Caribou Mitigation Plan for the Meltwater Project on the North Slope of Alaska, 2001

PHILLIPS Alaska, Inc.

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I. INTRODUCTION AND PROJECT BACKGROUND

PURPOSE AND NEED

This mitigation plan has been prepared as part of the permitting process for the Meltwater Project constructed by Phillips Alaska, Inc. (PAI). The purpose of the mitigation plan is to avoid or minimize, to the maximal extent practicable, the impacts of construction and operation of the Meltwater Project—as well as any future projects using the Meltwater infrastructure—on caribou. Development of the mitigation plan and corresponding monitoring study address comments and concerns expressed by the Alaska Department of Fish & Game (ADFG), the U.S. Fish & Wildlife Service (USFWS), the North Slope Borough (NSB), Kuukpik Subsistence Oversight Panel (KSOP), and local residents of Nuiqsut during the preapplication process and public review for the U.S. Army Corps of Engineers permit. The first draft of the mitigation plan was based on two meetings attended by ADFG, USFWS, PAI, and ABR in Fairbanks on October 3 and October 19, 2000. This final revised version is the result of further review and refinement of the plan following review meetings held in Fairbanks on January 11 and April 19, 2001.

PROJECT DESCRIPTION

The Meltwater Development Project is a new drill site with an associated 10-mile road, elevated pipeline, fiber optic cable, and powerline, located south of the Kuparuk River Unit (KRU) Drill Site (DS) 2N, the southernmost pad constructed for the Tarn Project in winter 1997–1998. Details of the project proposal were provided by PAI in the permit application materials submitted for agency and public comments in August 2000, and as modified through subsequent review and discussions.

The permitted development alternative for the project includes the following components:

- A single drill site, designated DS-2P;
- A gravel access road extending north from DS-2P to DS-2N;
- Three adjacent pipelines, constructed on a single set of vertical support members (VSMs), to transport water, miscible injectant, and produced fluids between DS-2P and CPF-2;
- An aboveground powerline from DS-2N to DS-2P;
- A fiber optic cable and communications tower; and
- A new gravel mine site (Mine Site S).

II. ISSUES OF CONCERN

The Meltwater Project is being constructed in an area that has been used by caribou of the western segment of the Central Arctic Herd (CAH) during the calving season from the late 1980s through the 1990s. Although the most concentrated calving activity has occurred east of the Meltwater project area, relatively high densities have occurred there occasionally (see color map figures in the Meltwater permit application binder and Burgess et al. 2000), primarily in years when snowmelt was delayed and calving occurred farther inland than in years of early melt.

After calving, caribou remain in the general area until mosquitoes emerge, which has occurred between June 20 and June 30 in recent years. During periods of insect harassment in late June and July, caribou move north out of the Meltwater area, returning only when insect activity is suppressed by cool, windy weather conditions (Burgess et al. 2000). In most years, variation of weather conditions between warm, calm periods and cool, windy periods keeps caribou north of the Meltwater Project area; 2000 was unusual in this regard, with a fair amount of caribou activity in the Meltwater Project area in July (Burgess et al. 2000).

Inland dispersal of caribou into and south of the Meltwater Project area begins to occur by August, and caribou may be found in the area in small numbers through the period of fall migration in September and into the rut in October. Late summer and fall migratory movements reported by Nuiqsut residents indicate that caribou also cross the study area when moving west toward the Colville River and Nuiqsut. Although winter surveys of the Meltwater area have not been conducted, the available evidence indicates that few CAH caribou remain on the Arctic Coastal Plain in the winter months (Murphy and Lawhead 2000).

SEASONAL PERIODS

Calving Season

During the calving season (late May–mid-June), the primary development issue is potential displacement of maternal caribou from calving areas because of behavioral disturbance by human activities or physical barriers to movement. Energetic stress resulting from decreased quality or quantity of forage intake and greater exposure to predation are the major potential consequences of displacement from preferred habitats. Post-parturient females are sensitive to disturbance and avoid roads and gravel pads with human activity for up to 2–3 weeks after birth, within a zone of localized displacement that ranges from 1 km to 4–6 km (Dau and Cameron 1986, Lawhead 1988, Cameron et al. 1992, Cronin et al. 1994).

Insect Season

For this project, the ability of caribou to move unimpeded from the calving grounds north to insect relief habitat is important. During mid- to late summer (late June to mid-August), access to insect-relief habitats is the primary issue of concern. Harassment by mosquitoes and oestrid flies are the dominant forces influencing caribou movements during this period, with caribou moving repeatedly between inland foraging areas and coastal insect-relief areas (White et al. 1975, Lawhead and Curatolo 1984, Smith 1996, Murphy and Lawhead 2000). These oscillatory movements are most pronounced during the period when mosquitoes are most active (late June–late July). Energetic stress resulting from increased time spent under insect harassment, increased movements, and corresponding decreases in the quality or quantity of forage intake are the major potential consequences of displacement from preferred habitats in this season (White 1983, Murphy et al. 2000). The condition of female caribou entering autumn has been linked to the likelihood of successful reproduction the following year (Cameron et al. 1993). This energetic pathway is the most likely way in which development-related impacts on individual females might be expressed at the population level (Murphy et al. 2000).

Late Summer and Fall Migration

Telemetry data from the 1980s indicate that caribou of the western segment of the CAH begin dispersing inland to the southwest by August. Caribou are the most important land mammals harvested for subsistence in northern Alaska. The harvest of caribou by local residents of Nuiqsut reaches annual peaks in late summer and fall (July–October; Pedersen 1995, Brower and Opie 1997, Fuller and George 1997). At that time, local hunters expect caribou to move from the east and become available for harvest in traditional subsistence hunting areas at various locations along the Colville River. Local residents have reported that caribou have not been available for harvest at times and in places where they were expected in the last few years, and are very concerned about the potential for elevated pipelines to deflect migratory movements away from traditional hunting areas. For this reason, the North Slope Borough added stipulations to the Meltwater permit specifically requiring PAI to study the migratory movements of caribou in the Meltwater area.

