Alaska Conference Proceedings

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Oil Field Operations on the North Slope: Melding Technology with Environmental Harmony
Remarks by
Robert W. Gee
Assistant Secretary for Fossil Energy
U.S. Department of Energy
in the
Established Oil Technologies and Practices on Alaska's North Slope Workshop
Anchorage, Alaska
April 25, 2000

Thank you, Gay. It is a pleasure to be here today. Yesterday, I spent a full day exploring the northern part of this beautiful and very large state. Being a native Texan, you know that we often boast of being the biggest and best at everything. After viewing just a small portion of Alaska's land mass, Texas seems to be about the size of Rhode Island.

We, at DOE, are proud to sponsor this conference along with the State of Alaska. I also want to point out that we appreciate the cooperation from the Bureau of Land Management, the Minerals Management Service, the State of Alaska, the Alaska Oil and Gas Association, BP-Amoco Alaska and ARCO Alaska, Inc. I would also like to recognize the DOE staff in the audience who helped make this happen. This includes two employees of our National Petroleum Technology Office in Tulsa, Rhonda Lindsay and John Ford; Bill Hochheiser of our Washington Headquarters staff; and from our Idaho National Energy and Environmental Laboratory, Greg White.

Most importantly, I want to thank everyone in attendance today for making a concerted effort in making this conference happen. Without your questions, without your technical expertise, and without your presentations, it is impossible to receive the feedback that is so essential to improve upon our industry's established practices and technologies.

The success of this workshop depends on the contributions of all the parties here. I see this as a team effort that will result in a database of information that can serve as a tool for State and Federal agencies, industry, academia and other institutions seeking knowledge of oil and gas operations on the North Slope or in similar environments. By sharing this information, really listening to each other, and making the data available to all, we advance the twin goals of environmental protection and resource development -- benefiting everyone.

As most of you know, the U.S. oil and gas industry employs 1.4 million people and generates about 4 percent of the U.S. economic activity. It is larger than the domestic auto industry and larger than education and social services, the computer industry, and the steel industry combined. In just the exploration and production sector alone, nearly 326,000 people were employed in 1998. The health, vitality and stability of this industry are necessary for our Nation to maintain a robust economy and to protect our Nation's energy security.

ADMINISTRATION'S ACTIONS TO PROTECT INDUSTRY

As you know, this industry has been on a roller coaster ride these last 18 months. The President and Secretary Richardson remain committed to actions to strengthen our own domestic energy security and to protect those Americans that can be harmed most by price fluctuations. These include proposals to permit additional tax credits and other initiatives to diversify domestic energy supplies; tax incentives to stimulate and maintain oil and gas production; and, continued investment in better technology to boost oil exploration and production. Other initiatives announced by President Clinton during his March 18th radio address include the proposal to establish a regional home heating oil reserve in the Northeast that could supply additional heating oil to the market in the event of a supply shortage; reauthorization of the Strategic Petroleum Reserve; and a request for more than $1.4 billion in budget requests aimed toward energy efficiency and alternative energy technologies.

Many of you will be interested in the tax incentive package which proposes new steps to support new domestic exploration and production, and to lower the business costs of producers when oil prices are low. These proposals will cost less than $1 billion over 10 years. Additionally, the President is asking for support for domestic exploration and production by adjusting the treatment of the costs of exploration and development – geological and geophysical costs – in the tax code. Current law allows deduction of these costs in the present year if exploration activity was unsuccessful, but requires capitalization if the exploration is successful. By modifying the law to allow industry to expense these costs uniformly, we will be encouraging the discovery of new reserves.

The Administration is also proposing that producers be allowed to expense delayed rental payments, thereby reducing the cost of doing business on Federal lands. Currently, the Federal tax code requires delayed rental expenses to be capitalized to the depletable base of the property to which they relate if the property is being held for development.

TECHNOLOGY DEVELOPMENT

In addition to the initiatives I've just mentioned, our Office of Fossil Energy continues to support the research and development of technologies to increase the efficient production and utilization of our Nation's domestic resources. Our petroleum technology efforts fit into two primary categories:

Preventing near-term abandonment of still-productive resources through the transfer of existing and improved oil and gas production technologies to domestic producers, especially the smaller independents; AND
Developing longer-range technologies that can ultimately produce the full potential of the U.S. resource.

In our Office of Fossil Energy, we are putting a large emphasis on energy efficiency. This is part of our "greener, sooner" strategy. For example, our Vision 21 concept is a prime example of "front end" energy efficiency – potentially doubling the amount of electricity that can be generated from a given amount of fuel.

Much of this new electric generating capacity – perhaps as much as 90 percent – will be fueled by natural gas. The technology of choice will be the gas turbine. Following an eight-year partnership with industry, a utility-gas turbine was tested in Greenville, South Carolina, that breaks the 60 percent efficiency threshold – the "four minute mile" of turbine technology. The new machine also cuts nitrogen oxide emissions in half from today's average, releasing less than nine parts per million with no expensive post-combustion controls.

We have also made memorable advances in clean coal technology, fuel cell technology and carbon sequestration.

Let us not forget that technology and best practices are enabling us to move quickly and continue to improve the very way we operate. We must "put our best technology foot forward" to meet our country's ever increasing appetite for petroleum and natural gas, while minimizing the impact on the environment.

TECHNOLOGY LEADS TO ENVIRONMENTAL STEWARDSHIP

From discovery to production, the entire oil and gas development cycle typically spans seven to ten years in frontier, hostile, or especially sensitive environments. Today, technology is enabling a quicker turn around. How technology has lessened the "environmental footprint" in the arctic region can be demonstrated by the following examples:

Drill pad size has decreased by more than 80 percent, from 65 acres with older pad designs used at Prudhoe Bay to less than 10 acres;
Horizontal drilling has greatly reduced the number of pads required to access target oil-bearing zones. Reservoir targets miles away from the surface well head can be tapped by extended reach wells, further reducing the number of drill pads needed;
Roadless development is eliminating long-term impacts to the tundra. Drilling can take place in winter on ice pads that leave no mark on the tundra after operations are completed;

Used drilling fluids and rock cuttings can now be disposed of by injecting them into underground formations, eliminating surface discharges and mud-reserve pits; and

Insulated pipelines can be laid inches above the surface without damaging permafrost and run beneath rivers through horizontally drilled tunnels.

The Alpine Project is a good example of technology and operating improvements in North Slope Development. To develop 365 million barrels of oil, industry has reduced the total surface footprint to only 97 acres – less than two-tenths of one percent of the 40,000-acre field.

ACCESS TO FEDERAL LANDS

A large portion of the best remaining domestic oil and gas prospects lie on Federal lands or beneath Federal waters overseen by BLM, the Forest Service, MMS and others. The Federal Government owns 657 million acres, or 29 percent of the onshore land area of the United States. Federal onshore lands in Alaska account for 31 percent of the government-owned acreage, while 62 percent of Federal onshore lands are located in 11 Western states.

Our Federal lands contain as much as 43 percent of the crude oil and 53 percent of the natural gas technically recoverable. Additionally, we are seeing a boost in production from our Federal offshore tracts. We have experienced an increase from 16.2 percent of domestic oil production in 1980 to nearly 27 percent in 1997. And the Federal share of domestic natural gas production has increased from 30.2 percent in 1980 to more than 39 percent in 1997. Oil and natural gas production on Federal lands is also an important revenue source. In 1997, the U.S. Treasury received $6 billion in royalties, bonuses and rents from production on U.S. Government lands.

While some acreage, such as the Arctic National Wildlife Refuge (ANWR) and certain portions of the Outer Continental Shelf, remains off limits as a matter of policy, the Administration supports oil and gas activities in other areas. As you know, ANWR has been set aside as a protected wildlife refuge for its inherent environmental values. Conversely, however, the National Petroleum Reserve - Alaska (NPR-A) has been designated as a petroleum reserve. We must direct our best efforts to this Reserve and other new fields on the North Slope.

NATIONAL PETROLEUM RESERVE (Alaska)

Specifically, in 1998, the Department strongly supported the rational and environmentally responsible development of the National Petroleum Reserve-Alaska. Many say that this is only a small fraction of our domestic demand. While it is true that we cannot drill our way to energy independence, our domestic oil supply is composed of numerous production streams, large and small, and all of them are vital to the whole. The NPR-A remains an integral part of our production capacity, and that is why this Administration decided to open that land for production leasing in 1999.

Further, on the North Slope, we see a high probability of gas reserves being developed eventually. For example, on the North Slope alone, approximately 25 trillion cubic feet of producible gas-in-place could be accessed with a cost-effective approach such as GTL technology.

I believe it is important to note that the estimated recoverable oil resources of the Reserve are equivalent to 14 percent of our present domestic oil reserves. The natural gas resources are also significant. DOE believes that the benefits of the Reserve's natural gas resources should currently be considered. This is because during the 10 or more years it will take to reach commercial development, substantial shifts in gas markets and major improvements in technologies for gas recovery and delivery are anticipated.

MULTIPLE-USE POLICY

The Department believes Federal lands should be managed to achieve a balance among multiple uses, including environmental protection, subsistence activities, recreation, minerals recovery and other economic purposes. Through rational, reasonable and environmentally protective practices, energy extraction can meet our energy policy goals while achieving good land management results.

JOINT STEWARDSHIP

Stewardship of public lands also requires close collaboration of industry and government. In the arctic region, protection of our national treasures entails complex logistical, organizational, and operational challenges. The oil and gas industry, in collaboration with the Department of the Interior and other Federal and State agencies, has employed a variety of advanced technologies and creative technologies to operate effectively in these areas to promote the necessary environmental stewardship.

Regarding industry, I applaud your commitment to environmental excellence when exploring or producing on Federal lands. Witness Unocal Alaska's award-winning operation in Alaska's Kenai Wildlife Refuge. Or Conoco's management of its operations in the Aransas National Wildlife Refuge on Texas' Gulf Coast. These operations demonstrate the ability to engage in environmentally responsible operations on our Nation's public lands - and advanced technology is playing a large part in this success.

We can be team players. But more important, we must be team players. Earth Day was just last Saturday. We have made great strides in protecting our lands since the first Earth Day. How we treat the Earth – our lands and our waters – is how we treat ourselves.

Roman emperor and philosopher Marcus Aurelius said, “That which is not good for the beehive cannot be good for the bees.”   Those are words that not only the oil industry can live by, but, words we can all live by.

Thank you for giving me the opportunity to share my thoughts with you.

Oil and Gas Development on Alaska's North Slope State Agency Perspective

Michele Brown
Commissioner
Alaska Department of Environmental Conservation

A very warm welcome, particularly to those who are visiting Alaska. Warmth carries a lot of significance to us this time of year as we go into our brief summer.

We're all here for this discussion today because although our perspectives and our political objectives may vary on the issue of Arctic oil development, we all do share one common goal – and that is to ensure that if oil and gas development does continue in the Arctic, it must be done right. This means a meaningful, continuous commitment to the identification and the use of Best Management Practices and Best Available Technologies. Because arctic conditions are so extremely harsh, they often mask just how extraordinarily fragile the systems existing there are. Impacts in the Arctic are greater, and they last longer than in any other environment. Yet in the Arctic, we are frequently more dependent upon this system and these resources. It forms our economy, our basic needs, and for many of us even our very sense of being.

Our job during this week is to recognize our common obligations for environmental stewardship, and to learn from each other how best to enhance that obligation. Environmental stewardship is not a role that Government carries alone. All who share in the benefits and uses of Alaska's oil resources must take responsibility for sustaining that environment. Our roles may very well be different, but government, industry, and interest groups all must work together to build and continually improve upon the safest and most environmentally friendly oil exploration, production, and transportation system that we have here. Governor Knowles calls it simply "Doing it Right".

"Doing it Right" is a policy direction that Governor Knowles has given me and other members of the Cabinet, and is founded on the premise that resource development must be done right or it shouldn't be done at all. "Doing it Right" for him is a comprehensive, interdisciplinary directive to manage resources so they can be used and enjoyed and sustained for present and future generations. It means that we all work with communities, citizens, and industry to ensure stewardship. It means that we protect traditional practices and cultural values, such as subsistence uses and harvest of fish and game resources. And it means providing well-paying jobs for our community and contracts for local businesses. It also has a fundamental meaning to me of challenging and partnering industry as stewards of our resources to go beyond minimal compliance.

More specifically, Governor Knowles have given us three mandates to accomplish to build the "Doing it Right" program. The first is sound science, which means to bring the latest and the best scientific information about resources to bear. That includes best technologies and local knowledge. Secondly he has charged us with prudent management: that is to ensure conservation and sustainability, rely on resident workers and contractors, and include field monitoring, verification, and local knowledge to ensure quality information and adaptive management. Third, he has required that we have responsive, meaningful public involvement. We'll be bringing in Stakeholders, communities, and citizens in an ongoing public review. Industry and Government alike will be judged by this "Doing it Right" philosophy. But to succeed, it means that we all must all build on the shared goal of responsible oil and gas development. We must take the time to understand each other's perspective and to actively collaborate.

At DEC, our goal to work with industry very early in project design, and stay involved throughout the life of the project. We expect our industry to make a commitment for continuous improvement, to using the best technology, and to making data readily available. We in government in return commit to focus on efforts to get results, and not just generate paper, and to issue prompt, fair and clear permits. And since it is the public who will ultimately judge us both, it is important that the public be brought into the process.

There have been many good examples on the North Slope of exactly what Governor Knowles calls "Doing it Right". You'll hear more details about that in the coming sessions, but I'd just like to highlight a few of them here as a preview of coming attractions.

The first is injection technologies that have led to many positive changes. Surface waste disposal pits took up a great deal of space, required ongoing fluid management, dewatering and leachate monitoring, and left significant volumes of waste exposed to the environment. Now, muds and cuttings are ground and injected, eliminating contact between the waste and the environment during generation, handling, and disposal of the muds and cuttings. This has also helped to reduce well pad size significantly. Reserve pit contents are being excavated, removed from the site, and permanently disposed of through grinding and injecting. Most produced water is now reinjected to maintain reservoir pressure and enhance oil recovery. Many exempt associated wastes and non-hazardous, non-exempt industrial oilfield wastes are disposed of through injection at the ARCO operated Pad 3, waste injection facility at Prudhoe Bay, and BP's newest injection facility at Badami. These injected wastes are permanently isolated, eliminating the hazards that are associated with medium- and long-term waste storage, transportation, and disposal.

Second, North Slope operators have conducted dozens of research studies, many in cooperation with Federal, State, and local agencies. These have given us invaluable information about the resources on the North Slope, and making sure we can track any impacts that may be happening to them.

Third, advances in technology have greatly reduced the surface area required for oilfield drilling and development. New production wells are up to 75% smaller than the original Prudhoe Bay field well pads.

And the last example I'd like to mention is that when gravel mining has occurred in active floodplains, operators in cooperation with the Alaska Department of Fish and Game have flooded the abandoned sites, increasing the availability of fish overwinter habitat, which is at somewhat of a premium in the Arctic. This has created additional water resources for industry as well.

These initiatives are excellent and deserve our commendation. However, we've got to remember that "Doing it Right" and responsible stewardship are not static concepts. Our goal has to be continuous improvement. We need ongoing reevaluation of oilfield technology and management practices, and the timely selection and implementation of best-of-class methodologies and management.

I'd like to highlight a few areas that we at DEC are working with industry on that we think deserve a lot of attention in the future. The first is Air Quality, and Peter will probably be talking some about that. We need to ensure that we are taking all reasonable steps to identify, evaluate, and implement new technologies to further minimize the emissions of air pollutants such as NOx, SOx, CO, and the greenhouse gases. We need to scrutinize our various development scenarios with an eye toward maintaining long-term compliance and the Prevention of Significant Deterioration increments.

The second area we need to pay attention to is infrastructure integrity. In Alaska, large-scale industrial development is a relatively recent phenomenon – something that has occurred to a significant degree only in the past 30 or 40 years. So since statehood we have enjoyed pretty much the luxury of a recently modern, up-to-date set of facilities. But this is now changing. Industrial facilities and pipelines, including those on the North Slope fields, are reaching the mature stage of their timelines. We all know that aging of pipelines, facilities, and equipment can be operated safely, but they must be actively monitored, inspected, maintained, and replaced as needed. So we need to recognize that these older facilities may require more frequent and more detailed oversight. Again the key is constant vigilance.

The third area that we need to focus on is spill prevention and response planning. The damage that was caused by the Exxon Valdez oil spill to the State and the problems that we all encountered in achieving a good response precipitated, as you all know, a major overhaul of State and Federal law. We have now significantly improved standards for spill prevention and response, but I think the more substantial and lasting change we have had in Alaska because of that spill is one of attitude. And that is that we no longer view spill prevention and response as fixed at a point in time, but we see the system as one of continuous improvement, requiring constant reevaluation, and a recurring challenge to both industry and regulators to go further, develop better technologies, and look for better management practices. This is especially pertinent now as we move in the North Slope, and into offshore areas where we need to be far better prepared to deal with response under broken ice conditions.

And finally, the most critical and most central part of this entire effort remains to prevent events that could lead to spills. To do this, DEC has laws that require using the Best Available Technologies. Our regulations define what technologies should be considered, and how to evaluate them to establish BAT, Best Available Technologies. An interesting point, though, is that the key concept on how to achieve BAT is actually more likely to be found in a business text than it is in an environmental statute or requirement. In that context, it is sound business and project management. Thinking about prevention and Best Available Technology must begin at project inception, it must be front and center during the design and planning phases of a project, it must carry through during construction practices; it must be upgraded during operation, and it must be designed into the ultimate cleanup and removal once the project is taken out of service.

So in closing, I'd like to note that these are some of the roles and responsibilities that we have allocated ourselves in stewardship, and some of the key issues that we need to be working on. But the only way this is going to happen is through partnerships, commitments, and practice. That is what will breathe life into the concepts of Best Available Technologies and Best Management Practices.

For partnerships to be effective, they must start very early. To quote someone a little more recent than Bob did, the American writer Mark Twain once said "when you need a friend, it's too late to get one", and that is definitely true when we're talking about oil and gas development in the Arctic. We can't wait to form productive relationships between government, industry and public interest groups until after an issue has become hot and stakeholder positions have become polarized. Each of us here today is a participant in this partnership process. We can choose whether our participation is positive or negative, constructive or destructive. I hope and urge that you will choose a positive, constructive approach and that we all work together to minimize pollution of all kinds, particularly from oil spills because of the devastating effects that they have on our communities and our resources. If we can develop the extraordinary technology that has been established to explore and produce in the Arctic, then I know that we can figure out also how to minimize the adverse effects of these activities. Today's dialog represents one more step toward the goal of ensuring environmentally sound, constantly vigilant Arctic oil development

I thank you very much for allowing me to be part of this exchange, and I hope that all of us continue to challenge ourselves to move forward and improve our commitment to responsible oil and gas development and to continue to create a course that has been started on the North Slope. Thank you.

Industry Overview – "Doing it Right" - The Alpine Development on Alaska's North Slope

Ryan Lance
ARCO Alaska, Inc.

I was in Kotzebue last week, talking to the Northwest Arctic Borough and the North Slope Borough, and in fact I see that Richard Glenn from the North Slope Borough is with us, and I guess it's a very germane topic because we were talking about the very same things that you all will be talking about over the next couple of days. So it is not just happening in Anchorage, it is happening elsewhere on a very important subject.

I don't have a quote today, but I'll actually quote Michele, and I think I'll even quote Bob during my presentation, so I think you'll see a lot of similarities, which I think is a testament to that fact that we are working together on the federal, state and on the local side, and even with the residents of the North Slope Borough in Nuiqsut. So I think I'll even quote Michele right off, when I steal shamelessly from Governor Knowles and say that we want to be doing it right.

Today I would like to discuss how the oil development in the Arctic and specifically at Alpine has set a new standard for minimizing the impact on the environment, and through the use of technology and innovative approaches, reduced the size of our development footprint. We set a high priority both on safety for our folks in the field who are working, and for the environment. Again, we call it "Doing It Right" in Alaska.

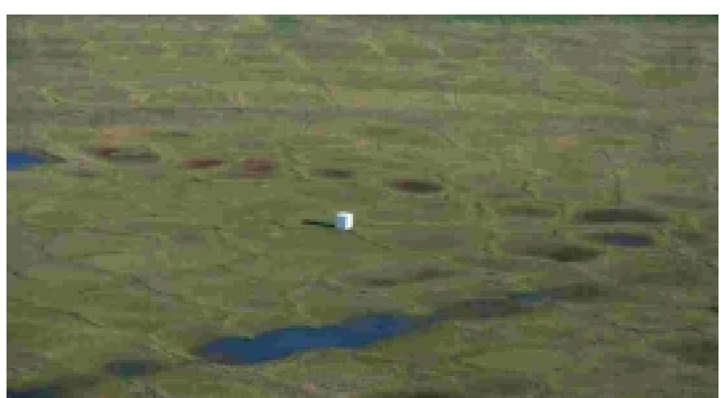
I've been involved with the Alpine oil field since it was discovered in 1994, and I'm looking forward bringing Alaska's first oil field of the new millennium on-line soon. To help you, Alpine is located about 35 miles west of Kuparuk and about 8 about miles north of Nuiqsut. The owners of the project include ARCO (or as of today, Phillips) 78% and Anadarko 22%, with a unique set of royalty owners. We have the State of Alaska, we have the Arctic Slope Regional Corporation, and their Village Corporation in Nuiqsut, which is the

Kuukpik Village Corporation, so all three will share in the royalty off of the Alpine field. Alpine is the largest discovery in the U.S. in the last decade. Bob's quoted production of 365 million barrels, but we are now at nearly 430 million barrels, so an additional 65 million barrels has been recovered, which I think that if you look at the last couple of years that the incremental recovery boasts one of the strongest in the U.S.

The Alpine project has faced many challenges, but we're on target to start up by this summer. Our challenges are like what any other Arctic - you must consider economic, geographic, environmental safety and Native issues. We've been able to address these issues using the best technology, state-of-the-art environmental practices, and closely working with the people of the North Slope Borough, like the Village of Nuiqsut and the Kuukpik Village Corporation.

Responsible development starts with exploration. The acquisition of 3-D seismic data is a key step in the exploration process. The data is collected by laying out large grids that can cover hundreds of square miles. On-shore seismic acquisition on the North Slope occurs only during the winter, and only after the federal, state and local governments issue permits authorizing tundra travel. Tundra travel doesn't begin until the tundra is frozen and there is at least six inches of snow cover. We use specialized low-impact tundra travel vehicles, and we use 3-D seismic imaging, which is much like comparing a CAT scan to an x-ray to get a 3-D image of the subsurface rock.

The next step in "doing it right" means drilling exploration wells in a responsible manner. The Alpine team took the best of the lessons learned in more than 20 years of oil development on Alaska's North Slope. This is a picture of an exploration-drilling rig at the Alpine site a few years ago. The rig was moved to this location via ice roads. It's sitting on an ice pad more than 12 inches thick, and when exploratory drilling operations were complete, as Michele talked about, all drilling wastes were injected back into the ground, or trucked back to an approved disposal site at Kuparuk, or injected back down hole. And in the spring when the ice melted there was no trace that the rig was there.



