

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to Address Subsistence Hunting and Caribou Issues

SUMMARY

Alternatives for design, construction, and operation of pipelines and gathering lines for the Point Thomson Gas Cycling Project are evaluated to address potential impacts on caribou migration, hunting, and access identified during the permit review process. The base case is for the Point Thomson gathering and export lines to be elevated a minimum height of 5 ft above the tundra and to be located the optimum (shortest) distance between facilities with due consideration to high value habitat, road-pipeline separation, water bodies, and other impact considerations.

The following alternatives have been identified as potential approaches to address some of the above concerns raised about pipeline design (note: costs identified are relative to the base case costs):

- Maintain current design and institute a hunting coordination plan (Alternative 2.2)
- Use non-reflective coating of the pipeline insulation sheath at <$1million cost (Alternative 2.10)
- Consider increasing the height of the lines above tundra to 7 ft to reduce concern about caribou passage at a cost of approximately $4 million (Alternative 2.9) with some construction and personnel safety issues
- Consider increasing the pipe wall thickness as necessary to withstand impact from bullets at a cost of approximately $4 million assuming increase in export line wall thickness to 0.5" and no change in gathering lines (Alternative 2.6)
- Consider the operating costs assuming reasonable hunting damage based on the selected design and identify benefit, if any, of adding reinforcement / deflector to protect line from hunting impact. Rank order of magnitude costs are approximately $13 million for the export line and $5 million for each gathering line. (Alternative 2.8)
- Relocation of the pipelines (with associated roads) inland (with some impacts to the hydraulic performance of the gathering lines) at an estimated cost of greater than $60 million (Alternative 2.3)
- Burial of the pipelines in the road (Alternative 2.4) or in the tundra (Alternative 2.7), which involve significant technical uncertainties and challenges relating to such issues as pipeline integrity and thaw settlement, at estimated costs of greater than $130 million.

1.0 INTRODUCTION

This document provides a summary evaluation of alternatives for design, construction, and operation of pipelines and gathering lines for the Point Thomson Gas Cycling Project. The proposed project, identified below as the base case, was formulated with inclusion of environmental, technical, economic, and logistical considerations consistent with most major pipelines installed on the North Slope of Alaska. Analysis of alternatives was conducted in the conceptual design of the project, and is further described here to address topics raised during meetings related to the EIS process.

This section will provide a brief overview of the Point Thomson Gas Cycling Project and identifies the key topics raised during the EIS meeting. Section 2 provides a summary of the alternatives considered and a brief technical description. Section 3 presents a comparison between the alternatives considered, and provides some analysis of the alternatives which are further detailed according to technical, practicability, safety, environment and human impact, and cost criteria in Tables 3-1 and 3-2.

1.1 Point Thomson Gas Cycling Project Description

The Point Thomson Unit is located on the North Slope of Alaska immediately west of the Staines River, approximately 22 miles east of the Badami Development. The "gas cycling" project is proposed to develop the Thomson sands reservoir. A gathering pipeline system will collect production from well pads located on the eastern and western margins of the reservoir and deliver the three-phase stream to the Central Processing Facility (CPF). Gas, water, and hydrocarbon liquids (condensate) will be separated from the three-phase stream at the CPF. Residue gas will be re-injected into the reservoir at the Central Well Pad (CWP) located near the CPF. The recovered hydrocarbon condensate will be shipped to market through a new 22-mile (35-km) export pipeline that will extend from Point Thomson to the Badami Development, where it will tie into the existing Badami and Endicott sales pipelines, with ultimate delivery to TAPS Pump Station No. 1. Figure 6.2 of the *Point Thomson Gas Cycling Project Draft Project Description Revision B*, attached, provides a map of the pipeline routes. A full description of the gathering line system and the condensate export pipeline is provided in Section 2.1.

1.2 Permit Considerations for Pipeline Interaction

The EIS process includes meetings to obtain input from interested parties on the proposed development. Input was requested from North Slope village residents related to impact of the Point Thomson Project Pipelines on hunting and other land use in the area. Key concerns identified at the meetings were:

- The above ground pipeline/gathering lines, on their own or combined with a parallel road, could act as a barrier to normal caribou migration access to the coastline for relief from insects. Proposals included raising the lines or burying them.
- Hunting in the Point Thomson area could be limited or eliminated by the presence of an above ground pipeline/gathering line. Hunters expressed concern that they may damage the pipeline inadvertently with subsequent environmental damage.

- The above ground pipeline/gathering lines could act as a barrier to human access between the coastline and inland locations.
- The above ground pipeline/gathering lines could be a visual impact, acting as a barrier to caribou migration, especially because of high reflectivity of the pipeline external sheath.

2.0 PIPELINE DESCRIPTION & OPTIONS

This section describes the proposed pipeline system (Alternative 2.1 described as the base case), and several alternatives (2.2-2.10). These alternatives are evaluated as compared to the base case in Section 3.