CUMULATIVE EFFECTS

The principal concern of resource agencies with regard to cumulative effects of oil development on Central Arctic Herd caribou is the potential for progressive displacement of maternal females from perennially used calving areas. Displacement from large areas of the calving grounds would raise the possibility that herd growth might slow or even decline. This concern is based on the two observations that (1) oil development continues to expand in the area west of the Kuparuk River, the region in which about half of the Central Arctic Herd has calved since at least the late 1970s, and (2) maternal caribou consistently show localized displacement from habitats within 4–6 km of roads with unrestricted traffic during and immediately after the calving season. Thus, the concern is that continued expansion of oilfield development may cause the area of displacement to expand accordingly.

Concerns about cumulative effects during the insect season relate to the energetic costs stemming from repeated episodes of deflections or delays in crossings at multiple pipeline/road corridors. Local residents of Nuiqsut are concerned that construction of new elevated pipelines has the potential to cause large-scale deflections of migratory movements that have been relied on to bring caribou within traditional hunting areas for subsistence harvest.

UNDERLYING ASSUMPTIONS

1) Behavioral sensitivity and responses to human activities and infrastructure vary with season, so that mitigation in one season may not necessarily be effective in other seasons. Therefore, mitigation to avoid or minimize displacement during the calving season (which is thought to result from a predator-avoidance response) would differ from mitigation to minimize disruption of movements across pipeline/road corridors during the insect season (which result from the conflicting responses of minimizing insect harassment and maximizing access to forage of higher quality or quantity) and fall migration.

2) Perennial use of specific areas of habitat for calving, insect-relief, and migratory movements reflects the importance of such areas for successful calving and rearing of calves (and thus for maintenance of herd productivity) and for subsistence harvest. For the purposes of this study, it is assumed that the broad patterns of habitat use seen in recent years will continue through the course of the study. This assumption will be examined by the monitoring study with regard to late summer and fall migratory movements, in particular.

3) Reduction of human activity to the lowest practicable levels on the road will reduce the zone of local displacement during the calving season. As is described in the Plan of Operations below, convoying of traffic on a restricted-access road will be the approach used to minimize displacement. Although the concept has been discussed for mitigation (Cronin et al. 1994, Murphy and Lawhead 2000), this plan represents the first time that traffic convoying has been implemented during the calving season on the North Slope. A basic assumption underlying the traffic control plan is that predictability of traffic on the road (low speed and frequency) will reduce disturbance and promote habituation of maternal caribou to the presence of vehicles, thus reducing the area of displacement. This assumption will be evaluated by the monitoring study.

4) Elevation of the pipeline (in this case, to a minimum of 7 feet above ground level during the snow-free period) and separation of the pipeline from the road by at least 300 feet will minimize the incidence of deflections and delays by caribou moving to and from insect-relief and foraging areas during the insect season, based on previous research in the North Slope oilfields. The extent to which the Meltwater pipeline may deflect migratory movements will be evaluated by this monitoring study and by telemetry studies to be conducted by ADFG (standard radio telemetry) and jointly by the NSB Department of Wildlife Management, ADFG, and BLM (satellite telemetry).

III. MITIGATION GOALS

The primary goals of the mitigation plan are to minimize the impacts on caribou associated with the Meltwater Project and all other future projects in the area and to design a study to evaluate the effects of the mitigation plan. The intent is to minimize negative impacts by controlling the variables known or suspected to have affected caribou in other areas, and then to measure the remaining impacts, if any, of the activities regulated under the plan.

The specific objectives of the mitigation plan are to

1) Minimize disturbance of caribou, especially maternal females, including behavioral disturbance and resulting displacement from preferred habitats, which may negatively affect energy assimilation or expenditure, potentially leading to decreased productivity, either on an individual or population level.

2) Minimize disruption, delay, and deflection of caribou movements during the calving and insect seasons and seasonal migrations (particularly in late summer and fall) in the Meltwater project area.

3) Assure that the mitigation plan applies to all potential future projects that use the infrastructure constructed for the Meltwater Project. Traffic controls will apply to all future traffic on the Meltwater road past DS-2N, including the Cairn prospect or other supplemental projects developed as a result of any growth-inducing effect of Meltwater construction.

IV. IMPLEMENTATION: THE PLAN OF OPERATIONS

CALVING SEASON

Restricted Access and Convoying of Traffic

The Meltwater access road will be gated by PAI at the southern edge of the DS-2N pad. Access will be restricted during the 5-week period from May 25 to June 30 each year (the caribou calving "window"). The gate will be locked and vehicles will only be allowed to drive on the road when they are escorted by a pilot vehicle during a scheduled convoy or during emergency situations (described below).

Convoy travel will be used for all work activities and travel to and from DS-2P during the period of May 25 to June 30 each year. The restricted travel corridor will consist of the entire 10-mile road section south of DS-2N to DS-2P (Meltwater), and beyond in the event that future developments are constructed in the area.

The period between May 15 and May 25 will be considered a "shoulder season" in which traffic restrictions will begin to be implemented to decrease disturbance as caribou move into and through the project area en route to calving locations farther north. In the first meeting with ADFG and USFWS on traffic restrictions for the caribou calving season, it was recommended that steps be taken just before the actual calving window to minimize displacement of pregnant cows. PAI plans to reduce traffic speeds to 25–30 mph; stockpile as much material as possible on the DS-2P gravel pad , to avoid a flurry of traffic activity right before convoying begins on May 25; and eliminate all foot traffic. Snow and ice removal from cross-drainage structures will occur during this period, to be completed before traffic restrictions begin on May 25.

Basic descriptive data on each convoy will be recorded on forms by a representative designated by PAI Operations. These data will include date, time of convoy departure and arrival, the number and types of vehicles in the convoy, whether any stops were necessary (and if so, for how long), and whether any caribou crossings were observed. Information on weather and the occurrence and extent of dust plumes also will be collected. These descriptive data will be compiled in a computer database for analysis of traffic frequency and volume.

Traffic Frequency and Volume

PAI will restrict traffic to 4 routine convoy round trips (CRT) every 24 hours and two special crew changeout CRTs per week from May 25 to June 30 during the 2001 caribou calving season. This schedule will continue to be utilized in subsequent caribou calving seasons unless a revised plan is approved. The highest traffic levels are expected to occur during the year of initial

construction and development drilling (2001) with significant reductions during subsequent operational periods. To further reduce the amount of traffic moving to and from the pad during the restricted period, PAI will defer Meltwater drilling activities during Year 2 until after the calving season ends. Similarly, potential development drilling at DS 2Q (possible drillsite located between DS 2N and DS 2P) will not take place during the caribou calving window.