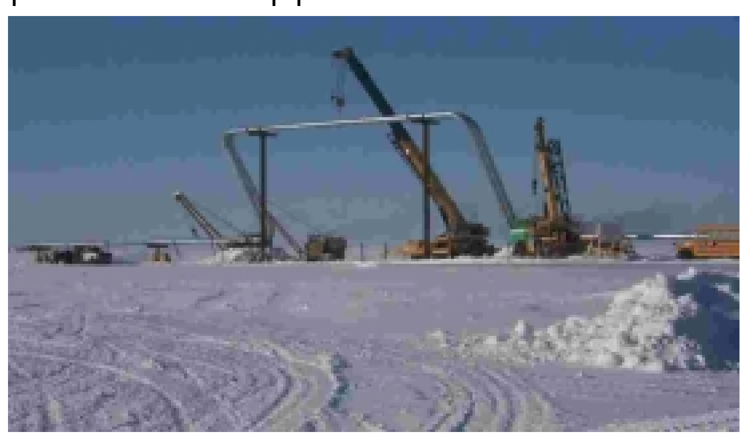
This is a photograph of the same exploratory well at Alpine taken the summer after it was drilled. Six months before this picture was taken, there was a

160-foot tall, 3 million pound drilling rig sitting on an ice pad that surrounded that well house. I think this is a picture of what it means to do it right; small impact and small footprint.

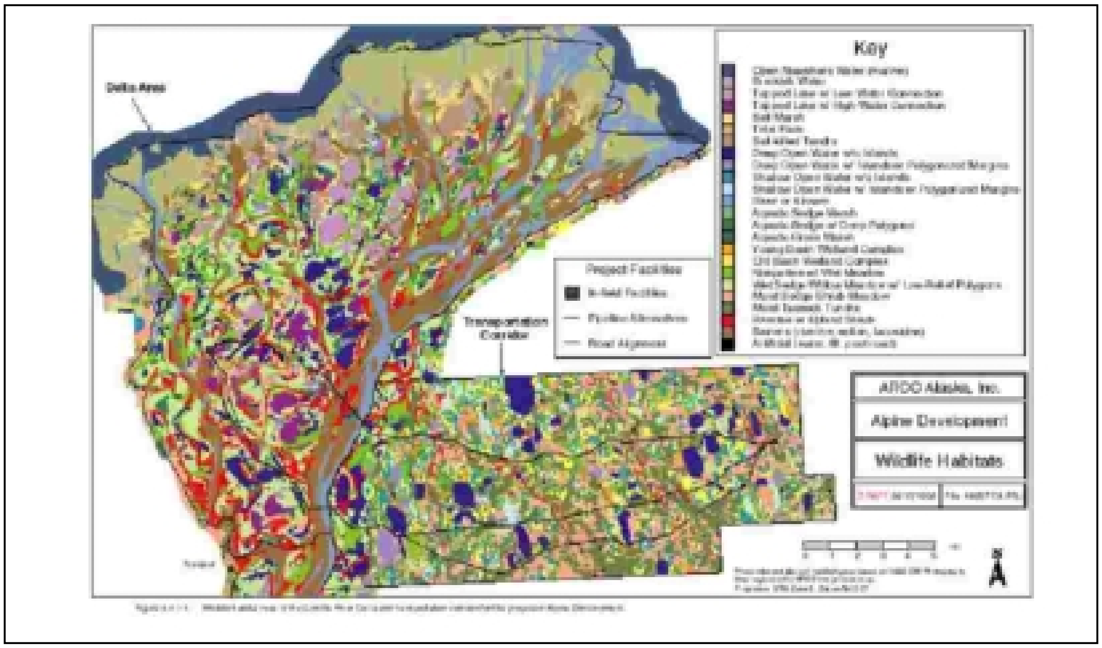
For Alpine, responsible development continued after the exploration phase as the development continued. Alpine, as Bob talked about, is a roadless development so the majority of construction occurred in the winter using ice roads to transport equipment and supplies. Just last week, we transported 15 Alaskan-built production modules to the field. The modules had a total weight of more than 15,000 tons and were moved on an ice road that crossed the Beaufort Sea. After the spring thaw on the North Slope - there will be no evidence of what we accomplished this winter -- again no impact.

Lets talk about some of the technology. Here we see the vertical pipeline expansion loops used in the Alpine pipeline design - an example of technology used to lessen the impact on the environment.

These vertical loops eliminate the need for costly valves in the pipeline and they significantly reduce the risk of an oil spill. The elevated pipeline also allows caribou to migrate unobstructed, as they seek insect relief as they travel to the Beaufort Sea. The new system is a win-win on all fronts: lower capital; lower operating expense; no periodic testing of the valves; and a better environmental solution.



Yet another example is the habitat mapping that we used for the Alpine project.



This map was developed using satellite infrared photography, and the information was verified by summer field studies on the ground. It shows 24 different habitat classifications that were identified and mapped using a geographic information system (GIS). The US Fish and Wildlife Service and the Alaska Department of Fish and Game assisted in the design of the baseline studies. The Nuiqsut residents also played a role in this process. Their traditional knowledge, their information about their subsistence lifestyle - we used that to make sure we understood the areas that they hunted and fished throughout the entire year. With this information in hand, the Alpine team modified facility designs and locations in areas where they would minimize impacts to the environment. In one instance facilities were moved away from a lake that was important to waterfowl and subsistence hunters from the village of Nuiqsut.

By the time Alpine is completed, we will have spent about $1.1 billion on the field's construction and development. More than $750 million will be spent in state, in Alaska businesses. And, it is a zero discharge development - all of Alpine's waste will be disposed on site. And as Bob indicated, the Alpine surface development encompasses about 97 acres, less than two-tenths of one percent of the land in size

Of course one of our biggest challenges, both technologically and environmentally, is how to cross the Colville River, which drains about 60% of the North Slope during breakup, and is almost a mile wide. We employed Horizontal Directional Drilling (HDD) and we were able to place over 4,000 feet of pipeline 100 feet below the water and did it safely and with little impact. The HDD technology that we employed is used all over the world, but this is the first application in the frozen grounds of the Arctic. This is what the Colville River crossing looks like today, after all the ice and snow has gone away. It was built over two construction seasons, and has met and/or exceeded the environmental challenges.

Of course none of this can be accomplished without working closely with the Inupiat residents of the North Slope. For Alpine, this meant working closely with our neighbors from Nuiqsut and the Kuukpik Village Corporation. Working with them, we've been able to create opportunities. Such as:

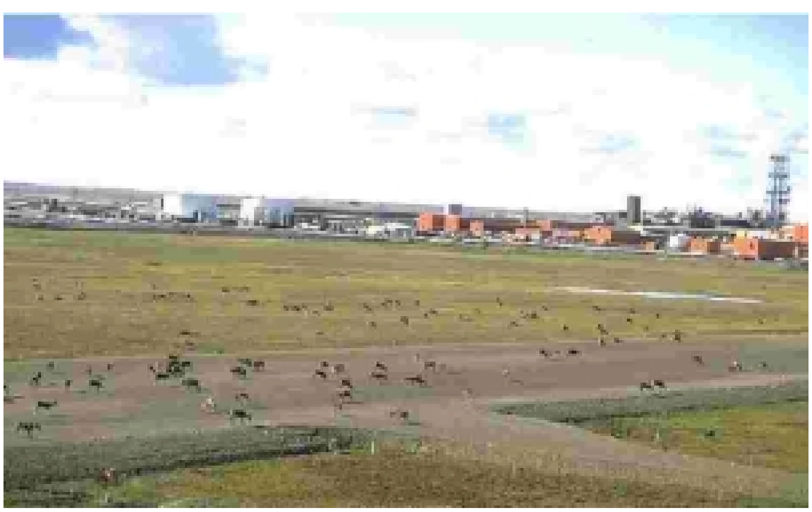
Matching scholarship program for graduating students, so they have the opportunity for a world-class education.

We have a subsistence oversight panel working on a daily basis to protect the village's subsistence lifestyle.

We will build a natural gas pipeline to improve air quality in the village and help the residents get off of costly diesel fuel.

We have put in air monitoring equipment in the village to assess the impact that the project has during the construction phase and the development phase.

And we continue to socioeconomic studies to access the impact of the Alpine project on the culture of the village, both now and in the future.



So how do we know that the improvements and technological advances we've made at Alpine make a difference? I think we need to look at our record on the North Slope for the past 20 years. This is a photograph of the airstrip at the Kuparuk oil field. In the background, you can see the Kuparuk Operations Center and the Central Processing Facility No. 1. Thousands of caribou still return to our fields to calve and rear their young. The herd is six times larger than it was in the early 70's, and our waterfowl populations are healthy. As Michele noted, we've turned our gravel mines into deep lakes that provide crucial winter habitat for fish. Crucial because most of the lakes on the North Slope freeze to the bottom. This is picture shows you what we mean by "Doing It Right". And we're getting better.

The Alpine development is on the doorstep of the Village of Nuiqsut. Through extensive research and input from local residents, future Arctic developments like the Alpine project can be developed with consideration for minimal impact. I think we have learned a lot over the years, and we're learning more every day. Minimal impact on wildlife, waterfowl and the subsistence lifestyle practiced by the residents of the North Slope.

Thank you.

Environmental Community Perspective – Established Oil & Gas Practices and Technologies on Alaska's North Slope

Written Statement of
Peter Van Tuyn
Trustees for Alaska

My name is Peter Van Tuyn, and I am the litigation director of Trustees for Alaska, a nonprofit, public interest law firm whose mission is to provide counsel to sustain and protect Alaska's natural environment. We represent local and national environmental groups, Alaska Native villages and nonprofit organizations, community groups, hunters, fishers and others where the outcome of our advocacy could benefit Alaska's environment. Our services are free of charge, and for most of our clients, we provide legal counsel they could not otherwise afford on issues that affect their ways of life.

Trustees for Alaska was established in 1974 to provide support to environmental organizations and community groups concerned about the impacts of construction of the Trans Alaska Pipeline System on the environment of Arctic and Interior Alaska, including impacts to water quality and wildlife habitat. Our work has grown since our inception to include advocacy efforts and legal cases dealing with oil and gas development, mining, hazardous waste management, air pollution, water pollution, wetlands management, land use management and protection of marine ecosystems. A significant segment of our work has always focused on limiting the environmental impacts of industrial development in America's only Arctic region, commonly referred to as Alaska's "North Slope", and the oil transportation system that sustains this development. It is our belief, and the belief of the organizations to which we provide counsel, that a balanced approach to management of natural resources is needed in America's Arctic, one that protects the region's most sensitive areas, resources and cultures. Our work in the Arctic over the past twenty-five years has focused on achieving this balance.

The focus of my statement is two-fold: first, to outline the extent of existing development in America's Arctic, including the extent of leasing that has occurred in the region and the number of new developments in the offing, the environmental impacts that have occurred from existing development, and the extent to which this development has been allowed to proceed with little oversight or monitoring; and second, to underscore the unique character of America's only Arctic ecosystem, including, most notably, the only portion of this region that has been set aside and made off-limits to industrial development, i.e., the coastal plain of the Arctic National Wildlife Refuge.

AMERICA'S ARCTIC

Stretching from the Canadian border to the Chukchi Sea, south to the Brooks Range and north to the edge of the polar ice cap, the Arctic Ocean coast of Alaska comprises a unique ecosystem. It is America's only high Arctic ecosystem. It is comprised of a vast expanse of frozen earth over which lies a complex network of treeless tundra, coastal lagoons, wetlands, streams and rivers, which in turn provide habitat for some of the largest and most unique concentrations of wildlife on the North American continent. Each summer, the wetlands of Alaska's North Slope host several million swans, geese, ducks and shorebirds. The rich saltwater lagoons of the Beaufort and Chukchi Seas provide essential calving, feeding and rearing areas for the some of the largest concentrations of marine mammals on the continent, including polar bears, Beluga whales and ringed seals. The watersheds of the region's major rivers are home to a unique population of Arctic Peregrine Falcons, as well as other raptors, including gyrfalcons, golden eagles and rough-legged hawks. The region encompasses the calving grounds of more than half a million caribou, including two of the continent's largest caribou herds—the Porcupine Caribou Herd and the Western Arctic Caribou Herd.

Progressing from the Chukchi Sea coast east to the Canadian border, the coastal plain of America's Arctic narrows as it reaches the Canadian border. The eastern portion of the coastal plain is encompassed within the boundaries of the Arctic National Wildlife Refuge. The 1.9 million acres that comprises this narrow extension of the Arctic Ocean coastal ecosystem is unique in that contains the full spectrum of Arctic habitats from the Brooks Range to the Arctic Ocean protected in an unbroken continuum. It provides essential habitat for the largest concentration of denning polar bears in America, and provides essential calving and rearing habitat for the Porcupine Caribou herd, which in turn sustains one of the nation's last remaining intact aboriginal cultures. It is truly a unique and irreplaceable part of America's Arctic. This is why it was first set aside for permanent protection by President Dwight D. Eisenhower in 1960. It is the only portion of America's Arctic that is closed to industrial development.

THE "FOOTPRINT" OF OIL DEVELOPMENT IN AMERICA'S ARCTIC

America's Arctic also encompasses some of the world's largest oil and gas reserves. Since the discovery of oil at Prudhoe Bay in 1968, oil field development in the American Arctic has entailed the construction of a massive industrial complex that now accounts for nearly 20% of the nation's domestic oil production.

Much has been said about the relatively small “footprint” of oil field development in America’s Arctic. The term, “footprint”, has been used to describe the acreage of Arctic coastal tundra that has actually been buried with an insulating layer of gravel in order to support oil field infrastructure, a total of over 9,000 acres[i]. It has been implied that this figure represents the extent of the impacts of development to the Arctic coastal ecosystem. But making such an implication is analogous to measuring the impact of a high seas drift net by measuring the amount of space it occupies as it lies curled up on the deck of a fishing boat. Since the discovery of oil at Prudhoe Bay in 1968, oil field development in America’s Arctic has entailed the construction of a vast network of seismic exploration trails, gravel mines, roads, drill pads, pipelines, processing facilities, operating and housing facilities, and waste and sewage treatment facilities that stretches like an industrial drift net across nearly 1,000 square miles of coastal tundra from the Colville River to the Canning River, and has changed forever the character of this Arctic ecosystem. Superimposed on the East Coast, this development would stretch from Washington, D.C. down Interstate 95 to Richmond, Virginia, and east to the shores of Chesapeake Bay, with two solid-fill gravel causeways below the Potomac River stretching out into the Bay and nearly reaching the Eastern Shore. It is one of the largest industrial complexes in the world.

OIL RESERVES AND OIL LEASING ACTIVITY

From the Canning River on the western boundary of the Arctic Refuge to the Colville River delta, the State of Alaska owns almost all of the oil-rich lands onshore. The only exception to state ownership are some subsurface lands in the Colville River delta owned jointly by the state and the Arctic Slope Regional Corporation (ASRC, a for-profit regional corporation created by the 1971 Alaska Native Claims Settlement Act). There are also a small number of Alaska Native Allotment Act “homesteads” in the Colville River delta, as there are in the Arctic Refuge. The federally owned National Petroleum Reserve-Alaska (NPR-A) extends from the Colville River delta west to the Chukchi Sea. Some state land inholdings are encompassed within the boundaries of the NPR-A, as are some Native allotments, as well as inholdings belonging to ASRC and Native village corporations.

The submerged lands in the offshore areas of the Arctic Ocean are owned by the state out to three miles from shore (except off the Arctic Refuge), and beyond three miles by the federal government.

Both the federal and state governments have had oil and gas leasing programs in America’s Arctic for decades. Since 1959, the State of Alaska has conducted approximately thirty lease sales in the region, resulting in the sale of oil leases that encompass some 32 million acres of state lands.[ii] Both onshore and offshore areas have been leased, such that virtually all lands between the Colville and Canning Rivers have been offered for sale at least once. In addition, the U.S. Department of the Interior (Interior) conducted a series of lease sales in the NPR-A beginning in the early 1980s, with the last sale held in May 1999.[iii] ASRC has also entered into oil and gas leasing arrangements for its wholly owned subsurface estate.

There have been six federal offshore lease sales and one joint state-federal lease sale in the Chukchi and Beaufort Seas. As a result of the federal outer continental shelf (OCS) leasing program, 660 leases encompassing 2.32 million acres have been sold,[iv] and over thirty exploratory wells drilled in Arctic federal waters between 1980 and 1997[v]. Five offshore prospects have been unitized[vi] for development (Northstar, Sandpiper, Hammerhead, Kuvlum, and Liberty.)

In June 1998, the State of Alaska offered for sale all state-owned lands not already under lease between the Colville and Canning Rivers. Despite low crude oil prices, 139 tracts spread from the Badami field in the east to the Colville River in the west were sold for more than $55 million.[vii] In addition, the May 1999 lease sale conducted by Interior in the northeast corner of the NPR-A resulted in the sale of some 130 leases for a total of $105 million.[viii]

Of these leased properties, most that lie between the Colville and Canning Rivers are either in production, are in the near-term planning/development stage, or are considered development prospects. Since 1977, 11.6 billion barrels of oil have been pumped from the producing fields.[ix] Since 1993, three new fields (Niakuk, Point McIntyre and North Prudhoe Bay/West Beach) began production, and North Star, Liberty, Badami, Alpine and Tarn are either under review for development or in progress. In addition, oil companies operating in America's Arctic have announced the discovery of onshore reserves in the Colville River Delta area that have not yet been developed. And in mid June 1998, oil companies announced two more discoveries, one in the Prudhoe Bay area and one in the Endicott area, that could total as much as 100 million barrels.[x] More than 32 oil and gas fields have already been discovered from past exploration activities.[xi] All told, there may be more than 50 satellite fields ranging in size up to 100 million barrels each found at the fringes of the producing fields.[xii]

A common theme that runs through arguments in favor of opening frontier areas like the Arctic National Wildlife Refuge to oil and gas development is the compelling need to search for new oil (usually couched in terms of providing for the nation's "energy security".) However, existing fields and new prospects within the Prudhoe Bay area hold the promise of many years of production. Industry projections indicate that production between 2000 and 2005 will equal or exceed the current rates.[xiii] An independent research report commissioned by the Alaska Legislature predicted an increase in North Slope oil and gas field "productive capacity" by the year 2005, without additional discoveries or production from the Arctic Refuge.[xiv] And the state estimates that the North Slope oil fields will produce 7 billion more barrels of oil by 2020.[xv]

OIL FIELD DEVELOPMENT IN AMERICA'S ARCTIC

The development of the existing oil fields in America's Arctic has involved the drilling of well over 2,500 exploration and production wells, construction of 400 miles of roads, placement of nearly 1,200 miles of trunk and feeder pipelines, and construction of six oil and gas processing facilities, as well as worker housing facilities and sewage treatment and power generation facilities. And it has entailed the excavation of thirteen gravel mines that collectively occupy a surface area of over 1,400 acres, from which 60 million cubic yards of gravel have been extracted to provide a layer of insulation under all production wells, permanent roads, and processing and support facilities.

All production wells are drilled from gravel pads, many wells to a pad. Huge amounts of water are injected into an oil-bearing formation to produce more oil. Feeder pipelines connect the wells to large central processing facilities, known as flow stations or gathering centers. At the central facilities, the mixture of oil, gas and produced water is separated, and recovered natural gas is used in the fields for fuel, or is re-injected into the oil formation to maintain reservoir pressure and thereby increase oil production. A road system services the fields, and a main road (the Spine Road) crosses from east to west, joined by access roads connected to the well pads. Other major roads connect to West Dock, a causeway on the north edge of Prudhoe Bay used for receiving equipment and materials from summer barge traffic. Utility lines head east and west from the Deadhorse area, transporting electricity to the fields from central power facilities.

Two companies manage oil field production in America's Arctic, British Petroleum Amoco (BP) on the west side and Atlantic Richfield Co. Alaska (ARCO) on the east side of Prudhoe Bay. Each company has a central operations center with living quarters, office space and workshops. ARCO operates the Kuparuk field, and is generally expanding to the west (e.g., to the Alpine oil field on the Colville River), while BP has continued expanding east from its Endicott field. Both companies depend on dozens of oilfield service contractors based in Deadhorse to supply drill rigs, pipeline cleaning, oil well "work-overs," oil spill clean up, seismic surveys, and other construction and operational needs. All oil produced from the fields is sent to Pump Station 1 of the Trans Alaska Pipeline System (TAPS) and then transported down the 800 mile-long pipeline to its terminus in Valdez. There the oil is loaded into crude oil tankers and shipped to refineries in the U.S., Japan, Korea and China.

The scope of oil field development in America's Arctic extends from the activities undertaken at the onset of exploration work to full oil field development and the transportation of crude oil to market through TAPS and the tankers loaded at the Valdez Marine Terminal. The portion of this development that has impacted the Arctic ecosystem begins with initial exploration work.

Seismic Exploration Activities

To decide where to drill exploratory wells for oil, the oil industry employs seismic exploration techniques. Seismic exploration uses either huge vibroseis trucks weighing 56,000 pounds, with heavy steel vibrators mounted on them,[xvi] or explosives, to produce sounds at or near the surface. This is done at thousands of "shot" points along lines that are surveyed across the tundra or offshore. Small microphones, known as geophones, attached to miles of cables are placed on the ground along the lines near the "shot" points. When the vibroseis machine or dynamite is detonated, the sounds produced, including echoes from underground rock layers, are recorded on tape. Computers process this data to produce maps of the subsurface layers.

There are many potential adverse effects from seismic exploration. Past studies of seismic exploration in the Arctic Refuge showed significant effects on tundra vegetation and permafrost.[xvii] In June 1998, after receiving objections from the Alaska Eskimo Whaling Commission representing Inupiat subsistence whale hunters, Alaska's North Slope Borough denied an application from Western Geophysical for offshore seismic exploration operations in the Beaufort Sea in several shallow coastal areas between Harrison and Camden Bays, citing new scientific information that "... showed the effects of one open water seismic survey displaced bowhead whales 12 miles from their migration path..."[xviii]

The latest development in seismic exploration technology is known as "3-D seismic" testing. 3-D seismic testing is more effective in determining geologic structures, but it can have more impact. The 3-D seismic crews are larger, and there are more tracked vehicles out on the tundra. The grid pattern is tighter. The 3-D seismic lines where vehicles travel laying out the grids of recording equipment are generally only about 1,000 feet apart. By contrast, conventional seismic lines are spaced six to ten miles apart.

The 3-D seismic crews on the North Slope in the winter of 1998 had 39 vehicles, including six bulldozers; ten vibroseis trucks weighing as much as 68,000 pounds each,[xix] fuel supply vehicles, and a variety of other vehicles all manned with a crew of 100-200 people. Typically, two crews operate at the same time in one season, so there may be as many as eighty vehicles involved.