2.1 Base Case

The condensate export pipeline and the gathering line routes are shown in Figure 6.2 of the *Point Thomson Gas Cycling Project Draft Project Description Revision B*, which is attached for reference. The export line and the two gathering lines share the same VSMs (Vertical Support Members) as they leave the Point Thomson CPF. After crossing under the road from the CPF to the West Pad, the export line and the gathering line from the west pad share VSMs on the south of the gravel road until a point close to the West Pad. From that point the export line traverses in a southwesterly direction to the Badami field location, crossing under the gravel road within the Badami development. There is no road from the separation point with the gathering line to Badami. The line from the East Pad crosses under the road from the East Pad to the CPF adjacent to the East Pad, and is installed parallel to the road until joining with the export pipeline and the west gathering line near the CPF. The east gathering line also crosses under the road from the CPF to the airstrip.

All lines are located on VSMs with a minimum clearance above tundra of 5ft, with an average of approximately 5.8 ft (see Table 2-1 below). In evaluating the base case of pipelines elevated on VSM's with buried and other alternatives, it is important to recognize why elevation on VSM's is standard practice on the North Slope for hot oil and multi-phase product pipelines (three phase production has a water content that will freeze if the temperature in the pipe is less than 32°F) and the advantages this mode of pipeline design provides. Clearly, the principal reason is thermodynamic to avoid thawing of the permafrost. The elevated mode also provides better flow assurance through being able to establish a profile that is the most hydraulically efficient (i.e. close to or horizontal) and, in the case of the gathering lines, to avoid hydrate formation. Surface disturbance impacts are minimal and the pipeline can be visually monitored unlike a buried line. Abandonment is relatively easy to accomplish through removal of the above surface hardware with minimal surface disturbance. The pipeline routes are selected to minimize the impact on high value habitat, minimize the number of VSMs in water bodies (ponds, streams) and to maintain a distance of approximately 300 ft from the road. The intent is that the gathering lines can be visually inspected from the road, enabling rapid discovery of pipeline damage or leaks. The pipelines have vibration dampeners installed on those spans expected to be subject to wind induced vibration. Such dampeners are designed to maintain the minimum 5 ft clearance above tundra.

The VSMs are typically single piled structures with horizontal beams for pipe supports. The pile diameters range from 8-30 inches. VSMs used for pipe anchors are typically twin piled structures. The pipelines are covered with 2" foam insulation encased within a spiral wound galvanized steel jacket.

Table 2-1 Pipeline Description

Description	Export Line	East Gathering Line	West Gathering Line
Pipe Outside Diameter	12.75"	18"	16"
Pipeline Outside Diameter (inc. Insulation & jacket)	16.75"	22"	20"
Pipeline Length	22 miles	6 miles	7 miles
Height above tundra • Minimum • Average • % 6-7ft • % > 7ft	 5ft 5.8 ft 11% 6%	 5 ft 5.9ft 11% 14%	 5ft 5.8ft 14% 11%

2.2 Base Case Plus Hunting Management Program

As case 2.1 with no change except that a hunting management program is initiated. This would require those hunting in the area of the Point Thomson facilities contact the operator and work through a safety program to minimize the potential for injury to Point Thomson personnel or damage to the Point Thomson facilities. This program could also identify acceptable firearms and safe ranges for hunting in the Point Thomson facilities area (i.e. those firearms not capable of penetrating the pipeline wall.)

Although no specific tests related to this issue have been conducted for this project, ExxonMobil team members familiar with ballistics and pipeline design have been able to make some preliminary observations about possible impacts to the project pipeline as a result of bullet strikes. As with all North Slope oil and gas operations, the primary concern over hunting in or near the production area is human safety. While it is assumed that reasonable safety standards will be used by hunters in the area such as not shooting towards modules, buildings, pipelines or facilities, or backstop is uncertain, exceptions can occur particularly in more remote areas where only pipelines are present. Rifle calibers used by subsistence hunters range from .22 to .338 - all with bullet trajectories over one mile. Two possibilities for bullet strikes to the pipeline exist: (1) assuming a clean miss at an animal and the bullet strikes the pipeline at a distance greater than 100 yards, or (2) assuming the bullet strikes an animal and passes through to hit a pipeline in the background. In the first case, if the use of normal hunting rounds with soft nosed or bonded bullets is assumed, none of these calibers posses sufficient energy or sectional density to pierce the approximate 0.75 inch thick corrosion resistant alloy (CRA) steel gathering lines. In the second case, the soft nosed hunting bullet would have expanded and lost much of its energy on the pass through the animal yielding a greater safety margin should the expanded and spent bullet strike a pipeline.

Bullets from the larger of the most used hunting rifles, the .338 Winchester Magnum, are not expected to penetrate the export line at distances greater than 100 yards. The pipe may become dented but not penetrated. At distances greater than 300 yards no damage is expected to occur. The hunting management plan would then be fashioned taking these parameters into consideration. Most of the export pipeline is greater than 300 yards from the shore. Accidental shots closer than 100 yards are not expected.[1] These observations could, if necessary, be confirmed through standard engineering calculations and this topic is also well addressed in the engineering literature.

2.3 Re-Route Pipelines

This case was proposed by the EPA to mitigate impact on hunting or damage to pipelines by routing the pipelines away from the coastline. Some have suggested moving the lines approximately 2 miles to the south of their current route. This would have the effect of increasing the east and west gathering lines by approximately 4 miles each, and increasing the export line's length by approximately 2 miles.