The basic requirements driving the need for traffic convoys include the following activities:

- Resupply efforts associated with drilling and construction activities;
- Road maintenance, which is expected to be heaviest in Year 1 as work is conducted to stabilize the newly installed road;
- Scheduling of specialized equipment—equipment used at Meltwater will be shared with the rest of the Kuparuk field, thus some flexibility is needed in the event the equipment is required for another job elsewhere in the field;
- Vacuum ("vac") trucks for pad "dewatering" during spring melt—PAI needs to comply with its stormwater management plan and therefore will need vac trucks for access to the pad. The availability of these trucks is unpredictable because they will also be dealing with other pads in the field and the amount of water they end up dealing with is variable. Well work—wireline and coil tubing units will need resupply; and
- General operations and maintenance access.

To address concerns expressed by both ADF&G and USFWS about the volume of traffic in each convoy, PAI has refined the plan for 2001 to increase the amount of equipment staged at DS-2P before the caribou calving window, to implement alternative methods for the handling and management of fluids, and to house necessary personnel onsite. These traffic reduction measures are described further below. Specific scheduling details are described below under Convoy Scheduling.

The number of vehicles in each CRT will vary but is expected to be highest in the first year during construction and development drilling. The number of vehicles per CRT will substantially decrease during the operational phase of the project. Originally, PAI estimated that the daily traffic volume required for the Meltwater Project would be 27–55 vehicles/24 hr in the first year, 16–53 vehicles/24 hr in the second year, and 4–12 vehicles/24 hr in the operational phase (third year and beyond). Refinement of the plan of operations (as described below) has substantially reduced the volume of traffic that will need to be moved in 2001. Additional traffic required to construct and operate new projects from the Meltwater road would be required to follow the restrictions outlined in this plan, subject to annual review and refinement.

PAI is continuing to refine plans regarding the equipment that would remain on the pad versus periodically travelling to DS-2P. For example, USFWS has suggested that a vacuum truck be kept at DS-2P for surface runoff collection to avoid daily trips to and from the pad. The main obstacle to doing this is finding an appropriate way to dispose of the collected surface water. PAI is continuing to investigate disposal/injection options for this water at DS-2P. If an affordable local use/injection option can be identified, the way will be cleared to keep a vacuum truck at DS-2P for this purpose.

PAI has been developing plans aimed at reducing traffic during the caribou calving window in accordance with USFWS comments on the first draft of the plan. The following four areas have been, and will continue to be, investigated:

- Stockpiling materials,
- Delivery of water for drilling needs via pipeline instead of truck,
- Management of drilling waste,
- Housing of construction personnel at DS-2P.

Stockpiling Materials.— Over the 37 days of convoy operations, PAI will complete the drilling of the second Meltwater well, fully drill the third and fourth wells, and possibly begin drilling the fifth well. PAI plans to stockpile all drilling mud and tubular pieces needed for these wells over this period of time. This stockpiling will eliminate approximately 22 round-trips per well, or about 66 total round trips. Cement volumes sufficient for two of the wells will be stored on the pad as well, eliminating approximately 16 round trips over the convoy period.

Construction of the on-pad facilities will be underway during the caribou calving window. All modules and major equipment are currently scheduled to be set on the pad before the beginning of the travel restrictions. Additionally, the vast majority of the other construction materials needed during this period will be stockpiled at DS-2P before the beginning of the travel restrictions.

The possible use of an insulated ice pad was considered if additional lay-down space was needed. Thus far, it appears there will be sufficient space on the gravel pad to store all necessary materials.

Delivery of Drilling Water Needs via Pipeline.— Water necessary for drilling operations is typically delivered to the site in vacuum trucks. Previous traffic estimates assumed a typical well would require 50–60 loads of water over a 2- to 3-week period. PAI is planning to use one of the new Meltwater permanent pipelines to transport water from DS-2N to DS-2P during the caribou calving season. Operationally, the main risk of doing this is accelerated corrosion in the pipeline due to the transport of oxygen-rich water. PAI feels this can be mitigated by chemically treating the water. There are also additional logistics issues and costs associated with setting up the transfer equipment at each end of the pipeline, including a booster pump.

Management of Drilling Waste Products.— Significant efforts have been undertaken to reduce traffic related to disposal of liquid and solid drilling wastes associated with the drilling of Meltwater wells. Current plans are to dispose of residual liquids and fine solids by pumping them down the annuli of adjacent wells. Permits have been requested to allow shallow gravel and other large drill cuttings to be washed sufficiently for re-use as gravel on the pad and/or road. When these steps are fully approved and implemented, there should be no truck traffic on the road associated with disposal of drilling wastes. These waste-handling practices should reduce traffic levels by approximately 60 round trips per well, or 180 total round trips.

Housing of Construction Personnel at DS-2P.— PAI previously planned to house the on-pad construction workers at the main Kuparuk camp. We had estimated it would take 20 round trips

per day to transport them to/from the work site. PAI now plans to use a 50-man camp at DS-2P to house the majority of these workers. This camp will be in addition to the drilling camp already planned for DS-2P. Traffic associated with these workers cannot be completely eliminated because of needs for camp services (water, sewer, food, changeout day, etc.), but it will be greatly reduced. All possible efforts will be made to consolidate camp service activities between the drilling and construction camps. We expect a reduction of at least 10 round trips per day (~370 total round trips) from the total traffic levels.

Traffic Reductions Resulting From Aforementioned Changes

PAI's previous estimate of the traffic level on the Meltwater road during the caribou calving season averaged 44 round trips per day. Incorporating the changes noted above reduces the estimated number of round trips by 30% to an average of 30 round trips per day. The vehicle trips that are being eliminated include large vacuum and "super sucker" trucks, some of the largest vehicles that would travel the road.

Estimated Average Convoy Sizes

The gravel maintenance convoys will contain between 2 and 6 vehicles. If they average 6 vehicles per day, that leaves an average of 24 vehicles per day for the other 3 round trips, resulting in an average of approximately 8 vehicles per convoy. Based on the inherent uncertainties with the assumed input values in this analysis, PAI recommends that an uncertainty range of at least ±50% be associated with these mean estimates. The size of any individual convoy will vary over an even larger range.