There is strong evidence that 3-D seismic exploration activities may cause lasting damage to the Arctic tundra ecosystem. One federal biologist documenting the aftermath of 3-D seismic work reported that, "… new trails and older ones in various stages of recovery are visible from the air and on the ground in the summer. Current seismic exploration produces a much denser gird of trails than that in the Arctic Refuge. While the trails in the Arctic Refuge were five to twenty kilometers apart, those being made now are from 200 to 500 meters apart. Despite the magnitude of this activity, no studies have been published on the effects of seismic exploration on vegetation and soils in the Prudhoe Bay area and the cumulative impacts of many years of exploration and re-exploration have not been addressed."[xx]

Drill Sites in America's Arctic

The sheer number of wells drilled in North Slope oil fields gives a sense of the scale of development in the region. Some 2,586 exploration or production wells were drilled on the North Slope between 1944 and July 1992.[xxi] According to the U.S. Army Corps of Engineers (the Corps of Engineers, or the Corps), there are now approximately 1,830 oil production wells, 97 gas injection wells, and 618 water injection wells in operation in North Slope oil fields.[xxii]

Numbers for offshore development activities and facilities in the Beaufort and Chukchi Seas are equally massive. As of 1993, oil development in the Beaufort and Chukchi Seas included the placement of 216 exploration and delineation wells, 1,209 development and production wells, the laying of hundreds of miles of pipelines, construction of nine causeways, docks and pipeline landfalls, and the transit of thousands of barge and boat supply trips, tens of thousands of aerial over-flights and hundreds of thousands of miles of seismic lines.[xxiii] These figures do not reflect the extent of the infrastructure associated with the onshore support activities necessary to carry out offshore development of this magnitude.

Water Use in Arctic Oil Fields

In 1980, the Corps of Engineers estimated that domestic use of water in North Slope oil fields (for drinking, washing, food preparation, etc.) was 85 gallons per capita per day, or a total of 800,000 gallons per day.[xxiv] In addition to these domestic uses, both fresh water and seawater are used in oil field production. Drilling operations require large quantities of water for blending into drilling muds. A typical 10,000 foot well could require about 850,000 gallons of water for drilling, in addition to the amount needed for camp use. Over a four-month drilling season, a one-well drilling operation could require 1.6 million gallons of water.[xxv] For ARCO's Alpine development, the total water demand over one winter season of 150 days is estimated to be 8.4 to 14.7 million gallons.

At Prudhoe Bay, treated seawater is injected into oil-bearing formations to enhance oil production. The Corps reported there were 624 of seawater injection wells supporting existing onshore oil and gas facilities in June 1998.[xxvi] The operating capacity of these wells totals some 2,884 thousand barrels of water per day, a huge number but well below the design capacity of the facilities.[xxvii] The seawater treatment plant on the northern end of West Dock causeway supports secondary oil and gas recovery in the Prudhoe Bay and Milne Point reservoirs. In 1998, it was processing 390,000 barrels of water per day, with the capacity to process up to 1.2 million barrels per day.[xxviii]

Vast amounts of water are also needed for the construction of ice pads, ice roads and ice runways that are used to develop exploration wells and isolated fields such as the Alpine field. For example, to construct a six-acre ice pad one foot thick requires about 500,000 gallons of water.[xxix] The U.S. Bureau of Land Management (BLM) estimates that 1.0 to 1.5 million gallons of water is needed per mile for a six-inch thick, 30-35 foot-wide road.[xxx]

To put the use of such huge amounts of water into ecological perspective, it must be remembered that the Arctic is very arid. Average annual precipitation across the North Slope oil fields ranges from about three to seven inches.[xxxi] Water withdrawal from the roughly 75 active permitted onshore water sources has the potential, therefore, of causing significant environmental changes.[xxxii] In areas such as the coastal plain of the Arctic Refuge, where water is very scarce, the impacts could be far more severe.

Gravel and Gravel Mining in America's Arctic

Gravel is a resource second only in importance to crude oil in Arctic oil fields. All of the onshore oil fields in America's Arctic are located in wetlands underlain with permafrost. As a result, a layer of gravel five feet in depth or greater is needed as a foundation for production wells, permanent roads, causeways, offshore man-made islands, airstrips, gathering centers, pump stations and all other oil field facilities. And all oil field development must be reviewed by the Corps of Engineers pursuant to Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act before it can proceed. According to records compiled by the Corps, over 900 applications for filling wetlands for oil and gas development activities in Alaska were approved between January 1979 and April 1992.

Gravel for development of oil field facilities has been taken from some thirteen large, open-pit mines in the floodplains and deltas of major rivers in the region. Seven of these are currently active.[xxxiii] Together, the mines cover a surface area of over two square miles. The U.S. Fish and Wildlife Service (USFWS) estimates that more than 60 million cubic yards of gravel have been mined from these mines for roads and drill sites in North Slope oil fields,[xxxiv] enough to cover the entire state of Rhode Island with an inch-thick layer of gravel. Just as with water, gravel is a scarce resource on the coastal plain of the Arctic Refuge. Mining and transportation of what gravel resources do exist in the Refuge for purposes of constructing oil field facilities could result in significant impacts to the area.

Oil Field Transportation Infrastructure in America's Arctic

Gravel roads. The Alaska Department of Natural Resources (ADNR) estimated that oil development on Alaska's North Slope included over 400 miles of gravel roads, excluding the 13 miles of road that lie atop gravel causeways jutting into the Beaufort Sea and the 145 mile-long TAPS "haul road", or Dalton Highway, that stretches from Pump Station 1 south through the Brooks Range to the Yukon

River.[xxxv] In 1996, a survey of traffic along the TAPS haul road showed a total annual transit of 45,236 trucks, an average of 3,770 a month.[xxxvi] Recently, the State of Alaska opened the TAPS haul road to travel by the general public (over the objection of the Alaska Native communities in the region), thereby increasing the impacts of road traffic to air quality and wildlife.

Ice roads. For frontier areas in the oil fields of the Arctic, ice roads are used for winter transportation.[xxxvii] Ice roads, ice pads and airstrips are constructed by smoothing or compacting the snow surface and spraying water on the surface to build up an ice layer.[xxxviii] Ice infrastructure is often pointed to as an improvement over infrastructure built with gravel, based on the claim that the ice will melt, leaving no trace.

In order to create the ice used for this temporary infrastructure, however, water is displaced from its natural location. This may have deleterious short and long-term effects on aquatic life and vegetation. New designs for ice pad construction have allowed pads to remain intact over a summer season, and " … limited, short-term impact does occur at multi-season ice pads, if tundra around the perimeter of the pad thaws and is blocked from sunlight."[xxxix] Long-term impacts from ice roads, pads and runways are not well studied. At a minimum, there may be a "greening" of vegetation when the ice melts, leaving square strips and miles-long rectangles strewn among the natural polygonal shapes of the tundra landscape.[xl]

Airports. While much of the huge amount of equipment and supplies needed for oil development in the Arctic comes by summer barge or on the TAPS haul road, development could not proceed without air transportation. At the time the construction of TAPS was contemplated, there were already four major gravel airports in the oil fields, at Prudhoe Bay, Deadhorse, Rivers Service City, and Sagwon (60 miles to the south), in addition to airports at Barrow and Nuiqsut.[xli] There were three jet runways and nine exploration support airstrips in the oil fields by 1987.[xlii] Today, the state-owned and operated Deadhorse airport accommodates Boeing 737 jets on its 6,500 asphalt runway, with arriving and departing passengers numbering some 140,000 per year.[xliii] In addition, BP and ARCO own and operate 6,500 foot-long airstrips at Prudhoe Bay and Kuparuk. These have annual arrival and departure passenger counts of some 220,000 personnel.[xliv]

ARCO has received permission from the Corps of Engineers to build a 3,000-foot airstrip in the Colville River floodplain to service its Alpine oil field, and there is a new airstrip at the Badami development. In addition, there is a 5,200-foot airstrip at Lonely; a 7,000-foot airstrip at Inigok south of Teshekpuk Lake; and a state-owned 5,400-foot airstrip at Umiat on the Colville River southwest of Nuiqsut.[xlv] The impacts of placement and operation of these airports is not well understood.

Docks. Marine barges bring oilfield supplies and equipment to Arctic oil fields in the ice-free summer months. To accommodate them, the oil industry uses two of three existing docks for unloading barges at Prudhoe Bay. Both are at the end of man-made, solid-fill gravel causeways, with West Dock the biggest at 13,100 feet long and 40 feet wide.[xlvi] Such causeways have had a long, controversial environmental history because they have disrupted ocean current and temperature regimes, and have caused impacts on migration patterns of fish and other sea life.

Oil Pipelines in America's Arctic

In 1993, the state estimated that oil development on Alaska's North Slope included 1,137 miles of pipelines, excluding the 798 mile-long main TAPS pipeline to Valdez.[xlvii] The State of Alaska only regulates a portion of these pipelines. In 1997, the BLM estimated that there were seven major trunk pipeline systems (above ground and elevated) carrying crude oil to TAPS, totaling approximately 141 miles in length.[xlviii] In June 1998, the Corps of Engineers reported that, " … approximately 1,123 miles (1,807 km) of pipelines connect producing wells to production processing facilities, and then to the TAPS."[xlix] None of these estimates include the hundreds of miles of additional product, gas and fuel lines strung throughout the oil fields.

Industrial Centers in the Arctic Oil Fields

The enormous industrial complex that comprises the oil fields on Alaska's North Slope includes an intricate web of oil and gas processing facilities connected by road and pipeline systems.

Power Plant. Power for most field operations in the Prudhoe Bay region is supplied by a central power plant located near Deadhorse. Power is distributed mainly via overhead power lines, although some lines are buried.

Central Processing Facilities. ARCO and BP operate a total of 6 central processing facilities.[l] According to the U.S. Environmental Protection Agency (EPA), as of 1995, there were a total of twelve gathering centers on the North Slope. All, but the Endicott gathering center, are onshore. (The Endicott field facilities are located on two man-made gravel islands in the Beaufort Sea.)

Refineries. ARCO's crude oil topping plant is one of 2 refineries located in the oil fields. This plant refines 1 million gallons of crude oil per day into diesel, jet and other fuels used on the North Slope.[li]

Residential Centers. ARCO and BP each have a base of operations that serves as a residential center and central office complex for the roughly four to five thousand oil company employees who live and work in the surrounding oil fields.[lii]

IMPACTS OF OIL FIELD DEVELOPMENT IN AMERICA'S ARCTIC

The impacts of oil field development in America's Arctic, including the impacts of the millions of gallons of surface discharges and thousands of tons of air emissions released each year from North Slope oil fields, are not well documented. While development on the North Slope has grown exponentially since the drilling of the discovery well in 1968, no state or federal agency has undertaken an evaluation of cumulative impacts of development in the region. No full environmental impacts review conducted pursuant to the National Environmental Policy Act (NEPA) has been undertaken for any onshore development in the entire region, with the exception of the Environmental Impact Statement (EIS) completed for TAPS in 1972. Development has been allowed to proceed "piecemeal" over the last thirty years, with no analysis of the full range of impacts from expanding industry activity in the region.

The TAPS EIS published in 1972 listed the Prudhoe Bay, Lisburne and Kuparuk "pools" as oil reservoirs to be developed, but it contained only seven sketchy, speculative pages devoted to development scenarios.[liii] Most of the oil fields that exist in the region today were not predicted in the TAPS EIS. No development was predicted for areas farther west than Oliktok Point or father east than the east channel of the Sagavanirktok River.[liv] The eastern developments at Endicott, Badami, Point Thomson, and Sourdough were not predicted, and western developments like Alpine, Tarn and others were also not foreseen. Of the fields not foreseen in the TAPS EIS and for which cumulative impacts have never been fully assessed, Milne Point, Endicott, Niakuk and Point McKintyre are considered "major" fields by the state.[lv] In short, for the region in America's Arctic from which over 20% of the nation's domestic oil supply is being extracted, no comprehensive EIS assessing the scope and magnitude of the environmental impacts of this massive industrial complex has ever been undertaken. In light of this fundamental lack of information and understanding, it is disingenuous for proponents of developing the Arctic Refuge to suggest that such development can be undertaken with little impact to the coastal environment of the Refuge.

Congress recognized this serious lack of information and understanding when it approved legislation in September of last year directing the EPA to contract with the National Research Council (NRC) to conduct a two-year review of the cumulative impacts of oil development in America's Arctic. It is anticipated that this study will not only provide some insight into the extent of the impacts, but will also provide information regarding the industry's compliance record and the effectiveness of state and federal agency oversight, as well as the effectiveness of mitigation measures taken to ameliorate development impacts. We have some concerns regarding whether the review will be fair and objective given the intense industry scrutiny it has been receiving, but we are hopeful.

The initiation of the NRC review is particularly timely. Three new oil fields are being developed in America's Arctic, which represent giant steps to the east, west, and north of Prudhoe Bay, further spreading existing oil field infrastructure. ARCO's new Alpine field, located entirely within the active flood plain of the Colville River delta, will require a thirty five-mile long pipeline to reach existing processing facilities. BP's new Badami field is located 25 miles east of Endicott, which marks the eastern boundary of current development, and, like the Alpine field, has necessitated the construction of a pipeline to connect it to the existing Prudhoe Bay area infrastructure. And to the north, BP's Northstar development will be located on a man-made gravel island in the Beaufort Sea about six miles offshore of the Kuparuk River delta in Gwydyr Bay. It will be connected to shore-based processing facilities by a seven mile-long subsea pipeline that will transect an active ice scour area on the Beaufort Sea coast. The use of a subsea pipeline represents untested technology in this harsh Arctic environment. How development and operation of these new fields will exacerbate the impacts of existing oil field development is not known. Nevertheless, development of these fields is moving forward.

Despite the lack of a comprehensive review of the cumulative impacts of oil development in America's Arctic, information is available that provides some insight into the magnitude of the pollution and waste streams generated daily from oil field operations.

Solid Waste. The only major solid waste facility in the oil fields is the Service Area 10 landfill at Deadhorse operated by Alaska's North Slope Borough. Metals, excess cement, sand, rubber, timbers, insulation, ash, non-hazardous chemicals, plastic, paper, household wastes, and other industrial garbage is disposed of at this landfill.

The principal contributors of solid waste to the Area 10 landfill are the BP and ARCO oil processing facilities, the TAPS pump stations, some 30 miscellaneous service contractors, and various industry camps.[lvi] About 23,000 tons of wastes were handled in 1994-95.[lvii] In 1996, nearly 53,000 cubic yards of waste were handled, and 38,000 cubic yards were handled in 1997.[lviii] BP says that between 1990 and 1997, its oil and gas development operations generated an average of 45,000 cubic yards per year of solid waste; and in 1997, it generated over 10 tons of hazardous waste.[lix]

Air Pollutant Emissions. Air pollution in the existing oil fields is generated in part from large stationary sources, which are permitted under state and federal air quality regulations. The oil fields contain one of the largest groupings of gas turbines in the world.[lx] Ninety-eight natural gas-fired turbines were operating as of 1988.[lxi]

The Corps of Engineers measured actual emissions from stationary sources at the main facilities for BP and ARCO's operations. According to the Corps' report, between June 1, 1994 and June 30, 1995, actual emissions of nitrous oxides (NO_x) equaled 56,427 tons. Emissions of carbon monoxide (CO) equaled 11,560 tons; sulfur dioxide (SO_2) equaled 1,470 tons; particulate matter (PM_{10}) was 6,199 tons; and volatile organic compounds (VOCs) was 2,647 tons.[lxii] To put these numbers in some perspective, the amount of NO_x emitted from the Prudhoe Bay oil fields dwarfs the total emitted in Washington, D.C, and is twenty thousand more tons per year than all other Alaskan sources combined. According to EPA data, the entire State of Washington has about 8,200 tons of NO_x emissions per year.[lxiii] Oil field CO emissions are one third of the total of all CO emissions for Anchorage, Alaska's largest city with a population of 300,000.[lxiv]

In addition to the emissions from major facilities, there are hundreds of other so-called "minor" sources of air pollution in the oil fields for which air quality control permits are not required and for which no monitoring of emissions is done. These include mobile oil drilling rigs, automobiles, buses, trucks, aircraft, heavy equipment like bulldozers and seismic vehicles, small incinerators, unregulated fuel tanks, and fugitive dust sources like gravel pits and road dust. Added into the mix of emissions are toxic pollutants, such as arsenic, nickel, benzene and mercury. Because the oil and gas industry is exempt from the toxic release inventory reporting requirements of the federal Emergency Planning and Community right to Know Act of 1986, information regarding these air pollutants is difficult to find.[lxv] But there are some troubling signs that these toxins are being produced as a part of ongoing oilfield operations. For example, elevated levels of nickel, mercury and other metals have been found in the snow pack in the Prudhoe Bay area.[lxvi]

Wastewater discharges. Wastewater discharges from oil field operations at Prudhoe Bay are governed by state and federal pollution control and discharge permits. There are over 400 pollution permits that govern industry operations in the Prudhoe oil fields. Permitted waste streams include discharges from sewage treatment plants, discharges from the water flood treatment plant, drilling muds and cuttings, and gravel pit de-watering discharges. During the period from 1991 through 1997, approximately 25 billion gallons of contaminants were discharged into surface waters under National Pollution Discharge Elimination System (NPDES) permits issued by EPA. There are also over 200 wastewater permits issued by the Alaska Department of Environmental Conservation (ADEC) for facilities related to oil and gas production in the Prudhoe Bay region. These permits represent millions of gallons of additional discharges into surface waters of the region.

In addition to the discharge of huge amounts of wastewater released by treatment facilities in existing oil fields, the arctic ecosystem has been changed by construction of facilities that alter normal water flow in the region and adversely affect water quality. For example, the placement of gravel roads and drill pads in some areas has disrupted the surface flow of water and created large, deep-water ponds that lack the biological productivity of natural, shallow water tundra ponds. In some cases, natural lakes have been drained, inadvertently or on purpose, for construction of support facilities. Pump Station 1 of TAPS is constructed entirely in the basin of a large tundra lake that was drained to clear the way for construction. And in the nearshore environment of the Beaufort Sea, according to the Corps of Engineers, " … (e)xisting causeways have been identified as a cause of significant exceedances of chronic state marine standards for water temperature, salinity, and turbidity."[lxvii]

Oil Spills. The State of Alaska only began collecting comprehensive oil spill data for existing Arctic oil fields in the mid-80's. The state's figures show spill numbers peaked at 1,314 annually in 1989.[lxviii] Between January 1, 1984 and May 24, 1993 in the oil fields, there were 1,955 crude oil spills involving 8,960 barrels (376,321 gallons), 2,390 diesel fuel spills involving 11,068 barrels (464,856 gallons), 977 gasoline spills involving 3,128 barrels (131,382 gallons), and 1,360 hydraulic fluid spills involving 1,840 barrels (77,301 gallons).[lxix] In 1990 alone, the state claimed that 4,096,348 gallons crude oil, petroleum products and toxic substances had been spilled on the North Slope, mostly from oil industry activities.[lxx] In 1996, 416 spills resulted from North Slope oil industry activities, with more than 60% of these crude oil and other hydrocarbon products.[lxxi] Other toxic materials spilled include acid, biocides, and ethylene glycol.

According to the BLM, " … the causes of Alaska North Slope crude-oil spills, in decreasing order of occurrence by frequency, are leaks, faulty valves/gauges, vent discharges, faulty connections, ruptured lines, seal failures, human error, and explosions. The cause of approximately 30 percent of the spills is unknown."[lxxii] The chronic nature of the spills and the large percentage that are of unknown origin suggest the existence of faulty spill prevention systems, sloppy practices, and inadequate government oversight and enforcement.

Almost all of the Arctic spills to date have occurred in connection with onshore developments. BP's proposed Northstar offshore development will be the first to include a subsea crude oil pipeline, running from an artificial gravel island to the shore and buried in the sea bed of the Beaufort Sea. Most of the year, the Beaufort Sea is covered in ice, and in near shore areas the ice completely displaces water to the depth of many feet. A large crude oil spill from an offshore well blowout or pipeline break would be an unmitigated disaster even under the most optimistic oil spill cleanup planning scenarios.

Contaminated Sites. As of 1996, there were 60 sites contaminated by oil-related industrial activity listed for the North Slope in the state's contaminated sites database. ADEC considered more than half of these high priorities for clean up. More than a third of the high priority sites have been on the list for more than 5 years. A number of sites have been identified for more than a decade, and still have not been cleaned up.

Reserve Pits. For years, EPA and USFWS expressed concern about the disposition and effects of oil field wastes. At Prudhoe Bay and other onshore fields, the companies dumped drilling muds and cuttings into open "reserve pits" that adjoined drill pads and were diked with gravel berms. About 2-6 billion gallons of drilling wastes were dumped into some 450 reserve pits on the North Slope.[lxxiii] The unlined pits filled with snow in winter. The snow melted in the spring and the mixture spilled over the dikes into tundra ponds and wetlands. Fluids also leaked through the gravel basins. A common way of getting rid of the excess water created by snow melt in the reserve pits was to pump it directly into tundra wetlands or to spray it on oil field roads to control dust.

In 1988, Trustees for Alaska and other conservation groups sued ARCO to halt discharges of reserve pit fluids into tundra wetlands, and to end other violations of the Clean Water Act. As a result of the lawsuit, the oil industry abandoned the use of surface reserve pits and began injecting production wastes underground into oil-bearing formations. According to BLM records, there are currently 262 abandoned reserve pits in North Slope oil fields that have yet to be cleaned up and closed out.[lxxiv]

Waste Injection. The standard practice for management of production wastes in Arctic oil fields today is to inject the wastes into oil-bearing formations deep below the earth's surface. EPA and the Alaska Oil and Gas Conservation Commission (AOGCC) have jurisdiction over the underground injection of oil field wastes. These agencies have permitted two classes of injection wells. The first, Class I wells, can be used to dispose of production wastes, i.e., wastes that are generated at the well site in the drilling process, such as drilling muds and produced water, and also wastes generated from non-production activities, such as used motor oil, solvents and paints. The second, Class II wells, can only be used to dispose of production wastes generated on site[lxxv]. Hazardous substances cannot be injected into either class of well, but must be transported to an authorized hazardous waste disposal facility.

There are three Class I waste disposal injection wells on the North Slope permitted by EPA. To date, over 325 million gallons of wastes have been injected into these wells. EPA is currently processing permit applications for two additional Class I injection wells. The AOGCC permits and monitors 30 Class II injection wells on the North Slope. Over 42 billion gallons of wastes have been injected into these wells.

While it is the environmentally preferred alternative over the aboveground handling and disposal of wastes, underground injection has not been without problems—problems that suggest an inadequate level of government oversight over oil field activities. For example, a drilling company working under contract to BP pled guilty in April 1998 to illegally injecting Class I wastes and other hazardous substances into a Class II injection well at the Endicott oil field, and then falsifying records to hide these illegal disposals. Some of the wastes reached the surface and the surrounding waters of the Beaufort Sea.