For the gathering lines the increase in length impacts the hydraulic performance, resulting in an increase in pipe diameter of at least one pipe size (i.e. 18" changes to 20" diameter). The gathering lines are constructed from CRA steel, which is much more expensive than carbon steel, in order to handle the specific well fluids. The impact of increasing the gathering line length as described would add approximately $57 million to the gathering lines cost ($7.1 million per mile). The increase in export line length would cost about an additional $1.8 million a mile resulting in an additional cost of nearly $4 million to construct the export line.

2.4 Install Pipelines in Road Above Tundra

This case proposed by the EPA assumes that the gathering lines and part of the export pipeline will be buried in the infield gravel roads throughout their lengths[2]. The cost of the pipeline would increase by a factor of between 2 and 3, resulting in an additional cost of approximately $1.8 million/mile using the factor of 2.0.

In order to successfully transfer the full wellstream (gas, condensate and water) through the gathering lines, minimum temperatures (approximately 80°F during normal operations) must be maintained to prevent formation of hydrates. Operating at temperatures which allow hydrates to form results in potential blockage of the pipeline with associated operational and safety impacts. This means the pipelines must operate at high temperatures resulting in special design and operation challenges when buried. Installation of large diameter, very high pressure (>3000 psig) gathering lines in gravel roads has no precedent on the North Slope. The feasibility of this approach is not established. Risks associated with upheaval buckling, excessive strains in the pipeline, integrity of the insulation system, cost increase due to additional road height and unproven installation method, and increased risk to safety due to proximity of the pipeline to the road would need to be addressed before feasibility could be established.

[1] The situations postulated in this section do not address malicious intent such as was the case with TAPS where a .338 fired repetitively at close range did eventually pierce the pipeline.
[2] This alternative does not apply to most of the export pipeline because it makes no sense to construct a road to Badami just to enclose the pipeline.

2.5 Install Pipelines Near Road on Sleepers

This case is similar to the base case except that the pipelines are close to the ground, and are therefore protected from line of sight by the road.

2.6 Design Pipeline Wall to Accept High Velocity Impact

This case as with case 2.1, the pipeline wall thickness is designed to resist penetration from the impact of a hunter's bullet from even a close shot. An estimated incremental cost for this alternative is approximately $4 million assuming an increase in export line wall thickness to 0.5" and no change in gathering lines wall thickness as their wall thickness is assumed adequate to resist penetration from a bullet impact (see Section 2.2).

2.7 Bury Pipelines in Tundra

This case proposed by the EPA assumes that the pipelines are buried in the tundra, and operate hot (similar to base case operations). The technical feasibility of this approach is not established for specific design requirements of the Point Thomson gathering and export pipelines.

The hot buried pipeline concept has many environmental, technical, construction and operating issues that need to be resolved before the feasibility of safe long-term operability can be determined. Environmental aspects include: thaw settlement, ponding, ditch subsidence, changes in water flow and drainage through the pipe ditch, and disturbance to the vegetation and habitat. Technical aspects include thermal design to minimize impact on the soil, corrosion resistant design, pipeline design to address thaw settlement, upheaval buckling, frost jacking and pipeline strain limit design. Construction considerations relate to trenching through ice rich soils, installation of insulation materials in the trench, design and installation of backfill around the pipe, and remediation/revegetation of the trench. Operating issues include maintenance of the pipeline and trench, corrosion monitoring of the pipeline, cathodic protection design and operation, position or strain monitoring of the pipeline and associated ground temperature and deformation monitoring, and leak detection.

The costs of a hot buried pipeline design, with the extent of technical uncertainty listed above, is difficult to estimate. Others have postulated that a cost factor of 2 to 3 times the cost of the conventional pipeline design is appropriate. With a 2.0 cost factor, this would result in gathering lines costing in the range of $14 million /mile (versus the base case cost of approximately $7.1 million/mile) and the export pipeline costing about $4 million per mile (versus the base case cost of approximately $1.8 million/mile). The cost increase for the project would approximately $90 million for the gathering lines (about 13 miles) and about $40 million for the export pipeline (approximately 22 miles) for a total incremental cost of about $130 million using the 2.0 cost factor[3].

[3] The base case cost estimate for the infield and export lines are very preliminary and more detailed cost estimating for the base case is currently on-going.

An alternative, applicable only to the condensate export pipeline design, is to chill the condensate to approximately 32°F and bury the line with minimal insulation. This approach reduces some of the technical issues listed above. To achieve this design a chiller is required at the Point Thomson end of the condensate line, the pipeline is increased to a 14" outside diameter, and a heater is installed at the downstream end of the pipeline in order to meet operational limits of the export system. Equipment to chill and then heat the entire production passing through the pipeline is large and expensive. Preliminary estimates for this equipment are approximately $50 million for the refrigeration and $27 million for the heater. It is important to recognize the full life cycle costs of chilling/heating the condensate not just the investment in the chilling/heating equipment. Operational costs are very high which was one of the major factors that this alternative was not progressed for the Badami project. Significant energy is required for chilling and then reheating the condensate. It will take approximately 321,000 kW of heating to bring the condensate back to sales temperature. This amount of energy could heat approximately 31,000 homes or a town about the size of Fairbanks. Adding to this would be the energy for cooling that will take approximately 5000 kW, which would cool 2500 homes in Houston, Texas. Successful operation of such a pipeline system is thus dependent on the reliability of the chilling and heating equipment. The pipeline is estimated to cost approximately $8 million more than the base design or approximately $2.2 million per mile.