Due to limited space on the DS 2P gravel pad and the need to have multiple vehicles on the pad between convoys, PAI intends to utilize the first 500' of the road extending from DS 2P as an extension of the pad for vehicle parking and staging.

Convoy Scheduling

PAI proposes to follow a fixed schedule for the first year, when the most intensive activity will occur. However, PAI will request that a more flexible system be put in place during routine operations in future years due to the reduced traffic levels and the uncertainties involved in supporting production operations.

The 2001 convoy schedule is being refined for optimal efficiency, but the basic pattern has been worked out. A total of 4 routine daily round trips and two additional weekly crew changeout round trips will be implemented The current draft of the schedule is depicted in the following table and Figure 1:

Caravan Number	Leave DS 2N	Travel Time	Arrive DS 2P	Time @ DS 2P	Leave DS 2P	Travel Time	Arrive DS 2N	Comments
1	1:00 AM	0:30	1:30 AM	1:30	3:00 AM	0:30	3:30 AM	Daily - General
2	7:00 AM	0:30	7:30 AM	3:00	10:30 AM	0:30	11:00 AM	Daily- General
Change Out	1:00 PM	0:30	1:30 PM	1:30	3:00 PM	0:30	3:30 PM	Twice Per Week
3	1:00 PM	2:00	3:00 PM	0:30	3:30 PM	2:00	5:30 PM	Daily-Gravel Maint.
4	7:00 PM	0:30	7:30 PM	2:30	10:00 PM	0:30	10:30 PM	Daily - General

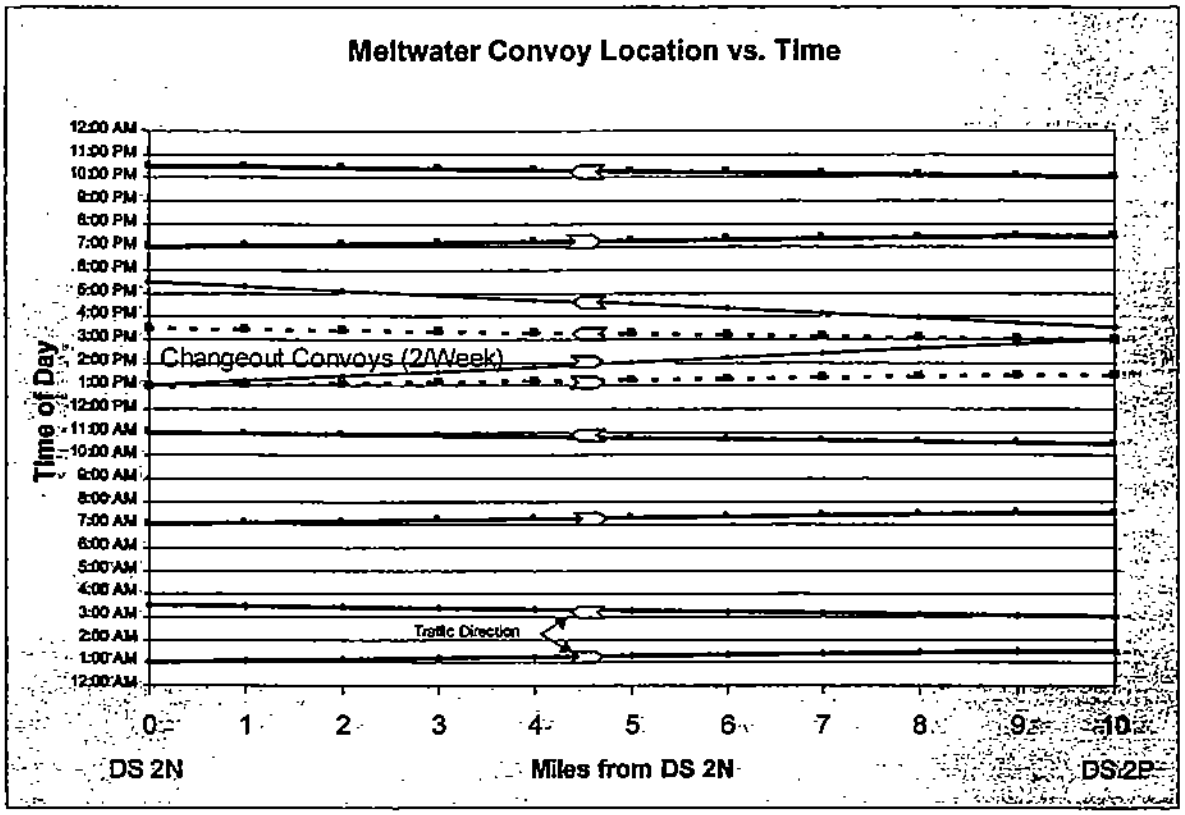

Figure 1. Convoy scheduling for the Meltwater access road during the period of traffic restriction in the caribou calving season, 25 May–30 June 2001. This graph depicts the traffic patterns for a full day along the entire Meltwater road. The *x*-axis represents location along the road from DS-2N (mile 0) to DS-2P (mile 10). The *y*-axis represents time of day, ranging from midnight (beginning of day, bottom of graph) to midnight (end of day, top of graph). Colored lines represent the legs of all convoys during the day. Points along the line represent the location of the convoy (*x*-axis) at a given time (*y*-axis). The two legs of each convoy are colored the same. The direction of convoy travel is shown on each leg. The vertical difference in time between any two convoy lines represents the time elapsed between convoy passes at that spot.

The "general" convoys are assumed to travel at 20 mph over the 10-mile length of the Meltwater road. The convoys will maintain as steady a speed as possible. The lead vehicle will set the speed, which will be closely matched by the following vehicles. This speed is a balance between the need to move slowly and predictably enough to minimize disturbance and displacement of caribou and the need to move quickly enough to reduce the amount of time that traffic is on the road.

The schedule shows that the 1:00 PM trips will be dedicated to road maintenance. These trips will consist of 2 to 6 vehicles, including road maintenance equipment such as graders and compactors. The road maintenance equipment will travel slower than the general convoys

during all or part of their trips. PAI estimates that the road maintenance equipment will average 5 mph on both legs of the trip, although they may move faster (although still less than 20 mph) if the road is in good shape.