The illegal dumping at Endicott was brought to light after a whistleblower reported the violations to federal authorities. Doyon Drilling, the BP contractor, was found guilty of 15 misdemeanors, ordered to pay $3 million in fines, and given five years probation for ordering workers to dump thousands of gallons of toxic waste into the unprotected well shaft, including lead, methyl chloride, toluene, xylene and benzene. Three Doyon employees pled guilty to federal charges and were ordered to pay $25,000 fines. One was given a year's prison sentence.[lxxvi]

In 1999, BP pled guilty to a criminal felony count of failing to report the discharge of these hazardous wastes, and concurrently settled a civil case brought by the United States concerning the same events. As part of the criminal case and BP's probation, BP paid $500,000 in fines and will pay $15,000,000 in an attempt to ensure similar problems do not recur. BP also agreed to pay a fine of $6,500,000 in the civil case. Consequently, BP agreed to spend $22,000,000 for one felony violation of a federal environmental law and a concurrent civil case based on the same facts.

That the illegal dumping occurred at the Endicott oil field is ironic. Endicott is often held up as a model of how oil field development should be done by proponents of opening the Arctic Refuge to oil development.

OIL INDUSTRY EXEMPTIONS FROM ENVIRONMENTAL LAWS

A significant impediment to determining the impacts of oil development in America's Arctic is that much of the needed information regarding pollution and waste management is not available. This is due in great part to the fact that the oil industry—unlike other heavy industries in this country—is not required under state or federal law to provide such information to state and federal regulators or the public. The oil industry enjoys a number of significant exemptions to environmental protection laws, a situation that speaks to the political power of the industry and its ability to influence public policy-making regarding environmental protection.

Among the exemptions the oil industry enjoys are exemptions from federal water quality, hazardous wastes and community right-to-know laws designed to reduce pollution and protect environmental and human health.

RCRA hazardous waste exemption. Congress exempted certain oil and gas extraction wastes from regulation as hazardous wastes under the Resource Conservation and Recovery Act (RCRA), pending an EPA study.[lxxvii] Trustees for Alaska sued EPA to force it to do the study. When the agency finally completed the study in late 1987 during President Bush's Administration, it determined that regulation of such wastes was not warranted.[lxxviii]

The RCRA exemption gives special treatment to the high volumes of oil production wastes, such as drilling muds and cuttings, oil rig wastes, produced water, and associated wastes, including tank bottoms, pit sludges, and well work-over wastes. If these wastes were produced by any other industry, such as dry cleaners, they would be regulated as hazardous wastes with special precautions taken.[lxxix]

Toxic Release Inventory. Anticipating that an informed public would pressure companies to reduce emissions, in 1986 Congress enacted the Emergency Planning and Community Right-To-Know Act. The Act requires certain polluters to report annually their toxic releases for inclusion in a Toxic Release Inventory, a database maintained by EPA and made available to the public. The database has been used to support calls for stronger regulations, and to publicize local polluters, as well as to prepare communities for accidental releases of toxic substances. Some financial advisors even use the database to screen companies for investors.[lxxx]

The oil industry is largely exempt from reporting oil field wastes to EPA for inclusion in the Toxic Release Inventory.[lxxxi] In 1996, the industry was successful in its lobbying efforts to ensure that most oil field exploration and production facilities were exempted from EPA regulations that addressed the kind of industries required to submit yearly "right-to-know" reports.[lxxxii] The exemption covers toxic air pollutants produced in oil field operations in America's Arctic, including lead and known carcinogens such as polycyclic aromatic hydrocarbons, benzene, and xylene.

No Net Loss Of Wetlands … Except In Alaska. During his Administration, President Bush adopted a "not net loss of wetlands" policy which called for compensation for wetlands destruction through purchase, creation, and/or preservation of other wetlands. In 1990, the Corps of Engineers and EPA entered into a memorandum of agreement concerning mitigation requirements under Section 404(b)(1) of the Clean Water Act that were designed to implement the no net loss policy. Because virtually all oil and gas development in America's Arctic occurs in wetlands, both the oil industry and the State of Alaska vehemently opposed these mitigation requirements. In August 1991, the Bush Administration revised its wetlands protection policy to exempt Alaska—and Alaska only—from the compensation and avoidance requirements of this national wetlands protection policy.

When the Clinton Administration came into office, it reversed the course of the previous administration on Alaska wetlands protection. Since then, the Alaska Congressional delegation has unsuccessfully pursued bills to revive the idea of special treatment for Alaska wetlands. In 1997, the Alaska Legislature passed a resolution demanding that Congress and the President require the Corps of Engineers to “customize a (wetlands) permitting process ... in Alaska that does not include burdensome mitigation, avoidances, and other requirements applying nationally ... ”[lxxxiii]

Low sulfur diesel fuel for mobile sources. Section 211 of the Clean Air Act[lxxxiv] forbids the sale of motor vehicle diesel fuel which contains a concentration of sulfur in excess of 0.05 percent (by weight) or which fails to meet a cetane index of 40. Section 211 was passed because Congress wanted to reduce emissions of diesel particulates, which cause cancer, genetic mutations and other human health problems. Despite the documented health risks, the State of Alaska petitioned EPA for an exemption from Section 211.[lxxxv] The state claimed that whatever particulate matter problems it has are not due to diesel fuel, and that because Alaska’s refineries do not produce such fuel, the transportation costs of shipping such fuel to Alaska would be too expensive. Alaska’s oil refineries lobbied aggressively for the exemption because sulfur content in refined products is directly dependent on the sulfur content of the crude oil refined. And Alaska North Slope crude is so high in sulfur content that refiners, including the operators of the refineries in the North Slope oil fields which produce diesel for the fleets of vehicles serving the fields, were not able to make a lower sulfur diesel fuel without significant additional investment.

EPA has granted Alaska’s petition[lxxxvi] on two separate occasions, giving rural areas of the state, including North Slope oil fields, a permanent exemption and urban areas temporary exemptions.[lxxxvii] Alaska is the only state in the nation to be granted these exemptions. EPA is now considering Alaska’s petition to make the urban exemption permanent and may either accept it outright or establish an Alaska-specific "phase in" period that could years.

Nonroad engines. Prior to 1990, the Clean Air Act divided air pollution sources into two groups, stationary sources and mobile sources. Mobile sources included common highway vehicles (cars and trucks). In 1990, Congress amended the Clean Air Act to mandate the adoption of emission standards for stationary sources, termed “nonroad engines” or NREs. NREs include any internal combustion engine that is not used in a highway vehicle. The definition includes oil and gas drilling rigs, which are equipped with generators and other fuel burning equipment.

Since the passage of the 1990 amendments, the oil industry operators in Alaska have routinely opposed any additional regulation of oil drilling rigs as NREs.[lxxxviii] They requested that ADEC exempt NREs from any permitting requirements. In response, ADEC examined the potential air quality impacts from oil drilling rigs and other NREs. After modeling potential NRE emissions and their impacts, ADEC decided that sulfur dioxide emissions posed a threat to ambient air quality. With respect to sulfur dioxide emissions, ADEC proposed an amendment to state air quality regulations that would have established allowable fuel sulfur concentrations for NREs, or allowed the selection of other alternative mechanisms for dealing with the emission threats. A group calling itself “The Alaska Stakeholders,” composed of oil companies, oil refiners, some utilities and other users of high sulfur diesel fuel, vigorously opposed the new regulation. After intense industry lobbying, the regulation was withdrawn.

In February 1998, a bill was introduced in the Alaska Legislature that exempted NREs and flares associated with oil and gas exploration and production facilities from all state air quality regulations—including permitting and analyzing the effects of air pollution from NREs. EPA said that if the bill became law it would be compelled to take over Alaska’s air permitting program and Alaska risked losing its federal highway funding. In a statement that reveals much about the current climate regarding oversight of oil industry operations in Alaska, ADEC’s Senate Bill 299 Summary Analysis claimed that one of the bill’s defects was that it “ … *could increase public scrutiny* of air pollution issues surrounding oil drilling activities leading to more burdensome regulation … ” (Emphasis added). ADEC also argued that if Alaska lost control of the air program to EPA, EPA would be much stricter. The bill passed, but was vetoed by the Governor. ADEC then entered into a non-binding agreement with oil rig operators in which ADEC agreed to allow a three-year transition period to implement the control of emissions from oil industry NREs envisioned by Congress when it passed the Clean Air Act amendments nearly a decade ago.[lxxxix]

State Laws Governing Oil Industry Operations. The degree to which the oil industry has been able to influence state public policy-making regarding oil development in Alaska is astounding. As a demonstration of this influence, one need only review the legislation passed by the Alaska Legislature in recent years:
Ch. 35 SLA 1994. Created a new oil and gas exploration licensing regime, one environmentally less restrictive than the existing licensing regime.
Ch. 38 SLA 1994. Limited the scope of judicial review of ADNR decisions regarding whether an oil and gas lease sale was in the state’s best interest.
Ch. 11 SLA 1995. Rescinded ADEC’s authority to regulate disposal of drilling muds, cuttings, non-hazardous oil and gas fluids and other wastes that are that are re-injected.
Ch. 53 SLA 1996. Created a program for royalty credits for companies that discovered new oil and gas fields in Cook Inlet. (The law has the potential effect of increasing industry profits and reducing state royalty income.)
Ch. 138 SLA 1996. Eliminated ADNR’s duty to make a finding that an oil and gas lease sale was in the public’s “best interests” if a finding was made in the previous ten years, absent the discovery of some unspecified kind of “significant” new information.[xc]
Legislative Resolve 3 and 5 (1997). Demanded that the Arctic Refuge and NPR-A be opened to oil and gas development.
Legislative Resolve 19 (1997). Asked Congress and the President to “require the United States Army Corps of Engineers to customize a permitting process for all

lands in Alaska that does not include burdensome mitigation, avoidances (sic), and other requirements applying nationally ... " to the preservation of wetlands.
Ch. 29 SLA 1997. Insulated industry from civil or criminal penalties for violations of environmental laws if the violations were "discovered" in corporate self-audits. The law also allows industry to keep audit information on the release of toxic substances confidential and withhold it from the public.
SB 299 (1998). Would have forbid ADEC from regulating air pollution from oil drilling rigs, oil and gas flares, and associated oil industry equipment. The governor vetoed the bill, saying "We will not be able to convince the federal government to explore new oil and gas areas in Alaska like the National Petroleum Reserve if we weaken environmental standards."[xci]
"Arctic Power" appropriations (1998). Appropriated $225,000[xcii] to Arctic Power, a private organization lobbying to open the Arctic Refuge to oil development, adding to the $378,000 Arctic Power had already received in state funds. In the same budget, the Legislature reduced funding for review of wastewater permits and for protection of drinking water quality in Alaska.

ENVIRONMENTAL ENFORCEMENT IN ARCTIC OIL FIELDS

The adverse impacts from the exemptions and special protections the oil industry has secured in state and federal environmental protection laws have been exacerbated by an accompanying lack of adequate enforcement of the environmental laws that do apply to industry operations in America's Arctic. While oil field development has expanded in the region, regulatory agencies responsible for overseeing industry operations on the North Slope have suffered significant budget cuts. These oversight agencies are chronically under-funded and routinely rely on industry self-monitoring to determine if permit stipulations are being met. As a result, conservation-minded citizens have had no recourse to ensure effective enforcement of state and federal environmental protection laws in Arctic oil fields, except courts of law. It is a great irony to these plaintiffs that many of the practices touted by supporters of oil development in the Arctic Refuge as examples of the oil industry's ability to "do development right" were forced on the industry as a result of successful citizen suits. Underground injection of oil field wastes serves as the best example of the changes forced by successful court action.

Successful oil and gas related litigation Trustees for Alaska has brought on behalf of public interest clients in the last two decades includes the following:
In the fall of 1985, Trustees successfully sued EPA for failure to complete a study of drilling muds and other wastes produced during oil and gas operations, as was required by the Resource Conservation and Recovery Act. The study was supposed to be completed by October 1982. Under a consent decree, EPA agreed to complete the study by August 31, 1987.
In February 1986, Trustees succeeded in securing a court order under NEPA requiring that the Secretary of the Interior solicit the views of the public through

written comments and public hearings before making any recommendation to Congress about opening the Arctic Refuge to oil and gas development.
In the spring of 1988, Trustees joined with the Natural Resources Defense Council in bringing a suit against ARCO over Clean Water Act violations at its North Slope drilling site reserve pits. The suit resulted in a multi-year settlement under which ARCO agreed to re-inject its drilling wastes.
* In 1990 and 1993, Trustees successfully challenged state of Alaska oil and gas lease sales offshore of the Arctic National Wildlife Refuge.
In 1991, Trustees sued EPA challenging an NPDES permit for a major sewage plant operated by ARCO on the North Slope. In January 1992, EPA withdrew the permit.
In 1992, Trustees successfully sued the Department of the Interior under the Marine Mammal Protection Act, forcing it to adopt regulations governing the incidental take of walrus, polar bear and whales during oil and gas exploration activities.
* In 1996, Trustees successfully challenged a state of Alaska oil and gas lease sale in Cook Inlet.
In 1997, on behalf of two Alaska Native villages, Trustees won a suit against the State of Alaska involving a state oil and gas lease sale. The state violated its own coastal zone management laws when it failed to evaluate the impacts of the proposed lease sale to fish and wildlife on which the villages depend for subsistence, and to habitats that sustain these subsistence resources.

FUTURE OIL DEVELOPMENT IN AMERICA'S ARCTIC

The extent of existing oil field development in America's Arctic serves as a yardstick by which proposed development can be measured. It also serves as a "reality check" to gauge claims that development of an oil reservoir of the size that some believe exists in the Arctic Refuge can be done with minimal surface disturbance and inconsequential impacts. It is true that today drilling for oil in the Arctic is more efficient and drill pads are, for the most part, not so numerous or so large as in the early days of field development. But technological improvements—particularly in the ability to find and extract oil—are allowing the industry to access oil reserves that in the past would not have been considered profitable and to develop fields more intensively to maximize oil production. In addition, the number of oil wells and the infrastructure needed to connect them to processing facilities is more a function of the geology of the reservoir than it is the availability of efficient development technologies.

As for pollution and industrial wastes generated from oil field development, the reality is that the extraction of crude oil—a toxic substance—from the earth's crust is a dirty business. Oil development in the Arctic Refuge or other pristine areas in America's Arctic can be expected to produce the kinds and volumes of pollution, loss of habitat from construction of roads and support infrastructure, disturbances to wildlife and loss of wilderness, that have been documented to date in existing oil fields. It is not possible to extract the oil that may lie beneath the coastal plain of the Arctic Refuge and, at the same time, preserve its ecosystem functions intact. Claims to the contrary, which lead the American public to believe that they can "have their cake and eat it, too" with regard to management of this unique slice of America's Arctic, are disingenuous at best.

Given the extent of oil development that currently exists in America's Arctic, the projections for oil production from as yet untapped onshore reservoirs within the boundaries of these developed areas, and the support infrastructure already in place to tap these reservoirs, federal oil policy should focus on bringing these fields into production while at the same time ensuring more effective enforcement of environmental protection laws for all oil development in the region. And federal land policy should focus on securing permanent protection for unique wild areas like the Arctic National Wildlife Refuge.

Thank you for the opportunity to provide comments.

Oil and Gas Development on Alaska's North Slope Local Perspective

Richard Glenn
North Slope Borough

Good Morning. In this morning of quotes I'd like to introduce one, perhaps the final quote from our Plenary Session, from an authority slightly higher than Marcus Aurelius, which goes, "Blessed are the peacemakers, for they shall be called the children of God". And after this morning's point and counterpoint presentations, I hope that some of the comments I provide can perform in that capacity.

I'm going to discuss for you, having been invited to represent the North Slope, a native's viewpoint on oil and gas practices and development. I'll probably represent kind of a centrist position. As you know, just like in any society, within our community there is a whole spectrum of opinions. So please accept my comments as something that is probably around the middle as far as the people who live in the North Slope are concerned. I'll try to move in either direction where I think it is appropriate. But I am here at the direction off our North Slope Borough mayor George Ahmaogak who agreed that it was okay for me to come and represent our municipality, our people.

In addition to myself, though, there are two people who are more qualified than me to speak this morning. Three, in fact. The first one is the director of our Planning Department, Rex Okakok. The second one is Kenneth Toovak, who you will hearing from tomorrow morning regarding utilization of traditional knowledge. The third guy is Tom Lohman if he is still here. Tom has been working for the Borough in the trenches for many years on the exact same issues that I will be discussing this morning.

The North Slope Borough is a municipality that some people compare to the size of Minnesota or Montana, that geographically covers the area we're talking about today. It is a home rule government comprised mostly of Inupiat Eskimos, so the positions of native peoples I'll be talking about this morning will be the positions of the native Inupiat Eskimos. As you know Alaska is like a quilt of native cultures, and this is one culture that just happens to geographically coincide with the area of active exploration and development. The Borough and its people have a long history in the areas of oil and gas exploration and development. They have become gray haired with oil and gas exploration and development.

Its almost symbolic that the first contact that our culture had with the outside world were with three separate groups of people: there were commercial whalers, there were missionaries, and there were oil and gas people – at first scientists, geologists, and people that were part of the exploration of what soon was called the National Petroleum Reserve Number 4 that began in the 1920s. These were people like People like Ernest Leffingwell, and Lt. Colonel Ray.

These were the people that first walked around on the North Slope and wrote notes to send back to the people in the Lower 48. But there are people still living in our community who assisted those folks, or their parents assisted those people. These are the elders of our region. So they bring to the table not only an immense traditional knowledge which we'll talk about tomorrow, but a long working history with people who are interested in resource development.

One image that I would like to dispel, I hope, about our region, the North Slope of Alaska, is that it is not isolated, is not desolate, is not frigid, and is not lifeless. Instead, if you look through the eyes of an Inupiat along the geographic footprint of the North Slope, you'll see a place that is alive with the history of our people, birth places and burial sites of our friends, relatives, and ancestors, traditional hunting areas, traditional gathering and trading areas.

If you look at a map that describes the North Slope today, you'll see eight villages. But this is not an accurate characterization of the way we view the North Slope. In the days when my grandfather was a young person like myself, he told me that there were settlements scattered a day's walk all along the coast, just stippling the whole coastline and up every major river drainage. Truly the people gathered in the major village centers, but when the time for gathering was over, we moved and spread ourselves out over the entire countryside. That's why when exploration, or scientists, or environmentalists, or anyone else comes to our region, and they want to learn about us, they come and talk with the local people. These local people, the elders especially, appear to possess acknowledge of the land that far exceeds the footprint of their community. This is not just an appearance, but is accurate

Some of the things that we are talking about this morning are the shrinking footprint of exploration and development. We applaud the shrinking footprint. We've seen it; we know its true. We've watched the evolution of this industry from the 1940s to today, and in one breath we're proud, as a lot of the changes we in part helped to create, working with industry, working with government agencies. But beyond that, more important than a shrinking footprint, is the absence of a footprint where you would normally expect to find one. And this is double-edged sword.

I think that if you look at oil production facilities on the North Slope, you will see a growing network that looks from a map perspective like growing tentacles of something that didn't used to be there before. But if you can put yourself on the ground, you can see that this perception is probably one that is based by people who are more familiar with looking at maps than they are with walking around on the landscape. If you cross a pipeline that is traversing the North Slope, you won't find it noisy, you won't find that it has disturbed the environment of its immediate surroundings, except for the pole that supports the VSM, the Vertical Support Members. If you were to look four feet in any direction you would be hard pressed find anything. In fact most folks I think would probably be looking for musk ox tracks or mastodon tusks, or something like that. This is the reason for the perception of the Arctic as a remote place – it is almost as if the ice age ended yesterday and development started this morning. But in between there has been a covering of our people across the landscape.

We're in concert now with development in our region – onshore development. We've seen it, we've observed it, and are confident that with our input we know that it is going to be done right. There is a big difference, though, between onshore and offshore development. If there is any forceful message to be made regarding development, our people would like to exert their strong opposition to any offshore development

I've been involved with development projects, research projects, and science projects things that take me out into the environment for about 15 years now – a youngster by many people's standards. Our people have a way of evaluating projects in a way that says three things: First "what the heck are you doing?" The second thing is "well, if you're doing it, don't you think there is a better way of doing it than the way you are doing it right now?" And third thing is, "why don't you let me help you show you how to do it a little bit better?"

This evaluation has been of a great benefit for me personally as I conduct, for example, remote ice experiments offshore Barrow, or when I've been looking for minerals in the foothills of the Brooks Range, and I know it has also been of great benefit to oil industry. This kind of informed consent works both ways – informed consent means that development occurs in our region in part on our terms. But is also means that information moves from us to the developers. Both sides benefit – both sides learn something. You'd be amazed at all of the assumptions that people from outside bring when they begin a development project. Some have never been in an Arctic setting before, they've never even been in a remote location before. There is a whole basketful of mistaken assumptions that they bring.

These mistaken assumptions can happen to the best of us! One time I was working offshore Barrow and a guy from Oregon State came to core the ice. He had developed a laser that was able to look from one core hole to an adjacent one, and by judging the amount of refraction and absorption of the laser he was going to determine the properties of the ice. The ice has a fabric, just like wood does, and if you're looking down the grain it is strong in one direction and of you're looking across the grain it has strength in another direction. He attempted to describe this experiment to me and he was going to core through the ice, and then he was going to drop his transmitter and receiver down these two adjacent holes. He forgot though that once he cored through the ice, that the water would rise to its level of buoyancy, just a few inches below the surface. None of his laser equipment was waterproof, and he would have had his laser and receiver stuck at the bottom of the ice sheet. He saved himself maybe tens of thousands of dollars of laser equipment by listening to my advice.

But he learned from my mistake, because a few years before he was there, I was there. I was coring the ice 15 miles from Barrow, with an electric chain saw auger, coring blocks out of the ice. I got down about three blocks down, each block about a foot think. My generator froze. The oil was so cold it shut the engine off so my electric chainsaw quit working. Here I am, this close to data. I've got to get that data, and I need a complete cross section of the properties of the ice. So I'm standing there on the bottom of my quarry, and the top of the ice surface is right about waist level, and my tools are strewn about my feet. I wanted to take a core to take me through to the bottom of the ice, through the last cross section. So I was standing there in my quarry, in the dark, in January. And right when I reached the bottom of the ice I discovered just what the true level of the water was in the ice. My tongs didn't float, my wedge didn't float, the heavy equipment I was using to pull out the ice blocks didn't float. None of that stuff floated - it all had to be retrieved from the hole. It's pretty hard work stopping the power of the ocean coming in through a six-inch hole.

So none of us are immune from mistaken assumptions. But the longer you live in an area, the more of these mistaken assumptions that you lose. In fact people marvel at the commons sense attitudes, or the good suggestions that exist when development occurs with informed consent with people who are more familiar with that environment. So I'd like to stress the benefits of that.

Cumulative impacts, as mentioned by our last speaker, is a growing, growing concern. We only need to look to Nuiqsut where Ryan mentioned that development is occurring at the Alpine field. The Alpine field is only the latest development. A few years ago Nuiqsut was an isolated village. You couldn't see any development at all when you looked out over the horizon on a clear night. But in the 70s the Kuparuk field was developed, in the 80s exploration occurred around the Colville delta, in the 90s Alpine was discovered and is now going to be developed. Pretty soon when you look from your bedroom window or your living room window in the village of Nuiqsut you'll see in a semi-circle around you: the lights of development.