2.8 Install Pipeline Shield

This case assumes current pipeline design and routing, but provides protection to the pipeline by a shield around or alongside the pipeline if upon further evaluation the pipeline is found to be vulnerable to penetration. One concept would be to install a pipe on the VSM alongside the gathering or export pipeline to act as a shield. Another alternative would be to apply a protective shield over the pipeline for protection. Rough costs for these options are around $0.5 - $1 million/ mile for various levels of protection of the pipelines.

2.9 Base Case Plus Increased Minimum Height Above Tundra to 7 Feet

This case is as the base case, but increases the minimum height of the pipeline above tundra from 5 ft to 7 ft. The additional cost for the increase in minimum height for all pipelines is approximately $4 million. Raising the height to a minimum of 7 ft above the tundra means that at some locations the pipeline is well above 7 ft. Both during construction and for maintenance operations this increase in height also results in more scaffolding and also more risk to personnel.

2.10 Reflectivity of the Pipeline

Although not covered in the tables, the EIS process has identified a visual impact concern related to the bright silver color of the external pipeline insulation sheathing and the reflected light at certain sun angles. The external surface of the galvanized steel sheath is initially bright silver in color, but dulls over time to a less reflective matte silver color. At least one pipeline has been installed with a medium-green colored matte finish on the external sheath to address this concern. The cost of this addition is estimated to be approximately $1 million for all pipelines.

3.0 ANALYSIS

Each of the cases identified in Section 2 is compared in Tables 3-1 and 3-2, with evaluations in the areas of:

- Technical/Design
- Practicability (including potential permitting, construction and schedule impacts)
- Operations & Safety
- Environmental & Human Impacts
- Relative Cost

Table 3.1 provides the evaluation for the Point Thomson field area, specifically where the pipeline or gathering line are running parallel to the infield roads. Table 3.2 addresses the stand-alone export pipeline between the West Pad and Badami.

This section provides an overview summary of the relative merits of the alternatives based on the information presented in Tables 3.1 and 3.2.

3.1 Alternatives 2.3, 2.4 and 2.7 have High Technical, Safety and/or Cost Impacts

Alternative 2.3 which re-routes the pipelines to the south adds greater than $50M to the cost of the pipelines.

Alternative 2.4 which buries the pipelines in a road has high technical uncertainty and significant cost and safety impacts. The technical design of the hot gathering lines in a gravel road bed is problematic in that integrity of the frozen soil, integrity of the insulation and integrity of the soil imposed restraints on the pipe (to control thermal expansion) have to be maintained to ensure safe operation of the gathering lines. Safety of personnel on the road is very important considering the very high operating pressure of the gathering lines. The condensate line could potentially be considered for operation as a chilled condensate pipeline. However additional cooling requirements at Point Thomson, heating requirements at Endicott and extension of the road to Badami all have significant cost, schedule and permitting impacts. The overall additional cost of the chilled condensate export system is greater than $80million more than the base case pipeline design.

Alternative 2.7, which buries the pipelines in the tundra, may not be technically feasible for the gathering lines. The integrity of the ice-rich thaw unstable soil cannot be maintained due to cumulative heat flux from the gathering lines over the life of the project unless costly mitigation measures are used. These might include excavation of thaw-unstable soils, replacement with thaw-stable soil (e.g. gravel), or construction of a well-insulated trench. If technical feasibility were established, the buried pipeline costs would likely be more than $130 million greater than the base case costs.

The cost of a buried chilled condensate line, including refrigeration and heating equipment, would likely be more than $80 million greater than the base case export pipeline cost.

The above cases are not viable alternatives.

3.2 Alternative 2.5 is Technically Feasible but may not Provide Advantage Over Base Case

Alternative 2.5 (pipeline on sleeper alongside road) may not meet one of the main design objectives of the review in that it becomes a potential physical barrier to both the caribou and to access by other land users[4]. Other deficiencies of this approach relative to the base case include operational and safety concerns about the insulation damage due to water intrusion caused by both snow cover in the winter and runoff accumulation during break up, lack of visual inspection under snow cover, and increased potential for corrosion under insulation.

3.3 The Remaining Alternatives are Technically Viable but have Potentially Significant Cost and Schedule Impacts

In rough rank order of increasing cost the following alternatives have potential for mitigating the impact of the pipeline on caribou migration and hunting interaction.

Alternative 2.2: maintain base case, but develop appropriate operating procedures and public awareness programs to promote safe hunting in the vicinity.

Alternative 2.6: maintain base case with additional tests to confirm adequacy of the pipe wall to resist bullet impact or increase wall thickness to meet this criterion. Without conducting the evaluation, our expectation is that the export pipeline wall thickness would need to be increased to protect the line particularly from a close shot, but the gathering lines wall thicknesses are adequate to mitigate initial penetration of the pipe wall by a bullet. This case in common with the base case elevated pipeline option also has operational costs as bullet impacts would cause damage to the insulation and coating, and potentially damage the pipe steel wall resulting in delayed pipeline failure unless timely repair is made.