The timing and degree of degradation of the gravel road and pad associated with the initial thawing of the frozen gravel are large unknowns at this time. PAI's only similar experience with this maintenance situation was with the Tarn road in early summer 1998. At Tarn, the road softened over a period of about 3 weeks. By the third week, rolligons were required to traverse portions the road. At that point, all drilling and construction operations were suspended for 7 days to remove traffic from the road and allow full access for road maintenance equipment. At the end of the 7-day period, the road was in very good shape and capable of supporting traffic through the rest of the summer.

PAI expects that the initial spring thaw of the Meltwater road will be less problematic than the Tarn road experience for the following reasons. First, the Meltwater gravel from Mine Site "S" is of higher quality than the gravel used for the Tarn road. Second, geotextiles and insulation materials have been used at critical sections of the road to provide for more stability and a slower thaw. Third, the steps that have been taken to reduce traffic on the road for caribou calving purposes will have the added benefit of causing much less wear and tear on the road during the initial thaw. Even with these improvements, there may be times when PAI has to send road maintenance equipment out with, or instead of, one of the "general" convoys.

Under these scheduling assumptions, the "quiet time" between the base convoys at the mid-point of the road will range from 2.0 hours to 4.0 hours.

Foot Traffic

Foot traffic on the tundra surrounding the Meltwater facilities will be prohibited during the period of traffic restriction. Foot traffic on the road itself will be restricted, and all project personnel will be advised not to leave their vehicles unless absolutely necessary for vehicle maintenance, brief close visual inspections of road or bridge conditions, or emergency purposes. Personnel will be advised to not exit their vehicles if caribou are present within a visible distance. Foot traffic on the DS 2P pad will not be restricted. PAI intends to utilize the first 500 feet of the road off the DS 2P pad as an extension of the pad for parking and traffic staging and consequently will allow foot traffic on this limited section of the road.

Emergency Conditions

Exceptions to the normal convey travel schedule will be limited to those required for "extremely urgent business." For the purposes of this plan, extremely urgent business is defined as that which is absolutely necessary to preserve the safety of personnel or to prevent potentially significant environment damage. It is difficult to specify in detail all circumstances that could constitute extremely urgent business, but the primary examples that may occur are listed below:

- Medical response;
- Fire response;
- Spill response to major fluid or chemical release;

- Operator response to a critical alarm for fire or a potentially significant spill; and
- Road wash-outs during high-water events.

Extremely urgent business would not include those actions required to maintain production, construction, or routine maintenance activities.

INSECT SEASON AND LATE SUMMER–FALL MIGRATION

The mitigation measures implemented to accommodate caribou movements during the insect season (late June to mid-August) are primarily design features of the pipeline and road corridor. It is expected that these mitigation measures should also apply to the late summer and fall migration period. Although specific research in that period has not been conducted in the study area, research efforts in 2001 and subsequent years by PAI, ADFG, and NSB will address the issue of deflection of migratory movements, through a combination of aerial and ground observations and radio telemetry (using both VHF and satellite transmitters).

Specific mitigation measures include the following, based on research conducted in the North Slope oilfields since the early 1980s (summarized by Cronin et al. 1994):

- Pipeline will be elevated to a minimum height of 7 feet above ground level (Figure 2). Where the terrain is variable (e.g., riparian crossings), this minimum will assure that pipe height will be greater than 7 feet.
- Oscillation dampeners or Tuned Vibration Absorbers (TVA) will be the "potato-masher" style rather than the hanging-ball style. The minimum ground clearance for the TVAs (at the bottom of their range of motion) will be at least 5 feet (Figure 2).
- The elevated pipeline will be separated from the Meltwater Road by 300 feet or more over as much of its length as possible.
- Drivers will be educated on the proper conduct for responding to caribou groups near the road, such as stopping completely when caribou are crossing or attempting to cross the road (and recognizing when caribou are not trying to cross); remaining inside vehicles and avoiding loud noises when caribou are nearby; and awareness and recognition of seasonal differences in caribou behavior and responses to human activities and infrastructure.

V. EVALUATION: THE MONITORING STUDY

This study plan was developed in conjunction with the mitigation plan. The goal of the study is to provide quantitative data on the effectiveness of mitigation implemented to minimize impacts of the Meltwater Project on caribou of the Central Arctic Herd, with particular emphasis on the calving season. PAI is actively seeking input from KSOP and Nuiqsut residents to incorporate local knowledge into the study review and design. The results of this study will be used to evaluate the effectiveness of the mitigation and to guide subsequent modifications of the plan, if necessary. Annual review of the plan will provide important feedback on the new mitigation technique of traffic convoying during the calving season. Specific study objectives include the following:

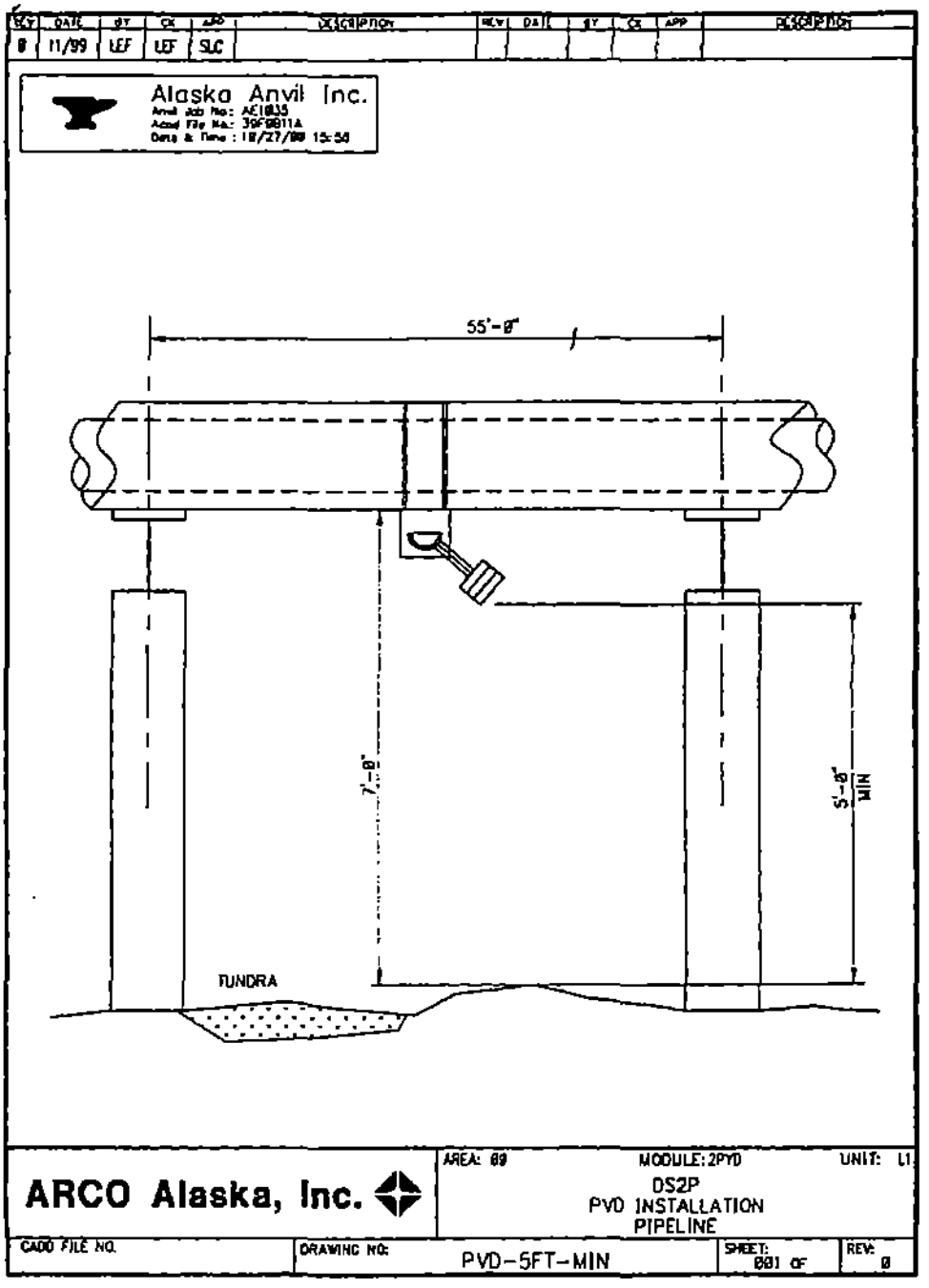

Figure 2. Elevated pipeline design (7-ft minimum clearance) with "potato-masher" style oscillation dampeners, or TVAs (5-ft minimum clearance), for the Meltwater Project, Kuparuk Oilfield, Alaska.

- Use frequent (2 per week) aerial surveys to monitor the distribution and sex/age composition of caribou in the Meltwater study area during the pre-calving, calving, and post-calving periods (15 May–30 June);
- Collect comparable distribution and composition data for caribou in the vicinity of the Tarn road (between DS-2M and DS-2N) and a reference area;
- Record responses of caribou to convoyed traffic on the Meltwater road and activities on DS-2P (possibly including mapping of caribou trails if snow conditions permit, and if a suitable mapping method can be employed without disturbing the caribou);
- Evaluate habitat characteristics (e.g., snow cover, terrain ruggedness, vegetation characteristics derived from remote sensing imagery) in the survey area to augment spatial analyses of caribou distribution within the survey area;
- Monitor caribou movements and distribution in and around the Meltwater study area during the insect season (late June and July); and
- Monitor caribou distribution in the Meltwater study area during late summer, fall, and early winter (August–October).

Other caribou surveys, supported by the Kuparuk River Unit, will provide important comparative information on the regional distribution of caribou. These regional surveys have been conducted annually since 1993 (except 1994) and provide a long-term data set that will be critical for interpreting the data gathered in the Meltwater–Tarn study area. A new VHF telemetry study (marking up to 60 newborn female calves, half of which will be collared in the general vicinity of Meltwater) by ADFG will assess calf survival and weight gain and will allow tracking of cow/calf pairs throughout the summer (in addition to the 80–100 VHF collars already deployed on CAH animals by ADFG). A new satellite telemetry study (using 10 collared animals), to be conducted jointly by the NSB Department of Wildlife Management, ADFG, and BLM, will evaluate annual movements by the western segment of the CAH, which will be helpful in identifying and delineating seasonal migrations and assessing the responses of caribou to the Meltwater infrastructure.

The overall strategy for evaluating the effectiveness of the mitigation plan will include

- evaluating the annual distribution and productivity of caribou within a regional and historical perspective;
- comparing the distribution of caribou in the Meltwater study area (restricted traffic) with the Tarn study area (no traffic restrictions) and with a reference area (no infrastructure); and
- comparing the distribution of caribou in the Meltwater study area as a function of habitat and distance from the Meltwater or Tarn roads and drill sites.

METHODS

Pre-calving, Calving, and Post-calving Season (15 May–30 June)

Aerial Surveys

Surveys will begin on May 15, ~10 days before the expected onset of calving, and will continue until 30 June, ~2 weeks after calving ends. We will survey systematically spaced strip transects

in a 389-mi^2 (1008-km^2) survey area extending 26 miles (42 km) southwest from DS-2M to 8.7 miles (14 km) beyond DS-2P and 7.5 miles (12 km) to the northwest and southeast of the Tarn and Meltwater roads. These dimensions will ensure that the survey area will be substantially wider (at least 12 km on each side of roads) than the maximal displacement distance (6 km) reported from studies in the 1980s along the Milne Point Road (Dau and Cameron 1986, Lawhead 1988, Cameron et al. 1992, Cronin et al. 1994). The survey area will be subdivided into three 7.5 × 8.7-mile (12 × 14-km) blocks (Tarn area, Meltwater area, reference area; Figure 3) for survey scheduling and for data analyses. An attempt will be made to survey the entire area on each survey day, to minimize analytical complications resulting from movement of animals among blocks.

A pilot and two observers in a fixed-wing aircraft—a Cessna 206 or airplane of similar capacity contracted specifically for this study—will follow transect lines oriented across the survey area, roughly perpendicular to the Tarn and Meltwater road and pipeline alignments. A third observer will record data. Working through KSOP, a representative from Nuiqsut will be invited periodically to accompany surveys (in place of the data recorder) as an observer. GPS receivers will be used to navigate and to record the locations of caribou along the transects. Transects will be spaced at intervals of 1 mile [1.6 km]). The two observers will survey 0.25-mi (0.4-km) wide strips on opposite sides of the aircraft, resulting in ~50% sampling intensity over the entire survey block. The distance of each group along a line perpendicular to the transect will be mapped as accurately as possible for spatial analyses. We will classify the sex and age composition of the caribou as accurately as possible, but may only be able to distinguish caribou either as "large" animals (adults and yearlings) or as calves. We will estimate snow cover visually on each survey as an index to survey conditions.