This has a plus and a minus for our people. The oil development - safe, responsible, onshore oil development is a benefit to our residents because it provides a tax base by which we can improve the living conditions of our villages. That is the purpose for the foundation of the Borough. We only need to look back to the incorporation of the Borough in the early 70s when we were sued by the oil industry and others to prevent this wacky idea of folks creating a home rule government to know how far we've come today where instead of suing each other we are working together, and we have developed a working relationship

But the cumulative impact downside for the people of Nuiqsut is the surrendering of what was once unfettered landscape. It doesn't mean that the caribou don't live there any more, it does not mean the fish don't live there anymore, it does not mean that there is seeping pollution from every development unit. But it does mean a surrendering of something – something that has value. Just because the caribou are there, does that mean that a person can visit a site where his Grandfather used to hunt? Or a traditional fishing site where a certain type of fish has always been caught – will that site always be available? Will people still be able to catch their fish there? Those are the kinds of questions the people of Nuiqsut are asking themselves.

They have answers. In Prudhoe Bay, of course, where development is of another era and there is a huge logistics base there anyway, this idea of wilderness abutting right up against developed sites probably is not accurate. But as you move further west toward Kuparuk you start to realize it is possible - that all I have to do is walk a hundred yards from this pipeline and as long as I don't look behind me I feel like I'm all alone. This place around me is untrampled. Here, industry has made agreements with our folks – if you want to go hunting through here you can. But if you talk with the people of Nuiqsut they will probably tell you that they avoid the areas of infrastructure when they go hunting.

The North Slope is not a stranger to it's own oil and gas development, and this is responsible for part of the mindset that we have. Our largest community is Barrow, and Barrow sits upon a gift from God, which is shallow natural gas. The Borough itself has been involved with seismic exploration, drilling, and development for its people to supply local energy for local needs. This is something, if I can inject a few personal messages into our discussion this morning, that I hope we can continue to consider for our other communities that are also being affected by development.

Again I applaud ARCO's efforts to work with Nuiqsut. Here is a little town that sees the lights of development all around it, is still importing diesel fuel just like it always has ever since they settled the village in the early 70s. With the one most massive infrastructure of America is right by them, they are still kind of stand-alone, isolated utilities, isolated energy. This has begun to change. With ARCO's commitment to provide natural gas to the community, this is a huge step. There is a large capital commitment that follows that offering of natural gas. What is needed now is millions of dollars of infrastructure to keep a town of 500 people warm and well lit through the winter.

The Borough has agreed to be a part of the solution here, so has the Federal Government and the State of Alaska thanks to this NPRA impact funds - I think this is a totally accurate use of these funds. We're looking for more help here. We'd like to look to industry for more help in processing the gas when it comes to the town. We'd like to look for help from federal agencies in converting the town from a diesel-fuel-based economy to natural gas-based facilities. Diesel fuel as we all know carries risks and environmental liabilities.

But there is a great assurance that comes from that blue flame burning in the house. It burns in houses around Anchorage and you don't even think about it, but if you come to my town, Barrow, you can see us burning local energy for local use with pride and knowledge. This is what we would like to consider for our communities.

Think of the up side for the environmental community if we can sequester the carbon that is coming out of the methane seeps that dot the North Slope lakes. Put a funnel on them and shut them off with a valve just like they did with the oil seeps in southern California. There is one less than 5 miles from Atqasuk a village 60 miles south of my town. If we could save all that harmful carbon from going into the atmosphere, and burning it for heat and electricity, I think there would be an upside on both sides. Look at the potential for common ground here between development and the environmental community.

Another personal thought is as we talk about the absence of impact to species, caribou species, fish species, I think that onshore development on the North Slope is a success. But here at the end of my presentation it is time for another quote, but it is only a paraphrase, one of our people who is kind of like our Thomas Jefferson. His name is Charlie Edwardsen Jr. Most people know him as Etok, and if any of you folks have gray hair within your government agencies or industry, you've met Etok. He is guaranteed to come up with something that will make you think. Etok was speaking at the U.S. capitol regarding native land selection and oil exploration. The big concern was about the survival of species on the North Slope, and he said "if you are going to think about the survival species of the animals on the North Slope, then think about survival of the Inupiat people AS A SPECIES!" That is something we should all keep in mind.
So the caribou enjoying themselves on the gravel strip, the fish enjoying themselves in the deep-water environments created from gravel extraction sources are lucky. I hope that industry and agencies can also work to preserve, enhance and nourish the human species on the North Slope as well.

The people of the North Slope - are we content with the development as it is occurring in our area? No, we're not. We have a long abiding distrust of offshore development. But we know that if it is going to happen, we're going to try to make sure it happens in a way that we work together to make it as good as possible. We do not believe that there is any way to mitigate or to take care of oil spills in broken ice conditions, for example. What happens now, though? Should production timing be scheduled to remove the potential for oil spills in broken ice conditions? Industry has to work with us to answer that question.

We also do not believe that the assembled commitment to say that we will use best available technology for oil spill prevention for oil spill in broken ice conditions is enough. We're asking for an insurance policy of some kind - details beyond that we don't know. But what kind of assurance is there to take care of offshore oil development if it goes wrong? That question needs to be answered.

So we are not content, but we are vigilant. We will remain vigilant as long as this development continues, because when it is done, when the infrastructure is abandoned, shut down, remediated, and industry walks away, we'll still be there. Our fish will still be there and our caribou will still be there thanks to the practices that are going on today. And the people will still be there too. The land, the sea, and the resources they provide for our future. Only by working together, observing nature together, will we be able to do this successfully. Observing nature is part of our lives – its what we've been doing for thousands of years. It's part of Inupiat living. Let's do it together – let's do it right.

Solid Waste Disposal and Minimization – Overview

Steve Taylor
BP Exploration (Alaska) Inc.

(MATERIAL NOT AVAILABLE)

Pipelines and Caribou Crossings – Agency Perspective

Dick Shideler
Alaska Department of Fish and Game

NOTE – THE FOLLOWING IS A SUMMARY OF MR. SHIDELER'S PRESENTATION. A COMPLETE MANUSCRIPT OF HIS TALK HAS NOT YET BEEN MADE AVAILABLE.

I had originally planned on concluding my talk by presenting the Department of Fish and Game Management Responsibility, but Mike did such a good summary that I guess I should start with it. I would summarize our philosophy regarding caribou management on the North Slope as this:

Because the Department is ultimately accountable to the public for the welfare of the Central Arctic Herd, we must scrutinize any influences on its sustainable viability, and make appropriate recommendations to land management agencies and to those making political decisions. Those recommendations are of necessity sometimes based on fuzzy results or trends rather than absolute evidence. The challenge is to ensure that the agencies, industry, and the public use the best available evidence to ensure that our collective decisions keep the welfare of the herd in mind.

The point I want to make from our perspective is that when it is all said and done we *all* have a responsibility in terms of what happens caribou, although the Department of Fish and Game is the actual management authority. When things happen with any population of animals, whether it is caribou or another species, for which we have management authority, we're going to be concerned about it, and we are going to scrutinize any kind of major change in the environment of that population. Certainly siting an oilfield into the area occupied by the Central Arctic Herd of caribou comes under that standard.

Regardless of the shared responsibility, I should point out that whenever something does go bad with respect to one of these species, we are ultimately the management authority responsible. And we are going to be the ones who are directly accountable to the public and who are going to have to make management recommendations. That doesn't mean we don't all share the responsibility - we're just the ones left holding the bag when problems arise. By necessity, we are going to be a little more conservative toward or protective of the animals than maybe others might. That doesn't indicate whether one side is right or wrong, but that is kind of the position we feel we must take.

I'd like to start out discussing the issue of caribou calving. One of the things we feel we really need is thorough predevelopment studies - but only recently have we really good before and after data. But for caribou calving, the bottom line is that response of the caribou to the roads and facilities really does complicate what our mitigation options are for future oil fields. If they are so very reactive, it is essentially unrealistic to expect that an oil field the size of Kuparuk or Prudhoe would shut down all traffic during calving, and in fact this might not be effective anyway. So we have to look at other options.

Mike pointed out that we have had a shift in proportional caribou habitat use. There has always has been some calving occurring in the hills south of Kuparuk, up through an area known as the Itkillik Hills. I can remember doing calving surveys with Ray Cameron in the mid-80s during heavy snow years on the coast, and we had a little more calving down in the southern parts of the field, south of Kuparuk. So some of the observed shift is probably related to snow conditions down on the coast.

We do not feel that the caribou can't physically get to the calving area. There is an impediment to ewes crossing the pipeline and roads, but it really has more to do with their behavioral response. On the east side of the Sag River where there is not yet any oil development other than the Bedami site, it can be used as a semi-control of what has been happening on the west side of the River where we have not seen a shift in calving of the magnitude we have seen on the east side. We have to remember that some caribou herds, like the Beverly Herd for example, will go through major shifts in calving area almost annually. On the other hand, herds like the Western Arctic Herd hasn't significantly changed its calving area in recent years, although its population has grown from 65,000 to almost a half a million animals in the last 25 to 30 years. The Teshekpuk Herd hasn't changed much either. From a biologist's standpoint, trying to integrate all of this conflicting information is difficult. The bottom line, and Mike as already alluded to this, is that we may never know why some of these trends occur.

So the real question is "what does it mean"? or "so what", as Mike put it. A lot of information is based more on modeling than on real data, and we are dealing more with inference than fact, but some of the modeling suggests that forage availability might be an important factor. The nutritional value of foliage might be better in Kuparuk, and the caribou are being selective in terms of their feeding. But modeling also suggests that it may not make any difference in what happens with the herd until there is a really severe environmental stress like a dramatic change in the weather, we really don't know.

Increased predation has probably been more hypothesized as a factor for the Porcupine Herd area, as there is evidence of their shifting their calving area. Certainly, grizzly bear densities are a bit higher in the Itkillik Hills area than along the coast, and we have collared bears in the area. Data from these collared bears indicate that the home regions of these bears are often overlapping both areas. However, what we do see as we progress southward farther is that grizzly bear density and wolf density both increase, with the highest density of grizzly bears and wolves in the foothills area. Wolves up until now have probably not been a factor in this herd, as trapping from the villages up there does a pretty good job of keeping the wolves down. We've seen quite a few wolves just in working with the grizzly bear population again in the hills, and there have even been a few reported down along the coast, but most of the wolf activity is found in the calving area during the winter. So I don't think really that predation at this point is a major effect. As for golden eagles, I think that there are more than we used to see, both along the coast and in the hills. So, I'm not sure what we can conclude from all of this in terms of predation on calving, but we feel that we really need to keep track of things, and there may be a negative aspect to that displacement. We'll have to see if we have a change in weather patterns over the next ten years of so, maybe that will help answer some of the questions of population fluctuations.

I also want to mention summer mosquito season, and I'll make the distinction between mosquito and fly season even though they overlap for part of the summer. I think that most people would agree that access to that coastal area for the CAH is really critical. They don't have a lot of mountains, and they therefore don't have the alternatives in habitats that the other herds have. It is therefore really important that they able to get to the coast. When the mosquitoes are bad down to the south, caribou move northward, up into the continuum of air temperature and wind where mosquito harassment abates and they can start feeding again. Sometimes they move way up to the coast, but sometimes they don't go that far. However, most of the movements observed early in the development days were strongly north-south along the major tributaries. More recently, their movements have become more of an "end run" around the densely developed areas.

Well, what does this mean? The movements themselves don't mean that much to caribou because they are so efficient at walking that the effect on their energetics are not significant. Really the only change is a minor loss of foraging time, and there is a question as to whether that is critical or not for these long movements. The real key might be to make sure that they get back to the south to feed as soon as they can. And, as Mike pointed out, caribou also respond strongly to traffic, probably just as a normal response of a prey animal to their predators, so any time you have traffic in conjunction with any kind of obstruction, that is going to create problems.

I'll speak a little about the separation of roads and pipelines. I think that Mike's mitigation list is a pretty good one, and we agree that all of those types of things work. As Mike pointed out, there are certain situations where ramps may work better than just pipe separator or a high pipe by itself, and those include some of the intersections where the caribou essentially get themselves into a corner. So in terms of designing pipelines or oil fields, if you can minimize those kinds of things you are better off. Ramps are probably of some use in these situations, but there is still a residual question because you don't have success in getting caribou in large groups under mosquito harassment to cross than we do with some of the smaller herds.

Unlike the case of the calving, we do feel that there has been habituation with caribou. The Central Arctic caribou over the course of oilfield development have lessened their reactivity to structures during mosquito season. I wouldn't say that they have habituated as far as calving is concerned, but they are definitely habituated during mosquito season.

During the fly season you get a lot of caribou movement onto the pads. This also occurs during certain parts of the mosquito season, but the caribou are definitely attracted to the taller roads for insect relief. What are the long-term consequences or benefits of this?

In general, I think we can conclude that the CAH has habituated to the activity in the Kuparuk area in general, and that the mitigation measures we have applied there can be used in designing future oil fields. However, we also conclude that there has been an effect of human activity in Kuparuk in terms of caribou calving. This is still being investigated. We hypothesize that if any substantial effect occurs, it might not show up until the population is really stressed, probably mostly by weather or some other factors. We have to be careful how we extrapolate from what we've done in the CAH to some of the other herds where the conditions may not be the same both in terms of human development and in terms of their habitat.

Thank you.

Well Construction for Injection of Oilfield Wastes North Slope of Alaska

Blair Wondzell, P.E.
Senior Petroleum Engineer
Alaska Oil and Gas Conservation Commission

In the early history of the United States, whale oil was used for lighting our homes. By the mid-1800s, whales were almost extinct from whaling. When Colonel Edwin L. Drake found "rock oil" in his Titusville, Pennsylvania well in August 1859,[1] he probably did more to save the whales from extinction than any man before or since. The whales were spared due to this "rock oil", but different types of environmental problems were created. These new problems were related to the drilling, production, transportation, refining, and marketing operations. This discussion deals only with drilling and production liquid waste disposal.

Major Oilfield Waste Types

Currently, most liquid oilfield wastes generated on the North Slope of Alaska are disposed by downhole emplacement. The bulk of these wastes consist of drilling mud, drill cuttings, and produced brine water. These wastes are generated from the drilling and production activities and can be described as follows:

Drilling mud - When a well is spudded, a drilling mud is constructed by mixing a bentonite clay with water to produce a viscous, thixotropic solution that is capable of performing several functions essential to drilling the well - some of the major functions are to mud the well bore, overbalance the formation pressure, and remove the cuttings from the well bore. As the formation is drilled, rock material is ground up; some to large particles and some pulverized and suspended in the mud system. This raises the viscosity to a point where the mud is not readily pumpable. As the rock-laden mud circulates to the surface, it passes over shaker screens (80 mesh) to remove coarse material. To maintain the mud at a pumpable viscosity, demanders, desilters, and centrifuges can be used to remove the finer particles. In addition, the mud is diluted "watered back' to reduce the viscosity; this increases the volume of mud, some of which must be disposed.

Drill cuttings - This is the solid material that results from drilling the formations. This material is recovered at the surface through the use of the shakers, demanders, desilters, and centrifuges. The resulting material is run through a ball mill to grind it fine enough so that it can be pumped into the formation without plugging the formation openings.

Produced water - Crude oil reservoirs were initially deposited in a water environment, normally a marine environment. When the migrating oil reaches the trap it displaces the water, but it does so inefficiently, leaving producible water in the oil portion of the reservoir. Generally there is an aquifer below the reservoir that is much larger than the reservoir. Additionally, water is frequently injected into the reservoir to improve oil recovery. Therefore, water is almost always produced with the crude oil and tends to increase as oil production decreases.

Early North Slope Waste Disposal Practices

Early Practices on the Slope consisted of reserve pits onshore to hold the mud, and the cuttings from the drilling operation. Offshore, the mud and cuttings were pumped onto the ice. Environmental agencies objected to some of these practices; therefore, annular pumping and downhole injection became the favored disposal methods. Downhole waste disposal in the oil industry is not new. Based on API data, by 1940 approximately 15 % of the produced water in the United States was being injected below ground. It started out by disposing of produced water into depleted downhole structure wells, but when production increases were noted in adjacent wells, the benefits were recognized. The prospect of increased oil recovery encouraged operators to favor this disposal option, by 1963, 70% of the produced water was being injected into wells; by 1985 the percentage had increased to about 88%. (12% is surface disposal).

Downhole disposal occurs through the annulus of a well, through disposal wells, and through secondary recovery wells. Frequently mud and cuttings from drilling operations are pumped down the annulus formed when another casing is cemented inside of the surface casing. Mud, cuttings, and produced water are also injected for disposal into wells completed below the permafrost for this specific purpose. Frequently, produced water is injected into enhanced recovery wells where the fluid displaces the need for water from other sources - sea water or cretaceous water from source wells.

In recent years the North Slope operators have been cleaning out the in-field reserve pits, taking the mud and cuttings to the large scale grind and injection plant near well DS4-19, in the EOA. This disposal well was drilled and completed as a produced water injection well in September of 1989. ARCO put the grind and inject plant into operation on March 1 995 and slurry injection was started into well DS 4-19 on March 31, 1995. Over 200,000 cubic yards of solid material had been injected when the plant shut down on March 18, 1997. Through 1999, an estimated 1.2 million cubic yards of solid material - mostly cuttings - has been disposed of down hole.' This amount of gravel would build a road 3' thick, 27' wide by 75 miles long - from
Anchorage to Willow.

Well Construction For Disposal

Statewide regulations govern the construction of wells drilled for oil and gas operations in Alaska A conductor must be installed to support shallow formations and to provide suitable anchorage for a flow diverter. All wells drilled on the North Slope must have surface casing that is set and cemented into a competent (confining) formation below the permafrost (below all fresh water zones). The surface casing must be of suitable metallurgy to withstand the forces for permafrost thaw subsidence and freeze-back' and must be fully cemented from shoe to surface to protect fresh waters and to provide anchorage for the blowout preventers - BOPS. The cement through the permafrost interval must be a "permafrost" cement, e.g., one that sets at low temperature and has a low heat of hydration.

A "long string" is then set through the injection or disposal interval or set just above the interval. This casing must be cemented with sufficient cement to fill from the shoe to at least 500'above all significant hydrocarbon zones or at least 500' above the shoe. Injection for disposal or enhanced recovery must be through tubing that has a packer set no more than 200' measured depth above the perforated interval or for disposal wells, interval that could be perforated.

Waste streams for disposal are being pumped through three types of well paths. 1) In annular disposal, the waste streams are pumped between the surface casing and the long-string casing. 2) In disposal wells, waste streams are pumped down a tubing string equipped with a packer and injected through perforations into a selected disposal zone. 3) In enhanced recovery wells, produced water is treated for injection and is pumped down a tubing string equipped with a packer and injected through perforations into the producing formation.

Annular disposal requires there are porous intervals below the confining zone at the shoe of the surface casing and above the "probable" top-of-cement depth of the production casing. In addition, the operator has to demonstrate the adequacy of the surface casing cement job by means of a cement quality log or a formation integrity test taken to break-over. Commission approvals limit the volume to 35,000 barrels per well - this limitation is to encourage the construction and use of disposal wells on drilling pads and to reduce the possibility of the disposal stream eroding the production casing in the wellhead.

For disposal and enhanced recovery well operations, the operator must demonstrate by a cement quality log or other means that the casing above the disposal or injection interval is adequately cemented to preclude the upward migration of disposal fluids between the casing and the formation. In addition, before disposal or injection is initiated, the operator must perform a mechanical integrity test (MIT) to demonstrate that the fluid will exit the casing through the perforations. Normally, an annulus pressure test is conducted. A commission Petroleum Inspector will witness this MIT, either prior to, during, or shortly after start of disposal or injection. Note: disposal and enhanced recovery well construction and integrity testing meet EPA's UIC Class 11 requirements.

Additional disposal well requirements are that there must be porous, water bearing formations below the surface casing that will accept fluids at pressures that will not propagate fractures through the upper confining zones and the disposal fluids must be compatible with the formation water.

Additional enhanced recovery well requirements are that the fluid must be beneficial in increasing ultimate recovery, the fluid must be injected at pressures that will not propagate fractures through the confining zones that protect fresh waters, and the injected fluids must be compatible with the formation water.

Environmental Benefits of the New Technology

The early practice for disposing of mud and cutting on the North Slope included placing them into reserve pits onshore and dumping on the ice offshore. (Produced water has always been injected on the North Slope.) Under these practices, the mud and cutting in reserve pits were considered to be in a place and condition for final disposal. Mud and cuttings placed on the ice disappeared when breakup came and the ice melted. Under current practice for both onshore and offshore, mud and cuttings are conditioned and are pumped downhole for final disposal.

Onshore, the elimination of reserve pits has decreased habitat destruction and has eliminated the possibility of reserve pit over-flow as a potential source of tundra and surface water contamination. Offshore, the probable benefits are not easy to specifically define, but directionally, that potential for contamination of the near-shore waters has been eliminated.

Economic Impacts to the Operator

The original North Slope method of getting rid of produced water was to pump it down a disposal well. That method is still in use, so there has been no change for produced water. These disposal costs are not significant.

The original North Slope method of getting rid of mud and cuttings were low cost - almost free. But they are no longer available. The options available today are below ground encapsulation, below ground injection/disposal, or truck the material south to a "lower 48" disposal site. Below ground encapsulation is estimated to cost as much as 100 $/cu.yd., and with no guarantee of being a permanent solution. Grind and inject disposal also costs about 1 00 $/cu.yd., but it constitutes permanent disposal. Shipment to the lower 48" for Class I wastes cost 600 to 1000 $/bbl - therefore the cost per cubic yard would probably exceed 600 $/cu.yd. and may or may not be considered permanent. Given the current environment climate, industry is probably using a cost competitive technology that provides assurance of permanent disposal.

Conclusions

I've tried to give you some insight into current North Slope oil field waste disposal history, technology, practices, environmental considerations, and costs. Some interesting numbers, cumulative through Dec. 31, 1999 are:

Total solids pumped down hole, est 1,200,000 cys AOGCC BULLETIN DATA[5]

Total	disposal well fluids	1,358,576,833 bbls
Total	water produced	7,578,002,498 bbls
Total	water injected	11,981,577,000 bbls
Total	oil injected	13,033,911 bbls

I'll be glad to try and answer questions. I understand that there will be a question and answer session immediately prior to the break.
Thank you.

References

1. API publication "History of Petroleum Engineering" 1961.

2. U.S. Dept of Energy, Office of Fossil Energy and Interstate Oil and Gas Compact Commission, "OIL AND GAS EXPLORATION AND PRODUCTION WASTE MANAGEMENT: A 17 STATE STUDY", June 1993.

3. Mike Bill, ARCO, personal correspondence, April 2000

4. ARCO "PRUDHOE BAY FIELD, PERMAFROST CASING AND WELL DESIGN FOR THAW SUBSIDENCE PROTECTION". May 1975.

5. Alaska Oil and Gas Conservation Commission, February 2000 "Bulletin

Effluent Management on the North Slope

Harry Engel
ARCO Alaska, Inc.

Good afternoon. I am going to spend a few moments to focus on the evolution of effluent disposal from exploration & production operations in Alaska. My observations are based upon experience as a waste generator when I worked on drilling rigs to my current role of being responsible for field environmental compliance.