Alternative 2.9: Increase pipeline height off tundra to 7ft minimum. This case has been identified as a way of mitigating the potential barrier effect of the pipeline, thus allowing easier caribou migration and user access, e.g. the Meltwater pipeline. This is estimated to cost approximately $4 million to address the increased construction cost of higher VSMs and associated scaffolding. A relative benefit between 5ft vs. 7 ft minimum height from the tundra for caribou migration has not been established in the peer-reviewed literature. Previous studies have shown that the pipeline at 5ft above tundra, combined with a distance of 300 ft spacing from a road do not have a significant impact on Caribou migration. Table 2-1 shows that the average height off tundra is ~5ft 8in and that 6-14% of the lines are above 7ft. The increased minimum height will also increase the extent of operations above 6ft which require additional fall protection practices per OSHA requirements.

Alternative 2.8: Provide a shield on or alongside the pipelines for protection from bullets. This could take the form of a pipe-in-pipe configuration, a protective pipe alongside the gathering and export pipelines on the VSMs or a shield (e.g. Kevlar) around the current

[4] In a recent meeting, North Slope Borough representatives indicated that this alternative might merit further review.

base design. Rough costs for these options are around $0.5 - 1million/ mile for various levels of protection of the pipelines.

Other Considerations

Based on feedback received from the North Slope village residents in a meeting in December 2002, it is clear that there are wider issues than simply the migration of caribou and the limitations on hunting identified. The following perspectives of others need to be addressed in our considerations:

- The Kaktovik Village subsistence hunters are the likeliest to hunt in the Point Thomson area, but we do not know the numbers of hunters or frequency of hunting. The Kaktovik representatives want the pipelines to have no impact on their ability to hunt in the Point Thomson area.
- The subsistence hunters would not hunt in the area of pipelines because of their concern that damage to the line could cause damage to the environment.
- Hunting is a traditional family activity and is a core to the cultural life of the Inupiat Eskimos.

TABLE 3.1 GATHERING LINES (COMBINED WITH EXPORT LINE WHEN ON COMMON ROUTE): Pipeline Alternatives Comparison

Case No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	O & M
2.1	Current Design Basis - Export pipeline and east and west gathering lines on VSMs at 5 feet minimum height above tundra, running along inland side of roads, approx. 0.5 mile from coastline. The pipeline will be installed at an average height above the tundra of 6 feet and the height above the tundra at stream crossings is generally greater than 7 feet.	• Widely used and proven	• Design recognized and generally accepted by JPO • Constructible using current NS methods	• Routine visual inspection from infield roads • Additional surveillance and inspection techniques to detect bullet strikes • Potential damage and leaks due to bullet strikes • Repair and cut-out of bullet strikes	• Low impact on wildlife movement and subsistence hunter/public access • Hunting near facilities and pipeline may be discouraged	Base case	Base case
2.2	Current Design Basis – Implement appropriate operating procedures and public awareness programs to promote safe hunting in the vicinity of the Point Thomson pipelines and facilities (e.g. hunting/village relations committee and joint ExxonMobil-Kaktovik hunting safety programs and field exercises)	• Widely used and proven	• Design recognized and generally accepted by JPO • Constructable using current NS methods	• Routine visual inspection from infield roads • North Slope standard	• Low impact on wildlife movement and subsistence hunter/public access • Operation of facilities and pipelines and nearby hunting are safely conducted and fully compatible	Base case +	Base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

Case No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	**O & M**
2.3	Re-route pipelines - Similar functional designs, but routed 2 miles due south from well pads and CPF before making east/west connections.	• Larger lines size due to extra length • More elevation change inland from the coastline	• Increased fresh water requirement to construct ice roads • Longer construction schedule	• Inefficient operation due to excessive cooling (e.g. hydrate formation, slugging)	• More stream and lake crossings due to additional length of tundra that will be traversed • Cumulative impacts (e.g. transportation) due to increased pipeline project scope • Draw down of fresh water and additional traffic to haul fresh water for longer ice roads	Significantly higher than base case	Higher than base case
2.4	Install insulated pipelines in road**bed** above the tundra.	• Insulation between road bed and tundra • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line	• Slow, difficult insulation jacket joining procedure • Facility construction delays due to road repair, restoration and recovery • Trench stability in unconsolidated road bed • Additional gravel required to build up road bed to accommodate pipelines • Field bending versus induction bends	• Thawing of road bed and underlying permafrost, poor road quality, subsidence • Inadequate restraint leading to pipeline exposure and interference • Routine visual inspection not feasible • Saturated insulation and inefficient gathering line operation (e.g. slugging, hydrate formation) due to poor insulation performance • Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Increased road repair/maintenance frequency	• Thawing and subsidence of tundra beneath road • Larger gravel pit, more traffic to haul and place additional gravel	Higher than base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

Case No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	**O & M**
2.4 A	Install uninsulated pipelines in road**bed** above the tundra.	• Insulation between road bed and tundra • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line	• Facility construction delays due to road repair, restoration and recovery • Trench stability in unconsolidated road bed • Additional gravel required to build up road bed to accommodate pipelines • Field bending versus induction bends	• Extensive thawing of road bed and underlying permafrost, poor road quality, subsidence • Inadequate restraint leading to pipeline exposure and interference • Routine visual inspection not practicable • Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Hydrate formation in gathering lines due to excessive cooling •	• Excessive thawing and subsidence of tundra beneath road • Larger gravel pit, more traffic to haul and place additional gravel	Higher than base case	Higher than base case
2.5	Install pipelines near roads on sleepers – parallel and approximately 100 ‘ off inland side of road so that top of pipe is below road top	• Sleeper stability • Modified anchor design required • Pipeline crossings required to facilitate wildlife movement • Elevation increases required at stream crossings	• New design likely to attract greater scrutiny, possibly resistance from agencies • Constructible using current NS methods	• Inefficient operation during winter due to snow/ice cover • Cooling and hydrate formation • Not inspectable from infield roads when lines are covered with snow and water • External corrosion of export line due to snow/runoff accumulation over pipelines (i.e. road will promote drifting and hold up runoff) • Frequent inspection for insulation jacket failure and external corrosion on export line	• Potential impediment to wildlife movement and subsistence hunter/public access	Base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