Airplane altitude will be 300 feet above ground level (agl) during the calving transect surveys when snow cover is present, and tape markers on the airplane wing struts will be used as visual delimiters of the transect strip. All other surveys (insect season and late summer–fall migration) will be flown at 500 feet agl. The lower survey altitude is required to detect caribou against the complex background caused by patchy snow cover during the period of melt, which coincides with the calving season. Past efforts to evaluate the use of other calving survey methods—such as infrared detection (FLIR)— have not produced a more effective survey method. Calving survey flights will pass by caribou in a straight line, rather than circling overhead, to minimize potential aircraft disturbance. Our extensive previous experience in this region indicates that this type of flight pattern causes very little overt disturbance of caribou, as shown by minimal change in caribou behavior. Nevertheless, this potential disturbance factor will be applied equally in all areas surveyed, thus standardizing the effect in all three survey blocks. We will attempt to quantify potential disturbance by the aircraft used in other studies in the region by contacting those investigators for records of their flight activity in the Meltwater survey area.

Ground-based Observations

A trained observer will ride in the convoy pilot vehicle to make daily observations along the Meltwater road during the period of traffic convoy restrictions. These observations will occur at all times of day to sample the distribution and reactions of caribou relative to the road and traffic. The primary objective of these observations will be to quantify and map the occurrence of caribou within sight of the road and to record behavioral responses of caribou to the vehicle

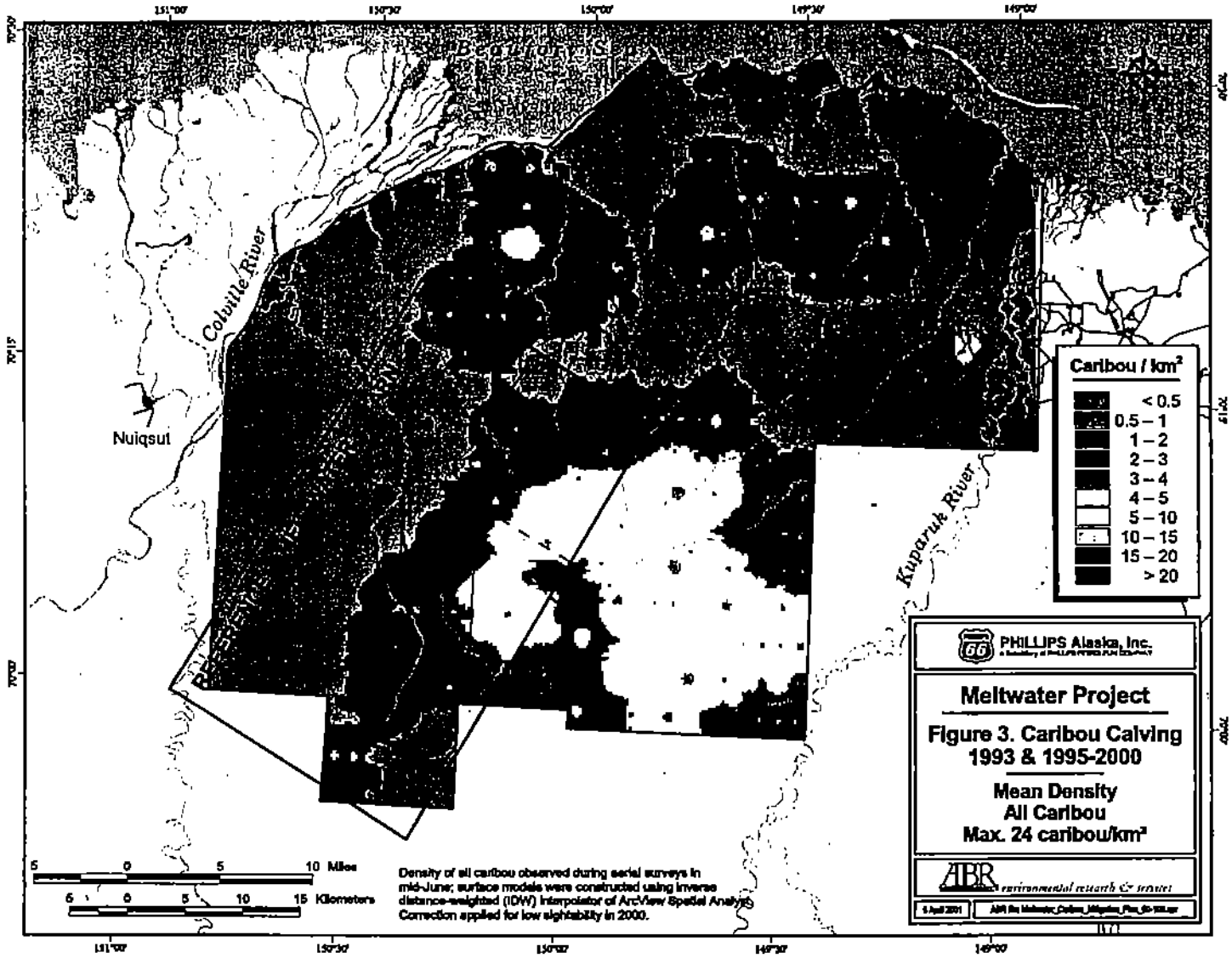

Figure 3. Caribou calving distribution (1993, 1995–2000) in greater Kuparuk area and study area boundaries for Meltwater caribou monitoring study.

convoy. Additional observations will be conducted from the DS-2P pad during construction and development drilling, to observe and map caribou movements near the pad. Observations will be made along the Meltwater (restricted traffic) and Tarn (unrestricted traffic) roads. Traffic data along the Tarn road will be sampled for comparison with convoy traffic on the Meltwater road.