Our industry has learned a lot about effluent management in the arctic over the past 25-30 years. This morning you heard about grind and inject technology and how it changed the way we manage muds & cuttings. G & I is a prime example of utilizing technology to improve an environmental management system. This permanent and environmentally sound disposal method isolates wastes, eliminates subsequent disposal and greatly reduces the surface space required for drilling operations. In 1999 over 10 million barrels of muds/cutting where successfully managed at G & I in the Eastern Operating Area of Prudhoe Bay.

Another option for handling drilling muds & cuttings is annular pumping. In this application, drilling wastes generated from the construction of new wells is pumped down the annulus, below the permafrost, which can be as deep as 2000 feet. In both of these applications, design and construction activities must be approved by appropriate regulatory agencies.

Produced water represents a major effluent from our production operations. Produced water is re-injected into the reservoir to help produce more oil, called water flooding. Excess produced water is injected below the permafrost into a confining zone. In 1999 ARCO Alaska successfully re-injected over 69 million barrels of produced water.

Non hazardous E & P effluents are managed in EPA administered Class 1 non-hazardous disposal wells. Up until 1997 only 3 Class 1 wells were permitted in EPA Region 10. They are located in the Eastern Operating Area of Prudhoe Bay, managed by ARCO Alaska Inc. Today there are several more Class 1 wells in the arctic to support activities from recent discoveries. (i.e.: Badami & Alpine). The 3 Class 1 wells in the Eastern Operating Area of Prudhoe Bay are approximately 2200 feet deep, completed just below the permafrost. The injection zone is composed of loosely consolidated sands & gravel with a porosity of 25% and a permeability ranging from 1-2 darcies. The surface facility consists of 3 injection pumps; surge tanks, solids removal equipment and a lined off-loading area for tank trucks. With the exception of a small volume of snow melt water from an adjacent drill site, all fluids injected in Pad 3 are trucked in. During the past 10 years of the existing EPA UIC permit at Pad 3, 7.5 million barrels from 40,000 truckloads have been successfully injected as Pad 3.

In addition to location, design and construction, an effective training and management system is crucial to the successful operation of an underground injection facility. I would bet our employees & contractors in Alaska have had more environmental management training and are more knowledgeable about regulations than most. Generators, transporters and receivers of waste are certified by attending waste-management training. A North Slope wide manifest system is utilized to document each load from its point of generation to its final destination. Refresher training is required to provide updates on regulatory or procedural changes. This morning I spent 2 hours with 15 others in a “train the trainer” session for the new Alaska Disposal and Reuse Guide.

Our industry has come a long way in improving the management of E & P effluent. Pollution prevention & waste minimization programs are effective in minimizing quantities. Programs like Green Star promote pollution prevention and waste minimize and recognize companies for their successes. ARCO Alaska was the first North Slope operator in Alaska to receive Green Star recognition.

As we move into the future, underground injection will play a key role in the effective, environmentally sound management of E & P effluent. Our industry has been working with regulatory agencies to expand the use of underground injection, to include other non-hazardous materials. In 1999 over 80 million barrels of oil field effluent from ARCO Alaska facilities have been successfully managed on the North Slope utilizing underground injection technology.

With proper planning, facility location, design and construction, coupled with an effective training and management system and monitoring plan, underground injection has proven to be an effective environmentally sound method to manage oil field effluent in Alaska. Thank you for this opportunity to talk about this subject. I’ll take any questions at this time.

Effluent Disposal and Minimization – Agency Perspective

Cindi Godsey
U.S. Environmental Protection Agency

I'm Cindi Godsey, and I work for the Environmental Protection Agency in the NPDES Permit Program. When I was asked to speak today, they asked me to talk about NPDES and technology, so what I want to do first is give an NPDES-101 course.

This is the history of Federal pollution control legislation, starting in 1899, so we have a long history of this. The latest is the Clean Water Act of 1987. Section 402 of the Clean Water Act states that no discharge of pollutants from a point source into waters of the United States unless the discharge is in compliance with an NPDES permit.

Federal Water Pollution Control Legislation - 1899 through 1987	
	River and Harbor Act of 1899
PL 80-845	Water Pollution Control Act of 1948
PL 82-579	Water Pollution Control Act Extension of 1952
PL 84-660	Federal Water Pollution Control Act of 1956
PL 87-88	Federal Water Pollution Control Act Amendments of 1961
FL 89-234	Water Quality Act of 1965
PL 89-753	Clean Water Restoration Act of 1966
PL 91-224	Water Quality Improvement Act of 1969
PL 92-50	Federal Water Pollution Control Act Extension of 1972
PL 92-137	Federal Water Pollution Control Act-,-Extension of 1972
PL §2-240	Federal Water Pollution Control Act Extension of 1972
PL 92-500	Federal Water Pollution Control Act Amendments of 1972
PL 93-207	Federal Water Pollution Control Act Amendments of 1973
PL 93-243	Federal Water Pollution Control Act Amendments of 1974
PL 93-592	Federal Water Pollution Control Act Amendments of 1975
PL 94-238	Federal Water Pollution Control Act Amendments of 1976
PL 94-558	Federal Water Pollution Control Act Amendments of 1976
PL 95-217	Clean Water Act of 1977
PL 95-576	Federal Water Pollution Control Act Amendments of 1978
*PL 96-483	Federal Water Pollution Control Act Amendments of 1980
PL 97-117	Municipal Wastewater Treatment Construction Grant Amendments of 1981
PL 100-4	Water Quality Act of 1987

I'll give you several definitions. The first one is the definition of "*pollutant*", which can basically be anything:

"Pollutant" means dredged spoil, solid waste, incinerator residue, filter backwash, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 *U.S.C. 2011 et seq.)),* heat, wrecked or discarded equipment, rock sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water (40 CFR 122.2).

The second is the definition of a *point source*, which may basically be from anywhere:

"Point Source" means any discernable, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged (40 CFR 122.2).

The third is *Waters of the United States or Waters of the U.S.* which is any drop of water that is "thoroughly natural":

Waters of the United States include:
(a) All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
(b) All interstate waters, including Interstate "Wetlands;"
(c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, "wetlands", sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:
(1) Which are or could be used by interstate or foreign travelers for recreational or other purposes;
(2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
(3) Which are used or could be used for industrial purposes by industries in interstate commerce;
(d) All impoundments of waters otherwise defined as waters of the United States under this definition
(e) Tributaries of waters identified in paragraphs (a) through (d) of this definition;
(f) The territorial sea; and
(g) "Wetlands" adjacent to waters (other than waters that are themselves, wetlands) identified in paragraphs (a) through (f) of this definition.

Section 301 of the Clean Water Act that requires the development of technology-based effluent limits for different categories of dischargers. Section 301 basically sets aside certain times for each category of discharger by which time they must have some form of technology-based limits developed for them. Of course we missed all the deadlines, but there are some out there.
EPA has to develop these deadlines by the time they issue the NPDES permit for certain categories that the permit writers have developed technology-based limits for you guys.

So in developing the effluent guidelines, as well as developing technology-based limits, according to each permit writer's best professional judgement, there are a few things that EPA takes into consideration. There are three different factors. The first is the *Best Practical Control Technology (BPT)* currently available. BPT takes into account:

The total <u>cost</u> of application of the technology in relation to the effluent reduction benefits to be achieved from such application;
The age of equipment and facilities involved;
The processes employed;
The engineering aspects of the application of various types of control techniques;
What process changes the industry might have to go through to upgrade; and
Any non-water quality environmental impact, including energy impacts.

The second is "Best Conventional Pollutant Control Technology (BCT)". This applies to Conventional Pollutants, which include:
Biochemical Oxygen Demand (BOD);

Total Suspended Solids (TSS);

pH;

Fecal Coliform; and

Oil and Grease.

In determining how to control these conventional pollutants, assessing BCT involves:

The reasonableness of the relationship between the <u>costs</u> of attaining a reduction in effluent and the effluent reduction benefits derived;

The comparison of the cost and the level of reduction of such pollutants from the discharge from publicly owned treatment works to the <u>cost</u> and level of reduction of such pollutants from a class or category of industrial sources;

The age of equipment and facilities involved;

The process employed;

The engineering aspects of the application of various types of control techniques;

Process changes; and

Non-water quality environmental impact, including energy requirements.

Finally there is "Best Available Technology that is economically achievable (BAT), which states that we must look at the direct cost. While the others were comparisons, the BAT involves looking at the cost associated with achieving the reduction. Here we consider:

The age of equipment and facilities involved;

The process employed;

The engineering aspects of the application of various types of control techniques;

The cost of achieving such effluent reduction;

Process changes; and

Non-water quality environmental impact (including energy requirements).

When EPA writes an NPDES permit, all of these things are considered, but they are considered also against water quality standards. And in setting permit limits based on water quality standards there is no cost that is determined, and that is really the deciding factor on many parameters where, for example, there may be a limit on metals, and if the water quality standard is more stringent, then that is what we have to go with on the permit, with no consideration as to how much that might cost to achieve that effluent limit.

I think I've pretty much covered it, and how we consider costs and other factors in writing an NPDES permit, but how these factors are superceded by the water quality standards

Emission Control for the North Slope

Tom Chapple
Alaska Department of Environmental Conservation

I'm going to spend just a few minutes talking about air pollution, emission sources, control options, what those emissions result in terms of downwind patterns, and where the Department is heading in terms of air quality management.

These are the contaminants we are interested in, the prime, regulated pollutants we review in the permit process:

Oxides of Nitrogen – NO_x
Oxides of Sulfur -- SO_x
Carbon Monoxide – CO
Particulate Matter – PM
Volatile Organic Compounds – VOC

The effects of these contaminants are varied:

NO_x - Results in a visible plume, and we also have number of health effects; nose and eye irritation, pulmonary edema, bronchitis and pneumonia, ozone precursor, acid rain, vegetation damage.

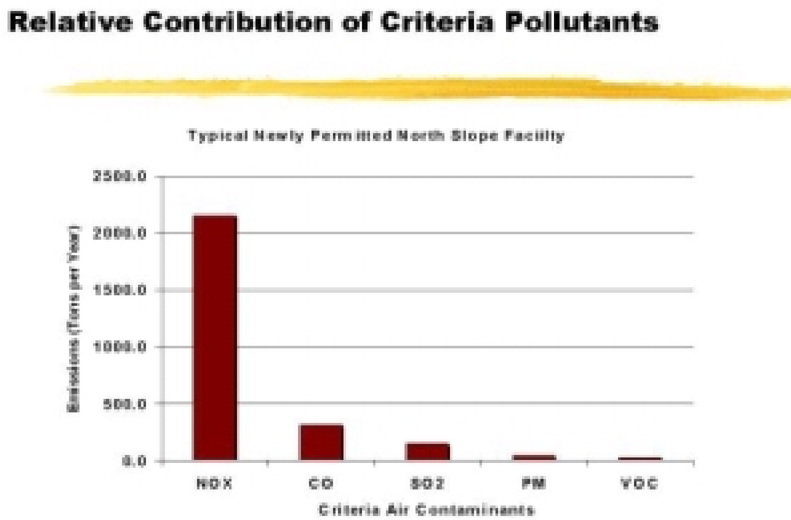
SO_x - Similar, but the health effects to humans are different. Reduced visibility, breathing difficulty, chronic coughing, acid rain, and can result in significant vegetation damage.

PM – Is not a contributor to acid rain but it can cause vegetation damage. Reduced visibility, respiratory tract diseases, can vegetation damage.

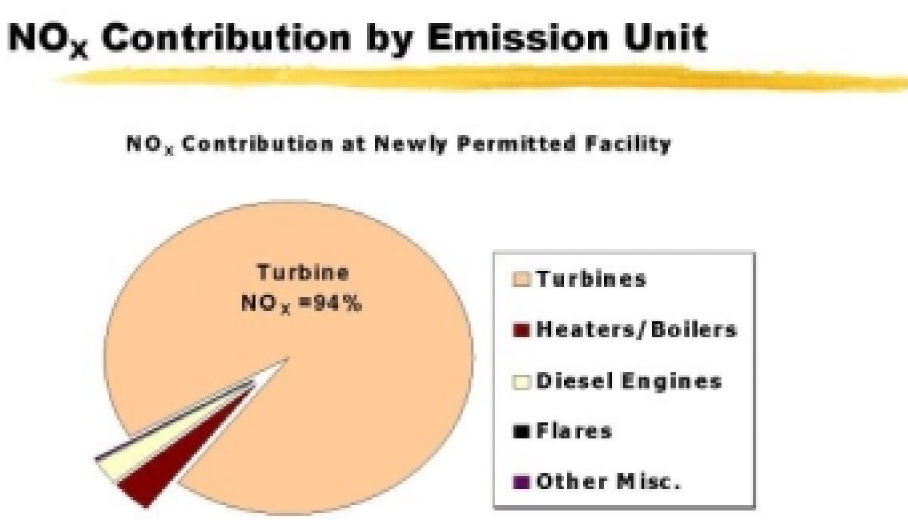
CO - principally a human health concern, most everybody knows about, automobiles, N slope doesn't really have that problem….reacts with hemoglobin to prevent oxygen transfer; can be fatal.

VOC – primary pollutant in forming ozone and photochemical smog.

The primary emission units on the North Slope are turbines, heaters and boilers, diesel engines, and flares.



Looking at what we see as relative contributions, the biggest bar on the chart is NO_x emissions. NO_x is formed from nitrogen in the air and the high temperature of combustion.



This graph shows an example of a typical facility, a new installation on the slope, a little over 200,000 tons per year NO_x, emissions, CO in the range of 300 tons per year. SOx is low, and generally is not of concern on the slope because natural gas is the primary fuel, and this has low sulfur content that is partly due to reservoir management by keeping biological activity down to that we aren't having reservoir souring on the Slope.

It's really important to look at where NO_x comes from, for instance the turbines. That's because turbines are the prime mover on the slope, both for electrical power and moving liquids for processing oil and gas. Approximately 94% of the NO_x on the Slope comes from turbine emissions.

This is a typical, single cycle, uncontrolled engine. As a reference point, NO_x emissions are running at about 100 to about 400 PPM NO_x in a standard engine such as this that has been marketed widespread over last decade or so. In this typical North Slope Turbine running at about 15,000 to 50,000 hp in size, and each unit would emits between 200 to 1500 tons per year NO_x. That is our starting point. But I want to remind you of that range but 100 to 400, and we'll look at three different control options: (1) water/steam injection; (2) dry low NO_x control; and (3) selective catalytic reduction. These will give you an idea of what we are seeing in terms of the trends in reducing NOX emissions.

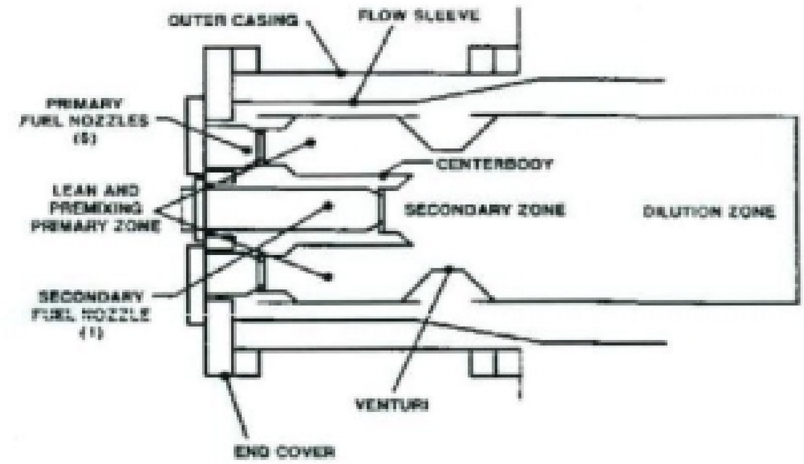
For Water/Steam Injection, the principal is that you are injecting either water or steam into the combustor zone to lower the temperature of combustion and therefore lower NO_x emissions. The benefits of water/steam injection are that we are seeing a 70 – 90% reduction in NO_x up the exhaust stack, so we're getting down to numbers around 25-75 PPM NO_x in the exhaust stacks.

It does have some drawbacks, including high capital costs and operating costs as compared with dry low NO_x. The biggest problem is water. A decade or so ago, when this was basically the only technology available for reducing NO_x emissions on the Slope, water considerations drove industry and government more toward dry low NO_x control because the Slope is arid, and water is not that readily available. Plus, you need to have to have very high purity water (<1 PPM dissolved solids). The process can also increase wear on industrial turbines, and may result in lowered fuel efficiency.

Water/Steam Injection is widely used throughout the U.S., but is not widely used on the Slope. I believe there is one installation on the Slope that is using water injection, at least on a periodic basis.

The next control technology is Dry Low NO_x Control. Here the concept is that you have a lean premix combustor process where air and fuel mix before they enter the combustion chamber to extend the duration of time the combustion occurs

Dry Low NO_x



This diagram shows a schematic of the combustion zone. So, you're trying to keep the temperature down by various design features, hardware features that are built into the engine as you come through the compression zone and into the combustion zone. Lean premix is the most popular dry low NO_x combustor.

Dry Low NO_x

This picture shows some of these combustors that are aligned radially in the engine. We're seeing a 70 to 90 percent reduction in NO_x emission (<10-40 ppm NO_x) through a Dry Low NO_x Control System. Ten to twelve years ago we would see Dry Low NO_x systems that would be about 150 ppm or 170 ppm, and I recently saw a notice out of South Carolina that they are permitting a new turbine that they are putting an emission limit on of 7 ppm for Dry Low NO_x control. It is a proven technology with no water required. The drawbacks are that the costs are higher than conventional combustion system, and that performance may vary with the load on the engine. Dry Low NO_x Control Systems are very widely used in the U.S. and on Alaska's North Slope, and I just want to acknowledge that technology has moved a long way in the last 10 to 15 years.

The newer technology on the horizon is Selective Catalytic Reduction. This also has moved tremendously forward in the last half dozen years. This principal is that ammonia or aqueous urea is injected into the turbine exhaust stream. This is an "add on" control that is installed after the exhaust has gone out of the rear of the engine. This results in the ammonia or urea, aided by a catalyst, to convert the NO_x to atmospheric nitrogen and water.

For the chemistry buffs out there, we have a few equations.

$4NO_2 + 4NH_3$ --> $4N_2$ + 6H2O

$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$

We are seeing greater than 90% NO_x control, down to two ppm, and it works well in tandem with these other technologies, such as the Dry Low NO_x design combustor unit coupled with an add-on technology in the exhaust stack. The disadvantages are that the capital cost is very high, and the operating costs are something to be concerned about too. We also have another issue now as we add ammonia to the equation. We have some "slip" of ammonia out of the exhaust, and that can be of concern. Manufacturers generally specify less than 10 ppm ammonia slip from the exhaust. SCR may also have some water requirements. Right now we are seeing over 100 installations across the U.S. since 1986. California is actually requiring as low as 3 ppm permitted for NO_x for SCR. We have not seen any SCR equipped turbines in Alaska.

That is a snap shot of those three technologies for NO_x control.

I want to make a few points about vegetation affects because you are really protecting health at the ground level, protecting vegetation or other habitat, or you may be interested in long-range transport of air pollutants, such as acid rain.

Not too long ago, between 1989-1994, there was a 5 year study looked at vegetation- funded by AOGA and the ASTF looking at what, if any, changes were occurring in the vegetation immediately downwind from the largest sources on the slope. So this looked at the Central Compressor Plant compressors, which would have been the largest sources on the Slope. They looked at three aspects, and I am not a vegetation biologist, so I don't know the details, but they looked at plant diversity – what the plant community was, foliar injury and physiology. Sometimes you will have an effect where one plant species may die out because it can't tolerate the pollution, while others thrive, so you will see a change in the composition, or a change in diversity. You can also see direct impacts to the foliage as spotting or burning edges of the leaves, and so on. And then we looked at the physiology in terms of the nitrogen uptake, and what impacts the NO_x had on the plant.

So those are the three aspects that were looked at. As for results, there were no observed damages during that five-year period. However, there is some caution in that the study needs periodic re-look for long term, so it needs to be revisited. There was one part of the report that indicated that for at least one of the species there was a higher N uptake by one of the plants closer to the facility, but in a lab situation, it didn't show it. So it left a question. Some of us that have been around the field for awhile know that if you go to certain areas near big smelting operations, you can visibly see where the vegetation has died off for 20 miles around the facility.

In managed air quality we try to control pollutants to "prevent significant deterioration", so you have a cap on pollution growth at the ground level, that is actually in this case for NO_x, is one quarter of the public health standard. So we are operating at a low benchmark, and that benchmark is meant to be protective of pollution growth.

So, I have a few conclusions. Again, to reiterate what you heard earlier this morning, the Department and Industry must continue too work together, and with the public as well, in a partnership to ensure and maintain clean air on the North Slope of Alaska. We have three proven technologies that are each effective in reducing NO_x emissions: Water/Steam Injection, Dry Low NO_x, and Selective Catalytic Reduction. The SCR is a technology that needs a closer look in the future.

We do not think of air quality as one of the front and center bright line environmental controversial issues for the North Slope. But I would like to leave you with the fact that it is very much an important issue. When folks talk about enhanced development they talk about the air pollution emissions. And I think it is important for all of us to remember that we do need to move forward on reducing emissions. Even though we meet public health standards with best available control technologies, and we push the Clean Air Act, we need to continue to develop these technologies.

With that, I'll say "thank you".

Drilling Technologies

Fritz Gunkel
ARCO/BP Shared Services Drilling

BP and ARCO have been working our drilling together for a number of years on the North Slope. The purpose of my talk is to provide a description of directional drilling and the impacts that advances in this technology have made on the North Slope over the last 20 years

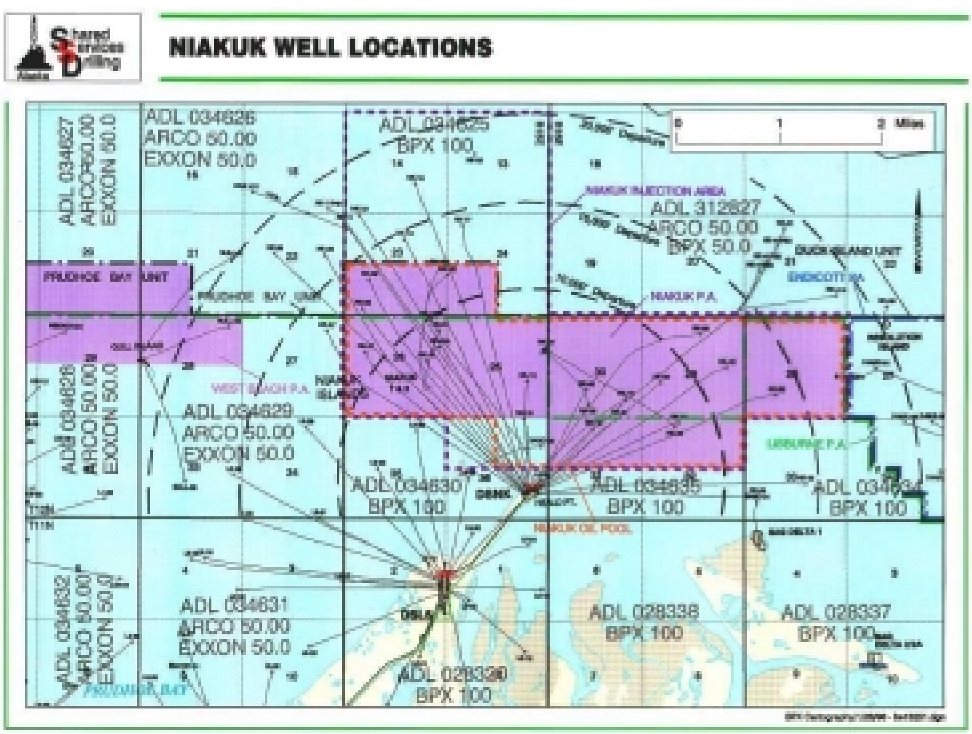
First some contrasts attributable to directional drilling technology: In 1980, in Prudhoe Bay, we considered the minimum economic thickness of oil saturated sand to be 100 feet. So, sand thicknesses less than the equivalent of an eight-story building were uneconomic to develop. We encountered reserves at drill site 18 in 1985 of less than that and plugged the well back. Today we drill horizontal wells a mile long in pays no thicker than from the bottom of that door to the top of that doorjamb.