Case No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	O & M
2.6	Increase pipe wall thickness - as necessary to provide adequate resistance to bullet penetration fired from high-powered rifles.	• Potential gathering line hydraulic restrictions due to pipe ID reduction if increased wall thickness required • Shorter spacing between anchors (i.e. more Z-type thermal expansion offsets) • Less prone to WIV • Analysis/lab testing to prove puncture resistance and long term integrity following bullet strikes	• Design recognized and generally accepted by JPO • Constructible using current NS methods	• Routine visual inspection from infield roads • Readily maintained • Additional surveillance and inspection techniques to detect bullet strikes • Potential damage due to bullet strikes • Repair and cut-out of bullet strikes	• Unrestricted hunting permitted • Low impact on wildlife movement and subsistence hunter/public access	Higher than base case	Base case
2.7	Buried pipelines - design and install pipelines for operation buried in tundra (insulated pipelines, thaw bulb, no condensate chilling required).	• Thaw stability of tundra along entire length of pipelines must be tested and proven • Addition of thaw stable material below pipelines • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line	• New design likely to attract greater scrutiny, possibly resistance from agencies • Arctic/permafrost trenching design and excavation • Field bending versus induction bends • Slow, difficult insulation jacket joining procedure • Mining, screening and hauling thaw stable material	• Routine visual inspection not practicable • Saturated insulation and inefficient gathering line operation (e.g. slugging, hydrate formation) due to poor insulation performance • Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Annual trench line maintenance program	• Thaw stable material source and screening plant • Additional traffic to mine, screen, haul and place thaw stable material • Extended and possibly indefinite tundra surface recovery period • Trench line will change drainage patterns	Higher than base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

Case No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	**O & M**
2.8	Pipeline shield – current pipeline design basis with a shield (e.g. metal, timber, sacrificial pipe, other material) on the ocean side of the pipelines to protect pipelines from bullets	• Analysis/lab testing to prove puncture resistance • Additional slot on VSMs for the shield • Spare line for lower pressure maintenance purposes (e.g. warm-up and purge gas) if pipe used for shield • Protection of pipelines at bends and from opposite side	• • Constructable using current NS methods	• Routine visual inspection from infield roads • Additional surveillance and inspection techniques to detect bullet strikes	• Unrestricted hunting permitted • Low impact on wildlife movement and subsistence hunter/public access	Higher than base case	Base case
2.9	Current Design Basis except that the pipeline height off tundra is increased to minimum 7ft.	• Taller VSMs & potentially larger diameter piles) •	• Additional scaffolding and lifting during construction	• Additional personnel risk due to more and higher scaffolding	• Low impact on wildlife movement and subsistence hunter/public access • No demonstrated biological (caribou) benefit.	Base Case+	Base Case
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Notes:
1) Includes potential permitting, construction and schedule impacts.
2) Includes wildlife, tundra/surface drainage, long term mitigation and restoration, subsistence and public access impacts.
3) Lower = 25 to 50 % lower, higher = 50 to 100 % higher, significantly higher = more than 100 % higher.
\+ Indicates cost increase relative to Base Case. See text for details.