Habitat Analysis

The principal challenge for the calving-season portion of the monitoring study will be to differentiate between the human and natural factors influencing the distribution and abundance of caribou in the survey area. No disturbance study can draw meaningful conclusions without first accounting for natural environmental factors such as habitat and weather conditions. Regional survey data collected since 1993 (e.g., Burgess et al. 2000) have been used to delineate classes of caribou density averaged over all years (Figure 3). This average pattern of use shows a strongly increasing gradient of caribou density proceeding east from the Meltwater road. To understand the distribution of caribou across the landscape, various factors identified by caribou biologists as being important for habitat selection by caribou will be quantified and analyzed. Without this understanding, erroneous conclusions may be drawn. For instance, the increasing density of caribou with increasing distance from the road probably would be interpreted as avoidance of the Meltwater facilities if the underlying density gradient were not already documented.

Only part of the aerial survey block used in this study has been mapped for detailed vegetation and habitat features as part of the Meltwater project. Therefore, we will use existing information from other sources to characterize habitats within our survey block, including snow cover and vegetation green-up from satellite imagery (e.g., Normalized Difference Vegetation Index [NDVI]; Wolfe 2000), digital elevation models (DEM) or terrain ruggedness index (TRI) models (Wolfe 2000), and vegetation maps (e.g., Muller et al. 1998 and existing maps produced by ABR for the Meltwater and Tarn areas). This detailed habitat information will be important for evaluating differences in caribou distribution in relation to infrastructure.

Several different analytical approaches will be possible with this survey design. The following approaches are being compared as selection of the analytical design continues:

- *Comparison with random points* — Random points can be generated in *ArcView GIS* for comparison with actual locations using logistic regression. This approach incorporates multiple variables such as area (survey block; distance to roads with and without mitigation; distance to pad; terrain ruggedness index; snow cover; habitat type) to compare actual locations with random locations.
- *Quadrat approach* — Grouping data into quadrats (e.g., 1 x 1 km) allows comparison of the caribou density in each quadrat based on distance to roads, snow cover, NDVI, date, block, etc. This can be conducted using general linear models with density as the dependent variable.
- *Analysis of variance (ANOVA)* — Simple comparisons can be conducted of distance to road among the three study blocks using ANOVA.

Most of the reference block, as well as locations in the other two blocks outside the maximum zone of influence of the road, can be used to compare habitat variables (NDVI, terrain

ruggedness index, snow cover, etc.) to caribou locations in the absence of a road to explore the influence of habitat variables on distribution. Through comparison with caribou locations near the road, we can determine how caribou densities near the road vary from expected values based on habitat variables.

Insect Season (July)

We will conduct aerial and road surveys during the insect season (the time of year when mosquitoes and oestrid flies harass caribou) to document the movements and abundance of caribou in the Meltwater study area. These surveys will be done opportunistically and in large part will not be systematic; rather, we will time our efforts to conduct surveys when aggregations of caribou are in the study area, as indicated by the regional Kuparuk study. An observer stationed at the Kuparuk base camp throughout July will monitor the regional distribution and movements of caribou and will use that general information to focus the timing of Meltwater-specific surveys. Regional observations during July will include daily weather conditions, levels of insect harassment, and caribou movements, which will be tracked primarily by aerial reconnaissance surveys using a helicopter or fixed-wing airplane, depending on availability.

When specific surveys are conducted in the Meltwater area, we will use a GPS receiver and maps to record the location of caribou groups. We will record group type (cow/calf-dominated, bull-dominated, mixed sex/age) and, when possible, age and sex composition of groups (bull, cow, yearling, calf, and unknown). Most surveys will be conducted "group-to-group" and will not follow transect lines. Whenever caribou are abundant and widely distributed, however, we will conduct systematic surveys similar to those conducted during calving. Road surveys will be conducted to provide detailed observations of caribou attempting to cross the Meltwater pipeline/road corridor. When caribou are present in the area in this season, we will select and follow focal groups of caribou to map and describe their movements and behavior in the Meltwater study area. Crossing attempts will be described in detail.

Fall Migration and Rut (August–October)

Aerial surveys will extend beyond the calving and insect seasons to further address issues of concern for local residents of Nuiqsut. As was described above, these issues are the ability of caribou to cross elevated pipelines and the potential deflection of migratory movements that subsistence hunters have come to rely on for harvesting caribou, the primary land animal in North Slope subsistence economies. Whenever feasible, knowledge about local caribou distribution and habitat use will be obtained from local residents for integration into the study. This effort will be facilitated through ongoing interactions with KSOP.

Beginning at the end of the insect season, systematic transect surveys will be flown at biweekly intervals over a broad area in the region between the Kuparuk Oilfield and the western Colville Delta, including the Meltwater study block. Surveys will be flown at 500 feet agl on north–south-oriented transect centerlines, with two observers viewing half-mile- (800-m-) wide strips on each side of the airplane. Transects will be spaced at intervals of 1 mile (100% sampling intensity) in the Meltwater study block and 3 miles (33% sampling intensity) outside of it. These surveys will complement others flown for PAI at similar intervals in the eastern NPRA, affording broad coverage of much of the hunting range of Nuiqsut-based subsistence hunters in

late summer and fall. Data collected on these flights will include date; precise map location (using GPS); group size; group composition, if possible (group type, at minimum); activity and direction of movement. Special attention will be given to groups observed in the Meltwater study block, particularly if they are moving on a course that would intercept the Meltwater pipeline and road corridor. If inclement weather prevents aerial surveys, then road surveys on the Tarn and Meltwater roads will be substituted.

In addition, data from VHF and satellite telemetry studies will be requested from ADFG and NSB Department of Wildlife management, respectively, to aid in interpreting the effects of the Meltwater project on caribou movements.

VI. MODIFICATION: PERFORMANCE REVIEW

An annual progress report discussing implementation of the plan of operations and reporting the findings of the monitoring study will be submitted to interested agency representatives from ADFG, USFWS, NSB, KSOP, and COE by March 1 of the year following each field season. The results of the monitoring study will be used to gauge the effectiveness of the mitigation measures incorporated in the plan of operations, thus providing a basis for modifying the plan for the following year. The basic goal of the performance review is to use quantitative data from the monitoring study to adjust elements of the plan and thereby reduce project impacts on caribou to the lowest practicable level. The criteria for plan modifications will be developed through consultation with ADFG and other agencies. It is expected that these criteria will evolve over the life of the mitigation plan as monitoring results become available and are evaluated and discussed by various agencies through a series of meetings.

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