In 1980, we thought the closest we could put two wells together was from that wall to that wall (approximately 120 ft.). We thought that for a number of reasons. The first had little to do with directional drilling. We thought that the impact of frost subsidence would be so severe that the two wells would impact each other. But we were also concerned about running into the other well while we were directional drilling. Today in an area the size of this room, we would line up 12 wells from there to there, and we would line up another 12 between you and I. As a result, where we used to have 60 acre well pads, we now have a five acre development that will include room for 35 wells, production facilities, and all the storage capacity and housing for the people. Now you've already heard that one reason for the reduced space required is the elimination of the reserve. The other reason for the reduction is directional drilling.

The last contrast I would like to draw for you is that in 1980 we thought we were doing pretty well to drill a well with an inclination from vertical of 45 degrees through the reservoir, and to push it out 5000 feet. Today we can do the equivalent of spotting a well here, drilling that well out under the Cook Inlet, over to the airport, riding the well down through the walkway and out to the airplane at Gate B-2. We can put it right there. There are eight rigs on the North Slope doing that kind of work right now. That is the progress that has been made in this area.

So how did the technology of directional drilling start? It started ages ago, actually in California off of Signal Hill as oil men looked longingly out into the ocean trying to figure out how they could get from here to there. The quest was to reach the offshore oil from onshore. This started with guys making wooden and later steel wedges and jamming them into the hole, to nudge the bit in roughly in the direction they wanted it to go. From those simple beginnings, directional-drilling technology has evolved at a dramatic pace.   The technology has benefited from advancements in navigation from aerospace, from advancements in metallurgies, and from many other scientific fields.

This morning you saw some pictures of well pads on the North Slope, and I'd like



to give you feel for what is underneath those well pads.

Without looking at the fine detail here, this is one of our well pads, our Niakuk pad, way out on the edge of one of the natural peninsulas on the North Slope. In 1988 I was asked as a drilling engineer, to describe how far we could drill a well from this well area. The question was "what is the maximum we will ever reach?" At that time, we thought the maximum was roughly about 10,000 to 12,000 feet sideways. But, in the last few years we've drilled wells that traveled laterally over 20,000 feet from its surface location. It is technically feasible to reach out 35,000 feet from the surface location under the right geologic conditions. At a place called Wytch Farm in the south of England 35,000-foot departures have been achieved by BP-Amoco.

The objective for directional drilling is to be able to reach out and touch oil and gas where we were not able to touch it before. Under each of the well pads on the North Slope you will find one and only one vertical well - every other well is deviated in some respect.   Most of the wells on each pad reach laterally to access oil not located near the vertical projection of the pad footprint.

Let me offer a quick look at the technology. It is an interesting combination of some pretty, simple, pragmatic things that work in the rough and tumble world of downhole drilling, and some highly technical pieces of equipment that really were taken from the aerospace industry. There are some basic tools in directional drilling: (1) a steerable motor; (2) a “measurement while drilling tool”; and (3) a directional drilling plan.

A steerable drilling assembly is made up of just a couple of key components. The only component that rotates in this assembly is the bit on the bottom. It is turned by a reverse Moyno pump, that is just a shaft that turns in an elliptical stator. Pumping drilling mud through this device turns the shaft. The motor assembly is bent, and we are able to control which way it is oriented. The bent motor assembly puts a lateral load on the well bore, and we’re able to carve our way along. It used to be that in the length of this room we might be able to turn the well bore three degrees. Today, using the right equipment, we can start on this end of the room, start down this way, and by the time we get to that wall we’re headed in the opposite direction. And amazingly, some of the same pipe, that we used to think would be permanently ruined by doing that, works just fine.

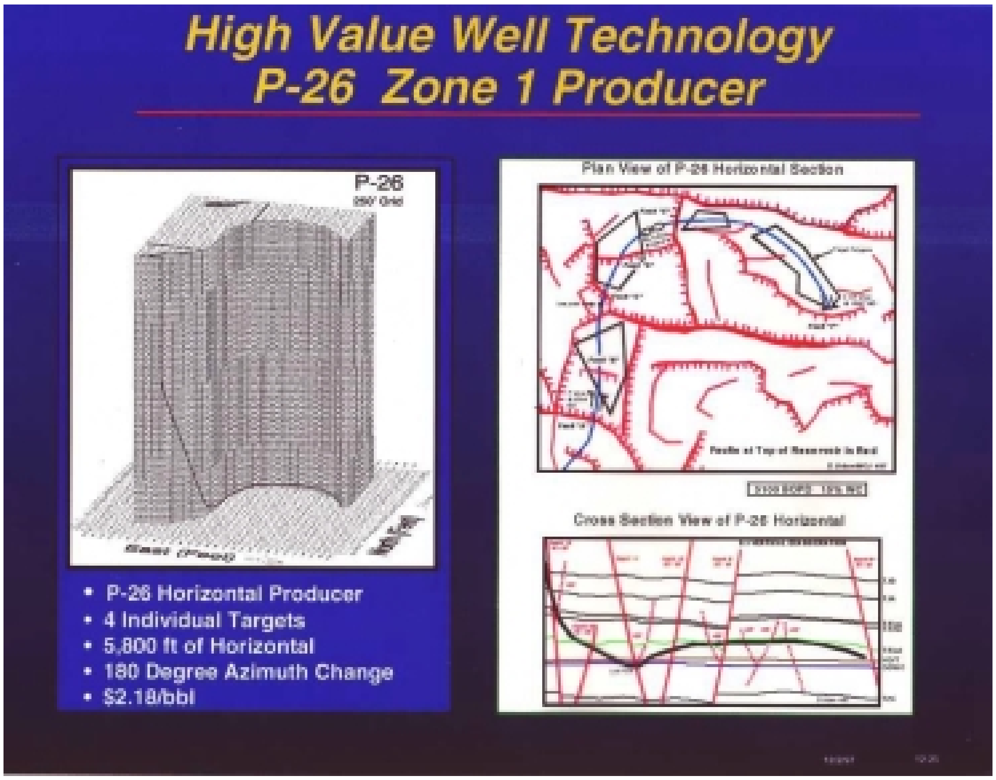
The other key pieces to this are the real high tech components. These are the downhole tools that read the chemical and mechanical properties of the reservoir. They tell us what the density, porosity, and the water saturation of the reservoir are; all important things to know. Are you in a sweet spot or not? When you are following ten feet of pay, you are susceptible to the hills and valleys that exist even in a flat depositional environment. These tools help us find our way.

Also today, we use more of our old wells to access reserves than we create new wells. Blair talked this morning about the cementing of surface pipes. We eliminate the need to make that investment in many of our replacement wells today because we use wells that were drilled 10 years ago as our starting point. We ensure the mechanical integrity of that well, and then we abandon the old zone and drill a new well from that existing one. Many times we don’t take any of the plumbing out of the well at all - we leave the well with the original tubing string in place. We plug back the old unneeded section, we mill a window in the existing casing, and we deviate out into new reserves.

This is been a solution to a few problems. Old wells down in the pay zone are susceptible to corrosion, and instead of going down and fixing those old wells, we just replace them. It also has reduced our costs of development significantly in situations where you get a lot less oil recovery from each well. A redrill of an existing well can cost as little as one tenth of what the original well cost in 1980.

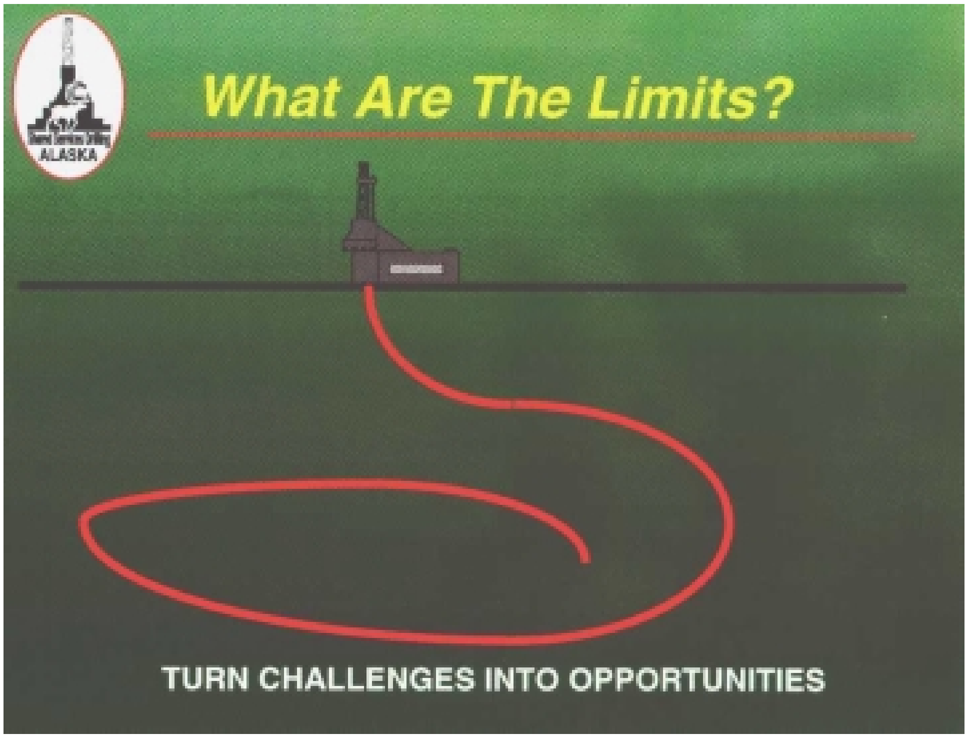
Now a little on directional planning when I was just starting out was pretty easy stuff. Today it is much harder. Planning is done in three dimensions, where we literally lay out the trajectory of the well bore according to the various horizons where we want to be. Frequently we want to porpoise up and down in the reservoir so that we cross the permeability barriers, and we have to be sure that we are allowing flow across vertical permeability barriers

I'll show you a three dimensional picture of one of many of the wells of this type that we have drilled.



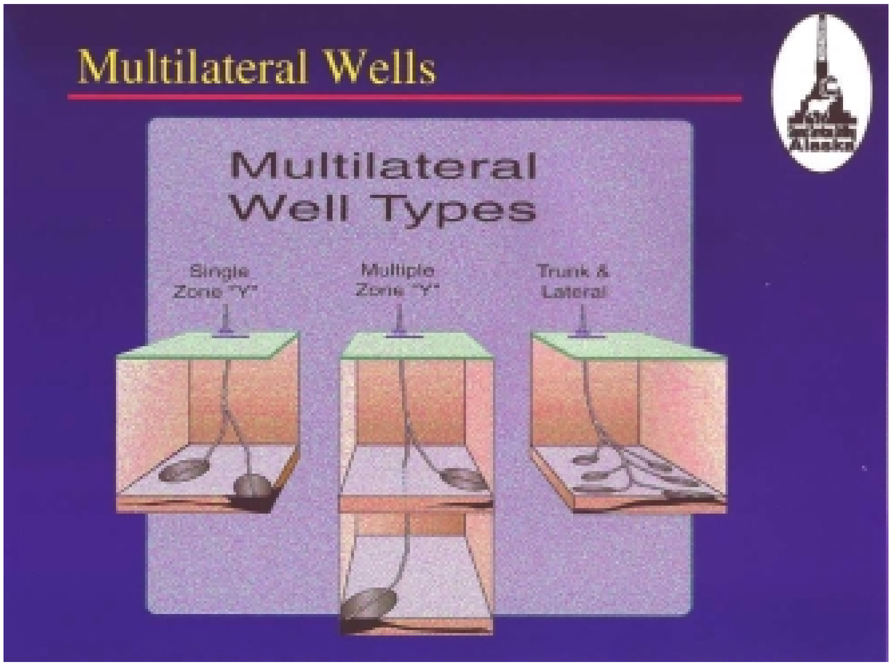
Here is an example of a well drilled on P-Pad. Steve Taylor showed you a picture of P-Pad showing development on ten-foot centers this morning. Here is an attempt to depict this three-dimensional well in two dimensional space. You can see that we've deviated it, and then we drilled a little fishhook at the bottom. This little fishhook is about 5000 feet long. Why did we do that? Because as you can see, we had four accumulations of oil against faults, and we wanted to be able to access those accumulations of oil. No single one of these accumulations of oil would have merited drilling a well here - no one accumulation of oil would have supported a million plus dollars of investment. But because we were able to access it like this, we were able to make this well an economic venture. Directional drilling has allowed us to continue developing the depleting reservoir by allowing access to smaller accumulations of oil with greater accuracy and at lower cost.

So what are the limits here?



Somebody drew this picture about a year and a half ago as a joke, then we drilled two wells that look much like this. We actually have thrown a well bore lasso around a production well, and then herded oil into the center by injecting miscible injectant along this horizontal column with the producer in the middle. We'll sweep the maximum amount of oil out of the reservoir.

A relatively recent development in directional drilling as is multilateral wells.



Multilateral wells use the same main well, and then drill multiple branches to a variety of locations out from that main well. So imagine today where you might drill two or three of these branches into the reservoir, all from the same surface system using the same plumbing on top to gather it together. This may be the way that we end up developing some of the shallow sands on the North Slope. We plan to drill a few wells in the Schrader Bluff this year testing our ability to deliver the goods.

This morning seemed to be a morning of quotes, and I have a quote of my own. As an ARCO guy working in BP's office, I found a quote from that famous British drilling engineer, Robin Hood. "Smaller targets require better aim". That is the name of our game on the North Slope.

Thank you very much

Corrosion Protection and Infrastructure Integrity – Industry Perspective

Belinda Breaux
ARCO Alaska, Inc.

NOTE – THE FOLLOWING IS A SUMMARY OF MS. BREAUX'S PRESENTATION. A COMPLETE MANUSCRIPT OF HER PRESENTATION HAS NOT YET BEEN MADE AVAILABLE.

I also appreciate the opportunity to speak to you today. I am very proud of the corrosion management program that we have put into place at ARCO, and proud of the accomplishments of the people that are part of the ARCO corrosion team and support team members that help us do our job every day.

From an ARCO perspective, then, I will share with you the North Slope corrosion program, and focus on what our practices are, and also on how technology has been developed and implemented because of the need for corrosion protection on the North Slope. Technology development and the best practices related to corrosion protection have worldwide impact, not just impact here in Alaska.

ARCO does have a proactive corrosion management program. We have a significant amount of given technical and financial resources dedicated to preventing corrosion and manage corrosion on the Slope. And I agree with Susan in that this is clearly good business sense, and ARCO management agrees with this. We know that this is the right thing to do for the protection of our employees, always our number one goal, protection of the environment, as well as protection of multibillion-dollar facilities that are our most valuable assets, and are what allows us to stay in business.

This is kind of a high level overview of our corrosion program. I'd like to share with you our documented philosophy for corrosion protection according to management ant ARCO. Our philosophy, as written, states that we are to maintain facility integrity in developing and continuously improving an integrated corrosion control program that was designed to minimize life cycle costs. Clearly this is not a reactive program. We invest really heavily on up front so that we prevent the damage from occurring in every case where we can. We minimize the amount of corrosion that does occur, and we take care of the problems as soon as we are aware of them. Our goal is preventative corrosion - we don't try to manage corrosion at some calculated corrosion rate that is acceptable. Frankly the science and technology in corrosion management is not good enough for us to do that.

The corrosion program at ARCO is one of the largest in the world. On the Slope, we are responsible for protecting over 1000 miles of pipeline, over 1500 smaller diameter pipelines on our drill pipe pads, we have somewhere on the order of 70 drill sites, and somewhere on the order of a dozen or so processing facilities.

There are over 100 professionals for ARCO working on the corrosion team. This includes ARCO employees, monitoring and inspection personnel, vendors who are developing our chemicals that help prevent corrosion on the North Slope, and technical experts that stay on the North Slope with us. We have corrosion engineers, chemical engineers, mechanical engineers, metallurgists, Ph.D. microbiologists, chemists, monitoring and inspection technicians, and we have links into university R&D programs. The results of the program can be seen when you look at the spill trend on the North Slope. We've had one report the last two years that went on the tundra that was caused by corrosion.

As a summary of the major components of our corrosion program, the primary program is for internal corrosion, that is corrosion that occurs inside of piping and vessels that has resulted from the corrosivity of the fluids that are produced, primarily produced waters. Another major program that Susan alluded to is corrosion under insulation. That is the corrosion that occurs when water gets into the insulation, sits against the hot pipe, and causes corrosion to occur. As for erosion, Susan showed a BP facility that had a very serious incident a couple of years ago caused by erosion. That is where the metal surfaces of pipe are worn away physically. It is not really a corrosion mechanism, but is a mechanical mechanism where the metal is worn away from the outside. And then finally there is a tank and vessel inspection and compliance program. These aren't the only components of our of the program, but they are the four biggest.

Corrosion protection on the North Slope is a classic continuous improvement process. The first step in the process is to evaluate the risk to evaluate the risk we look at both the likelihood for corrosion to occur in this particular system and then the consequences if corrosion does occur in that system. So there are certain things that we take into consideration when we are evaluating the likelihood, including corrosion engineering training and experience, historical knowledge of where leaks have occurred in similar systems elsewhere, and where they occur that we know about in our own process. We look at the design parameters of the facility, process conditions, temperatures, fluid characteristics - they all tell us something about whether corrosion is likely to occur. This is only one half of the equation. The other half is that if corrosion occurs, what kind of consequences will we have? Here, we look at what are the risks to personnel from the system, what is the risk to the environment, what are the risks to our facilities in terms of repairs or replacement, and what is the production loss.

Once such risks are recognized, we develop a mitigation plan. One of our highest risk areas on the North Slope is the internal corrosion of our cross-country pipelines. Internal corrosion is bound to occur in the pipelines, they come into contact with all of the corrosive fluids coming out of the ground. And the consequence of failure from internal corrosion on our cross-country pipelines is also high, both from a safety standpoint as well as from a spill or environmental impact standpoint. And obviously there is a cost to the industry from a cross-country pipeline spill.   We develop a mitigation plan for internal corrosion that primarily involves chemical corrosion inhibitor treatment.

The next step in the process is to implement that mitigation program. When we went to implement the internal corrosion treatment programs at both Prudhoe Bay and Kuparuk in the 80s and 90s, we found that we had to not only find the chemicals, but we had to develop chemicals that would work in our process conditions. We had to develop the infrastructure to transport, to deliver, to store and to inject the chemicals. And then we go into monitoring results. There is a huge effort that goes into monitoring for internal corrosion - thousands of data points for monitoring the results of the program to determine whether what we do is good enough, or to determine whether we have to ramp things up and come around again. This is the nuts and bolts that Susan alluded to in her presentation of earlier.

At a high level, there are three main pieces of information that we look at to determine our chemical inhibitor treatment rate. The first two, probes and coupons, are monitoring devices that I will be giving you more information on later. They tell us something of the corrosivity of the fluids and whether or not the fluids are remaining inhibited. They do not necessarily tell us whether corrosion is going on in the facilities themselves, but they tell us a little bit about the process conditions. The third item is inspections where we actually look to see if there is damage to the facility or pipeline. If we see that there is evidence of corrosion, we increase the inhibitor rate, because our goal is to prevent corrosion from occurring. We want the data to be flat, and I'll show you what I mean by that in just a second.

Corrosion probes are inserted into the system, inside the pipe or vessel that is likely to see corrosion. Most are electrical resistivity probes. We measure the electrical resistance of a piece of metal that sits in the process fluid. If there is corrosion, the piece of metal gets smaller and changes the electrical resistance measurement, and gives us a correlation of what the corrosivity of the process fluids are. We have about 200 of these locations in our facilities on the Slope, primarily in the cross-country pipelines. These are on-line monitoring devices, and they have collected continuously, remotely, transferred to our computers, and our engineers can pull up this sort of data as often as they like. We generally look at this data on a weekly or even a biweekly basis.   Probe data is put into graphic form in a probe plot.

Corrosion coupons are similar to probes in that they tell us something about the corrosivity of the fluids that come in contact with the coupon, but they don't necessary tell us what is happening to the metal surfaces of the piping. We have a couple of thousand of these coupon locations on our North Slope pipelines and facilities. Coupons are pulled on a regular basis - 3 months, 6 months, 12 months is the normal cycle. You pull them according to the cycle, weigh them for metal loss, and calculate a corrosion rate. This is a coupon from an inhibited system, and it looks virtually the same way it did on the day we put it in, kind of nice and shiny and new. When corrosion is evident, we know we have to increase inhibitor in the system, or in some cases change inhibitor. But generally increasing inhibitor corrects it. Coupons are a proactive method because the coupons are more susceptible to corrosion than the piping itself. As soon as we see damage to the coupon, we immediately react. In our cross-country pipelines, we pull these coupons about every three months, and if we don't get a near pristine coupon out we are going to assume corrosion.

The last leg of that flow chart I showed you on program management was inspection. We use x-rays of piping to look for metal loss. This is the type of information that every good corrosion engineer would like to have on every pipe 24 hours a day. But getting an x-ray is an involved process. You take a camera, attach it to the pipe, and sometimes it takes an hour develop the film of that shot. It is a really slow process. We've taken approximately 100,000 x-rays of section locations at ARCO operations. This is a phenomenal program that requires that we have an awfully sophisticated data management system. When we find evidence of damage, the first thing we do is to examine the location to see if it needs to be repaired or replaced now. Then, we obviously adjust the inhibitor range. The next thing that happens is we put it on a repeat schedule, an automated, computerized schedule that kicks it out on a monthly "hit" list. We'll go back out and look at it again, and if we see some change in damage, if we see damage still increasing, we've probably already seen it on a probe, we increase the inhibitor. And then we keep looking at the location until the damage stops, or if the damage gets to the point where we have to go in and do some repairs. But we never let get past that point.