TABLE 3.2 CONDENSATE EXPORT PIPELINE: Pipeline Alternatives Comparison

No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	O & M
2.1	Current Design Basis - Export pipeline on VSMs at 5 feet minimum height above tundra, running cross country 1 to 2 miles from coastline. The pipeline will be installed at an average height above the tundra of 6 feet and the height above the tundra at stream crossings is generally greater than 7 feet.	• Widely used and proven	• Design recognized and generally accepted by JPO • Constructable using current NS methods	• Additional surveillance and inspection techniques to detect bullet strikes • Potential damage and leaks due to bullet strikes • Repair and cut-out of bullet strikes	• Low impact on wildlife movement and subsistence hunter/public access • Hunting near pipeline may be discouraged	Base case	Base case
2.2	Current Design Basis – Implement appropriate operating procedures and public awareness programs to promote safe hunting in the vicinity of the export line (e.g. hunting/village relations committee and joint ExxonMobil-Kaktovik hunting safety programs and field exercises)	• Widely used and proven	• Design recognized and generally accepted by JPO • Constructable using current NS methods	• North Slope standard	• Low impact on wildlife movement and subsistence hunter/public access • Operation of pipeline and nearby hunting are safely conducted and fully compatible	Base case +	Lower than base case
2.3	Re-route pipeline - Similar functional design, but routed 5 miles due south from CPF before running west toward Badami.	• Larger line size due to 2 miles extra length • Significant elevation change inland from the coastline • Steeper, more undulating topography • Fewer stream and lake crossings inland from the coastline	• Increased fresh water requirement to construct ice roads • Longer construction schedule	• More remote, fewer water sources to build ice roads and pads for inspection, repair and maintenance	• Cumulative impacts (e.g. transportation) due to increased pipeline project scope • Drawdown of fresh water and additional traffic to haul fresh water for longer ice roads • Larger potential spill volume due to larger line size	Higher than base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	**O & M**
2.4 A	Install insulated pipeline in roadbed above the tundra.	• Insulation between road bed and tundra • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line • Road and bridges required	• Slow, difficult insulation jacket joining procedure • Trench stability in unconsolidated road bed • Gravel mine(s) required to build road • Field bending versus induction bends	• Thawing of road bed and underlying permafrost, poor road quality, subsidence • Inadequate restraint leading to pipeline exposure and interference • Saturated insulation and excessive tundra thawing due to poor insulation performance • Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Increased road repair/maintenance frequency • Better access to the export pipeline	• Thawing and subsidence of tundra beneath road • Gravel mine site(s) • Additional traffic to mine, haul and place gravel for the road	Significantly higher than base case	Higher than base case
2.4 B	Install uninsulated pipeline in roadbed above the tundra.	• Insulation between road bed and tundra • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line • Road and bridges required	• Trench stability in unconsolidated road bed • Gravel mine(s) required to build road • Field bending versus induction bends	• Extensive thawing of road bed and underlying permafrost, poor road quality, subsidence • Inadequate restraint leading to pipeline exposure and interference • Cathodic protection system operation and maintenance	• Excessive thawing and subsidence of tundra beneath road • Gravel mine site(s) • Additional traffic to mine, haul and place gravel for the road	Significantly higher than base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

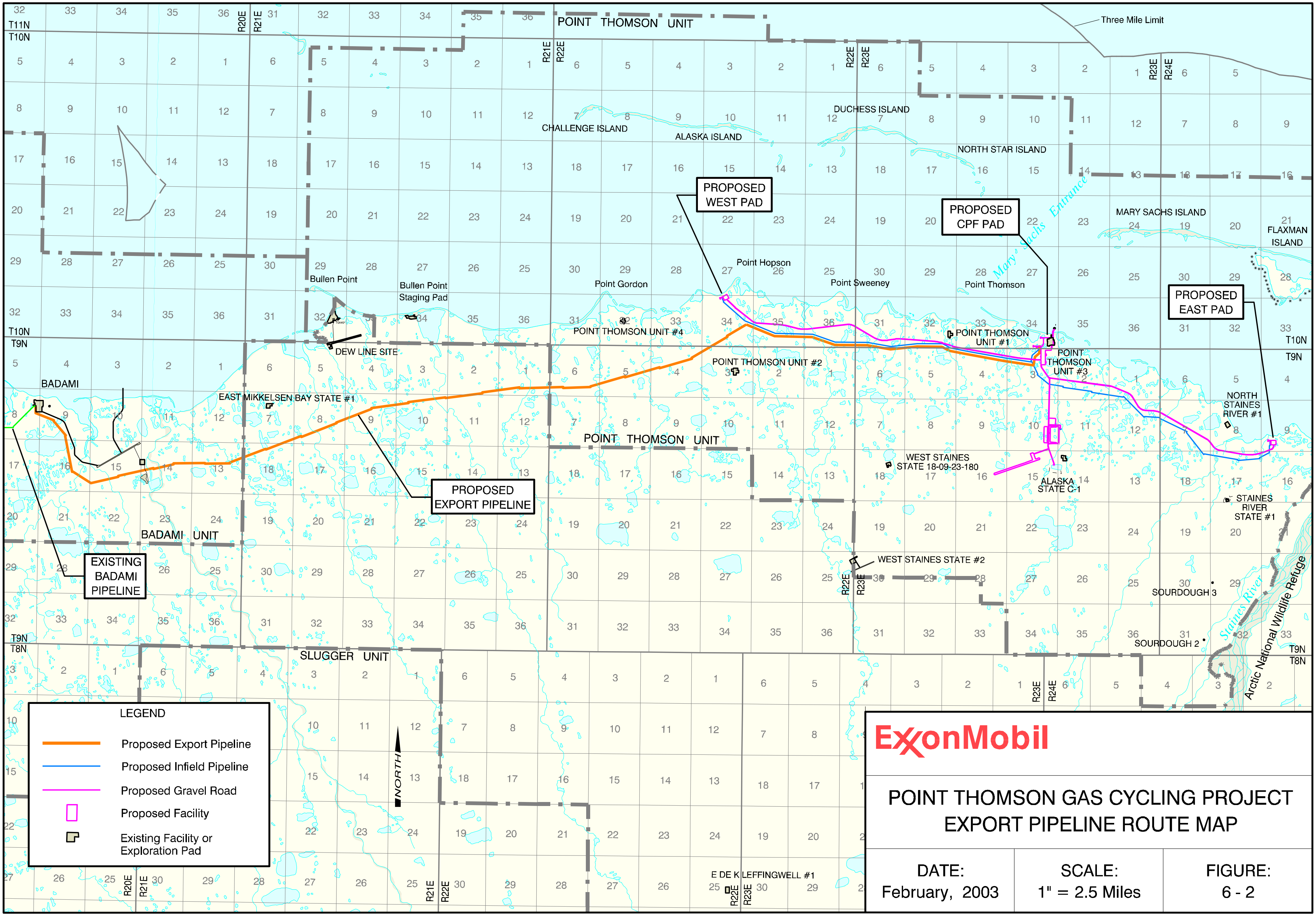
No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	O & M
				• Frequent internal inspection and investigative excavations • Increased road repair/maintenance frequency • Better access to the export pipeline			
2.5	Install pipelines near road on sleepers – parallel and approximately 100 ‘ off inland side of road so that top of pipe is below road top	• Sleeper stability • Modified anchor design required • Pipeline crossings required to facilitate wildlife movement • Elevation increases required at stream crossings • Road and bridges required	• New design likely to attract greater scrutiny, possibly resistance from agencies • Constructable using current NS methods • Gravel mine(s) required to build road	• Not able to inspect from road when lines are covered with snow and water • External corrosion of export line due to snow/runoff accumulation over pipelines (i.e. road will promote drifting and hold up runoff) • Frequent inspection for insulation jacket failure and external corrosion on export line	• Potential impediment to wildlife movement and subsistence hunter/public access • Gravel mine site(s) • Additional traffic to mine, haul and place gravel for the road	Significantly higher than base case	Higher than base case
2.6	Increase pipe wall thickness - as necessary to provide adequate resistance to bullet penetration fired from high-powered rifles.	• Potential hydraulic restriction due to pipe ID reduction if wall thickness increase required • Shorter spacing between anchors (i.e. more Z-type thermal expansion offsets) • Less prone to WIV • Analysis/lab testing to prove puncture	• Design recognized and generally accepted by JPO • Constructable using current NS methods	• Additional surveillance and inspection techniques to detect bullet strikes • Potential damage due to bullet strikes • Repair and cut-out of bullet strikes • Additional pumping power due to hydraulic restriction	• Unrestricted hunting permitted • Low impact on wildlife movement and subsistence hunter/public access	Higher than base case	Base case

No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	O & M
		resistance and long term integrity following bullet strikes					
2.7	Buried pipeline - design and install pipeline for operation buried in tundra (insulated pipeline, thaw bulb, no condensate chilling required).	• Thaw stability of tundra along entire length of pipelines must be tested and proven • Addition of thaw stable material below pipeline • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line	• New design likely to attract greater scrutiny, possibly resistance from agencies • Arctic/permafrost trenching and excavation • Field bending versus induction bends • Slow, difficult insulation jacket joining procedure • Mining, screening and hauling thaw stable material	• Saturated insulation, excessive tundra thawing due to excessive cooling • Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Annual trench line maintenance program	• Thaw stable material source and screening plant • Additional traffic to haul and place thaw stable material • Extended and possibly indefinite tundra surface recovery period • Trench line will change drainage patterns	Significantly higher than base case	Higher than base case
2.7 A	Buried pipeline - design and install pipeline for operation buried in tundra (uninsulated pipeline, chilled condensate)	• Condensate chillers • Cathodic protection system • Shorter due to elimination of Z-type thermal expansion offsets • External coating on export line	• New design likely to attract greater scrutiny, possibly resistance from agencies • Arctic/permafrost trenching and excavation • Field bending versus induction bends	• Cathodic protection system operation and maintenance • Frequent internal inspection and investigative excavations • Annual trench line maintenance program	• Extended and possibly indefinite tundra surface recovery period • Trench line will change drainage patterns	Higher than base case	Higher than base case

PIPELINE DESIGN MODIFICATIONS FOR PERMIT INTERACTIONS

No.	Alternative Description	Technical/Design Impacts	Practicability (see Note 1)	Operational/Safety Impacts	Potential Environmental and Human Impacts (see Note 2)	Relative Cost (see Note 3)	
						Capital	**O & M**
2.8	Pipeline shield – current pipeline design basis with a shield (e.g. metal, timber, sacrificial pipe, other material) on the ocean side of the pipelines to protect pipelines from bullets	• Analysis/lab testing to prove puncture resistance • Additional slot on VSMs for the shield • Spare line for lower pressure maintenance purposes (e.g. warm-up and purge gas) if pipe used for shield • Protection of pipelines at bends and from opposite side	• Design recognized and generally accepted by JPO • Constructible using current NS methods	• Additional surveillance and inspection techniques to detect bullet strikes	• Unrestricted hunting permitted • Low impact on wildlife movement and subsistence hunter/public access	Higher than base case	Base case
2.9	Current Design Basis except that the pipeline height off tundra is increased to minimum 7ft.	• Taller VSMs & potentially larger diameter piles) •	• Additional scaffolding and lifting during construction	• Additional personnel risk due to more and higher scaffolding	• Low impact on wildlife movement and subsistence hunter/public access • No demonstrated biological (caribou) benefit.	Base Case +	Base Case

Notes:
1) Includes potential permitting, construction and schedule impacts.
2) Includes wildlife, tundra/surface drainage, long term mitigation and restoration, subsistence and public access impacts.
3) Lower = 25 to 50 % lower, higher = 50 to 100 % higher, significantly higher = more than 100 % higher.
\+ Indicates cost increase relative to Base Case. See text for details.



ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
EXPORT PIPELINE ROUTE MAP

DATE:	SCALE:	FIGURE:
February, 2003	1" = 2.5 Miles	6 - 2

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