I've alluded to some technology development, but I'd like to talk in a little more detail about other aspects of technology that has been developed for our corrosion program. I asked some of the senior staff here in Anchorage to take a few minutes and make a list of all the different technologies they could think of that have come about during the course of their careers. If you added up the experience of these three people, there would be somewhere like 60 or 70 years of North Slope experience. I thought I might get a short list of technologies to highlight, but what I got was two full pages, single spaced and in tiny font print. I'm obviously not going to cover all of those, but it was an eye-opener for me, especially since I've been working in corrosion control for less than five years. But the main focus has been in these five areas: chemicals; monitoring; inspection; data management; and database management. We probably have a world-class database on corrosion protection here. In fact, when I was working just at Kuparuk, and we hadn't yet had the concerns with corrosion that Prudhoe had, we decided to go out and buy a corrosion data management system off the shelf. Well, there wasn't one. The one that was created by the ARCO engineers is really the best there is, and it's a wonderful system. It has allowed our engineers to spend most of their time on analysis and evaluation, not sorting through data.

Facility design has also been affected by technology development. Our corrosion engineers get involved on the front end of all of our projects. We've got sections in the ARCO Designs Standard and Criteria that are specifically related to corrosion. Corrosion engineering get involved early on for each project in things like metallurgy, simple geometry, and the location of coupons and probes so that we can be able to effect monitoring in the future.

In the late 80s, in Prudhoe Bay, when corrosion rates were really high, internal corrosion on our cross country pipelines was at the point where they were having regular repairs, as well as leaks. The inhibitors that were available were not working as well as we would like them to be. There were estimates made at that time as to what the costs of corrosion would be in the Prudhoe Bay field if things continued at this rate. The estimates were that by the mid-1990s, over 200 million dollars per year would be spent just on corrosion control. As a result of improved technology and practices, at Prudhoe we now spend on the order of $25,000,000.

The development of more effective chemicals was a big key for this savings. We supported early chemical development and testing, we've partnered with university R&D programs, and we've helped develop world-class chemicals. We've also have developed some field testing facilities that were not previously available. As the result of this, there have been a lot of advances in monitoring technology. For chemicals, we have improved their effectiveness five fold since the late 80s. That means that instead of using two rail cars per day of corrosion inhibitor, we use less than a half a rail car per day, so we have really minimized the chemical logistics and the impacts these chemicals would have. And these chemicals are now being used in other parts of the world, not just in Alaska.

One of the new technologies is a crawler, which looks a little like a small tricycle that crawls along a pipeline. It may look like a relatively simple piece of equipment, but what it allow us to do is to take that manual process of taking x-rays and make it automated. It crawls down the pipe and produces a digital x-ray image that is transmitted through those cables to the truck on the side of the road. There is a person sitting in the truck nearby with a laptop computer watching the image of the pipe. With this technology we can scan thousands of feet of pipe in what would have taken us maybe a year.

Weld packs are the source of much of the problem corrosion of insulation on the pipeline. On ARCO facilities alone on the North Slope we estimate that we have about 100,000 weld packs, and the only way to know if there is corrosion there is to look for it – you have to look at each individual weld pack.   We prioritize them based on things like temperature, age of service, and we'll try to get the oldest one and the hottest one first. We've looked at virtually all of the cross-country weld packs, and we're starting to look at the ones on the drill sites using the same priority system.   Susan showed a pipeline spill that was due a failure of a weld pack at one of our sites.

Another new technology developed to inspect for corrosion under insulation at weld packs is called tangential radiography. We use this to look for the image of rust or scale, that indicates that there might be corrosion there. This technique does not tell us how much corrosion is there, or whether there is damage there, but any time we see any of these products, we come back and do a more detailed investigation. If we need to repair, then we repair the pipe. Sometimes we can alleviate the problem, then we come back in say three to five years. Basically we use this to double check. We've done probably on the order of 100,000 of these weld packs.

A third technology we are currently field-testing at Kuparuk is the UT Mat. These involve the use of small ultrasonic transducers, a nondestructive inspection technique that gives us very exact measurements of the pipe wall. The signal from the transducers goes into an automated data collection system that works kind of like a radio transmitter and receiver, collected in a computer back in the home office, and we get continuous measurement of pipe wall thickness. You can pull off as many thousand data points that we want and trend where that pipe wall is doing. It takes the concept of the corrosion probe light years ahead. If we can prove this technology works, we will be able to monitor pipe wall thickness on a continual basis.

That may have been more of the nuts and bolts than what you came here to hear. Twenty years ago, corrosion engineers managed their programs effectively by trading leaks. We don't do that anymore. The success of the program, has been due to the people on the team, and its been due to the supportive leadership of the ARCO management. We spend over 50 million dollars a year on our corrosion program, and I've never once been asked if that is the right thing to do. It is ARCO management's expectation that we have a proactive program.   So even though the North Slope facilities are aging, we do have a proactive corrosion management program in place. Our goal is to maintain the integrity of those assets, to maintain them so that it is safe to operate them now and in our future. It is important to our people, important because we feel that we are stewards of the environment today. And it is just good business.

Thank you again for the opportunity to speak to you.

Corrosion Protection and Infrastructure Integrity – Agency Perspective

Susan Harvey
Alaska Department of Environmental Conservation

I want to thank you for the opportunity to talk to you today about a very important issue facing North Slope operators and Alaska as a whole. I manage the Industry Preparedness and Pipeline Program for DEC, and as you can see from our Mission Statement, we "Assist Industry Keep the Oil in the Container". We work closely with the oil industry across the state, from the exploration and production activities on the North Slope, to pipeline and tanker transportation systems, to refineries and fuel storage operations. Overall we work with about 140 regulated industry members in the state. Corrosion protection and infrastructure integrity is critical to this mission.

With just about 15 minutes to go through a very important topic, I'm just going to be able to hit a few of the key highlights. What I plan to outline today is: (1) who the regulators are, certainly DEC is not the only player, (2) I'll take a few minutes to show what is happening in this issue in other parts of the state that have operated long before the oil industry was here, then (3) I'll focus on North Slope issues, and (4) I'll wrap up with some summary comments.

Who are the Regulators?

As you can see, there are a number of local, state, and federal agencies that are involved with operations on the North Slope. Therefore there are a number of people who believe that corrosion protection and infrastructure integrity is an important issue.

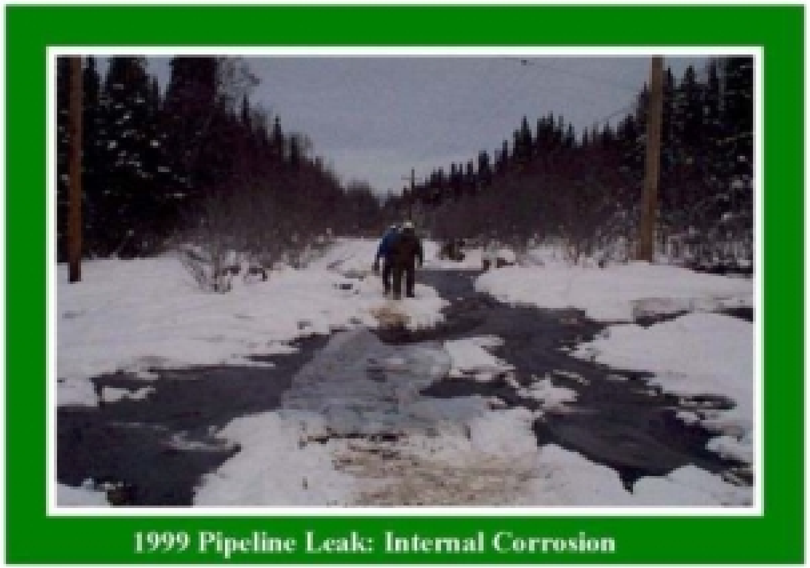
I'm going to talk a little about the State of Alaska perspective. Alaska's focus is on Prevention. Thinking about prevention is a critical component of every project's inception. It must be in integral part of project planning through design, construction, and operation. All new facilities installed in Alaska must be installed to meet Best Available Technology (BAT), and must be managed using Best Management Practices (BMP). Although relatively new, North Slope facilities, as well as other facilities around the State, are beginning to show signs of wear after operating a short time in the hostile Arctic environment.

As indicated by our Mission Statement, our goal is to keep oil in the container, and not risk losing it to the environment. Clearly this is why corrosion protection and infrastructure integrity is a key issue for the successful operation of world class facilities. In terms of risk to the environment, we typically categorize the big risks in terms of pipeline leaks, tank leaks, and processing facility explosions. There are many lessons learned through the State. I would like to highlight some of these lessons to show the importance of corrosion protection and infrastructure integrity. When developing best practices, it is critical that North Slope operators evaluate the lessons learned from other industry members operating in Alaska. Since the North Slope facilities are relatively new, we do not expect to see many corrosion or infrastructure integrity issues at this point in time. But, as the facilities age over the next 50 plus years that they plan to operate in Alaska, this will be a growing issue.

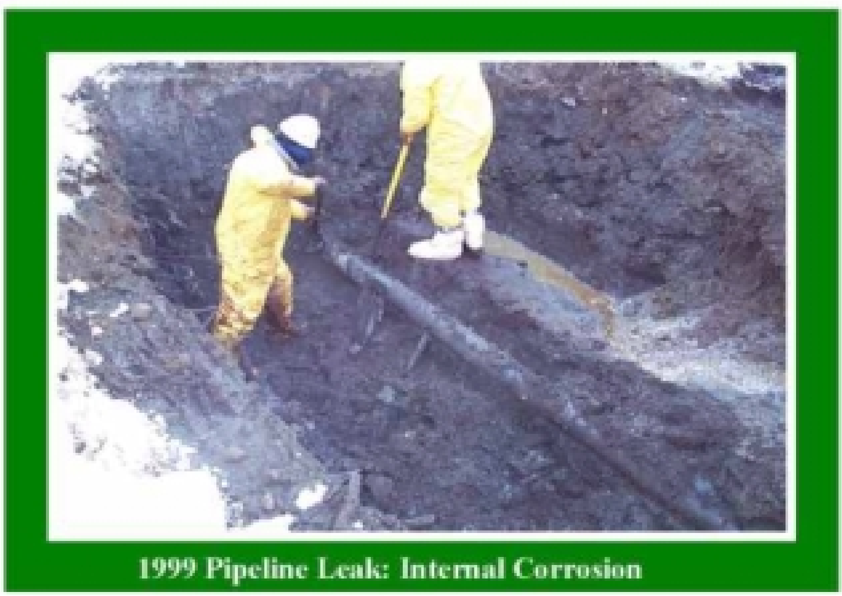
So this is how I will begin my talk, with a few sobering pictures of significant, actual oil spill events that occurred in Alaska as a direct result of corrosion and infrastructure integrity issues. These are facilities that do not operate on the North Slope, but they can give you an idea of the impacts that an Arctic environment can have.

There are two basic approaches that operators can take relative to corrosion protection and infrastructure integrity. One is a reactive approach where we respond to a very large spill, certainly not the approach of choice. Or we could have a proactive approach where we mitigate the potential impacts; certainly a preferable choice.

Lets start with a reactive approach. Industry becomes "reactive" when it is unable to put in an effective prevention, inspection and monitoring system in place for detecting failures before they happen. This is a picture of a pipeline leak in Cook Inlet area.

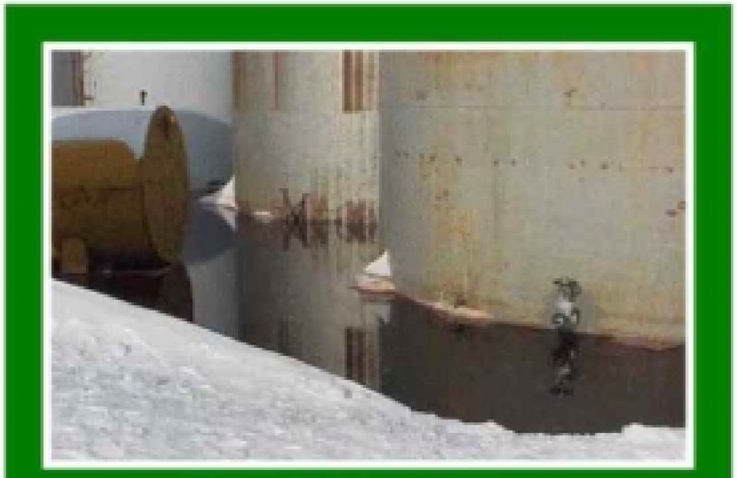


You can see the oil and water pooling up around the snow. About 134,000 gallons of oil and water leaked from a four to six inch buried gathering line. Here is a picture of the line once is it was excavated



There was a 3/8 inch hole found in the pipe. This hole was caused by internal corrosion. A routine program of monitoring, inspection and repair could have prevented this spill.

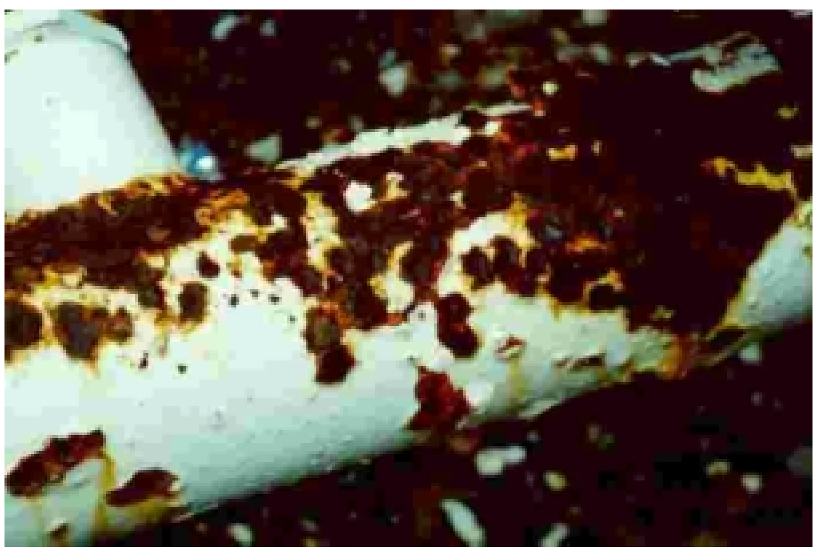
Here is another example, and a more recent one, from a tank farm in a remote Arctic location. The bottom of the tank completely failed, releasing 8500 gallons of aviation gasoline.


2000 Tank Bottom Failure

Luckily, the tank leaked into a secondary containment area, but it leaked very fast. In about 30 minutes the whole contents of the tank got away, so there wasn't a whole lot of time to react. Once again, a program of routine inspection and repair could have avoided this spill.

Since we inspect facilities throughout the state, I thought I would show you a few other pictures of some of our recent inspections in order to help you visualize the extent to which the Arctic environment can impact an Alaskan facility.   This is a picture of a pipeline with severe external corrosion

The winters here are very hard on facilities, and we must work very diligently to keep them protected.



Here is another picture from a remote facility that has been in Alaska for a very, very long time

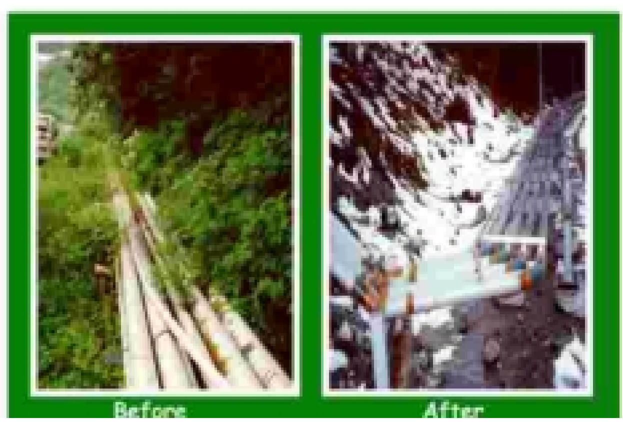
The importance of this picture is to show you the detrimental effects permafrost. As you move north further in Alaska, permafrost is a very tough thing to deal with. The North Slope operators have successfully dealt with it for a long time, but it is an issue across the state that takes careful planning and design. These tanks were clearly not designed with permafrost issues in mind. The photo clearly depicts the settling effects after years of having hot tanks sitting on cold permafrost

From the proactive side, one of the most important lessons that North Slope operators can learn from other industry experience around the state is that after operating for a number of years in the harsh Arctic environment, it really takes its toll on facilities. Most operators in state have been driven to upgrade or replace substantial portions of their facilities because it is just good business. It is sometimes it is more cost effective to make a capital investment in terms of a repair or replacement, than it is to pay the high chemical treatment cost, or the high cost of more frequent inspection or monitoring, or worse. Yet the extreme high cost of cleaning up oil spill or remediation of environmental damage.

Over the last ten years as the result of Alaska's tougher oil spill prevention and response regulations, a number of facilities across the state have undertaken significant upgrades in terms of repairs and replacement.

In this picture, you see a tank farm with fully upgraded tanks with secondary containment. Clearly we don't see anything like this up on the North Slope because they have installed their facilities to an industry standard above this. But it clearly shows the effects of what our program has done in terms of really keeping a watchful eye on industry and ensuring that facilities either install them correctly in the first place, or they upgrade them. In the next picture you see an older tank farm that was fully upgraded.

The last picture is of an upgraded pipeline facility.



So now lets move to the North Slope. Now that we've had the opportunity to see some of the challenges that have been faced by other well-established industries around the state, we can now compare and contrast them with the North Slope. The North Slope infrastructure is relatively new. The facilities at Prudhoe were built in 1977, and many fields have come thereafter. The oldest oil facilities in the State are located in Cook Inlet. Many of the Cook Inlet facilities were built in the 1950s and 60s. Thinking about prevention must begin at project inception.   Prevention must be an integral part of the project through planning, design, construction, and operation, and the North Slope facilities were definitely built with state-of-the-art technology. We are also pleased to see that North Slope operators have been continuing their commitment by instituting corrosion inspection and maintenance programs at their facilities that Belinda will be talking to you about next. .

Overall, the facilities are well maintained, and North Slope management is committed to running a world-class operation. Alaska has over 950 miles of crude oil transportation lines, with a capacity of over nine million gallons. There are 800 miles of gathering lines, with a capacity of over 750,000 barrels. There are over 19 miles of refined product transportation pipelines with a capacity of over 41,000 barrels. Most of this infrastructure resides on the North Slope, or supports North Slope operations like TAPS. So clearly if we are going to make an impact on corrosion protection and infrastructure integrity, we will be focusing our energy on the North Slope.

Even with the most aggressive programs, it is clear that across the state Arctic conditions accelerate aging and corrosion processes. Although relatively new, North Slope facilities as well as others around the State are starting to show signs of ware after operating for a short time. Increased vigilance is warranted.

I'll show you a few more pictures. In our inspections, as we start to move along the edges of the field, we are definitely starting to see the signs of aging on North Slope facilities. This is a picture of a pipeline that was recently taken by one of our inspectors that shows that many of the pipelines are starting to sag and have structural integrity problems. These pipelines are no longer properly supported, and could potentially pose a spill risk.

Here is another picture of a pipeline. Up on the North Slope internal corrosion is quite a problem , due to water damage to the insulation. Here is a pipeline that has had an internal corrosion problem, we see that the insulation has been taken off the pipeline so that we can further examine that problem. We also see some problems with pipeline supports.

Corrosion is a common problem with tanks.   This is a picture of a tank where there is significant corrosion at the base. There are thousands of barrels of oil and hazardous materials stored in tanks across the North Slope. Upon close inspection, we are starting to see some problems, and are working closely with industry to make sure that there are remedies.

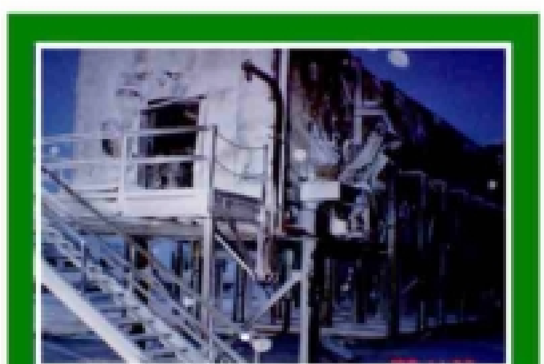
Here is another picture of a pipeline that has such severe internal and external corrosion that a hole has been eroded right through the pipe. From the DEC database, our data show that about 75% of the spills that have occurred on the North Slope to date have been attributed to structural or mechanical failures, so there is a direct link between reducing spills and infrastructure integrity.

Corrosion rates are affected by environmental factors: temperature, velocity of the material through the container, maturity, contact with exposure time, and stress. Corrosion detection and monitoring programs are key. Industry must establish where corrosion is occurring, and detect changes in corrosive conditions. Corrosion control is not only a critical safety issue, it is an environmental-impact issue, and is just good business.

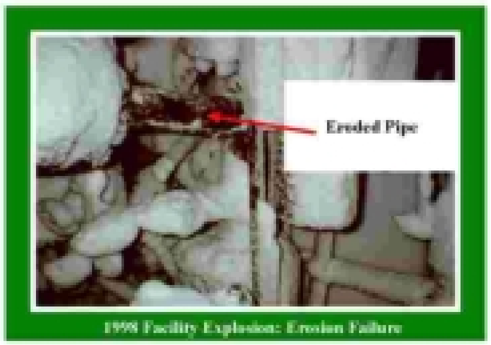
1999 Pipeline Leak: External Corrosion

Recently the North Slope has had a few severe corrosion-related incidents that have increased the awareness of both industry and regulators. This is a picture of a North Slope pipeline leak. A flow line broke due to external corrosion under the insulation. As you can see in the picture, the incident resulted in a complete severing of the line. You can see that the pipeline crimped back upon itself about 10 feet, preventing the wellhead casing system from activating properly and automatically shutting in the well. Approximately 1700 gallons of oil sprayed out across the pad.

Here is a picture of another corrosion and infrastructure integrity problem. Erosion caused the failure of a pipe component in a production module, resulting in the release of gas. The gas found an ignition source and resulted in a large explosion. As you can see, this facility completely exploded. The photo is very dark due to the winter season and lack of light; however, you can see that the explosion was so significant that



1998 Facility Explosion: Erosion Failure the module walls were ripped off.   This is a picture of the offending pipe.



The pipe was eroded and that is where the gas leak had occurred from, resulting in the explosion. I have shown you a few of these pictures just to give you and idea of why it is good business from the severity of the issues, and why it requires increased vigilance.

So in summary, I'd like to go through just a few highlights.

North Slope facilities are relatively new, but are beginning to show the signs of aging, as will occur in any industry.

North Slope facilities are unique in that they operate in a very hostile Arctic environment, unlike oilfield facilities in the lower 48.

There are many lessons to be learned from other facilities that have operated for in Alaska for a number of years in the same type of Arctic conditions. We've seen these problems before, we know they exist, and we know the solutions to the problems.

Maintaining a "world class" oil field requires vigilance: protection, inspection and monitoring, repair and replacement are vital.

Declining revenues in industry and in government is a primary driver of complacency. With complacency comes the loss of vigilance, and we definitely don't want to be in that position.

Thank you, again, for the opportunity to talk to you today about this important issue to the State of Alaska.

Traditional Knowledge

Kenneth Toovak Jr.
North Slope Borough

Thank you. I can't escape. You're on top at this point, you know. I'll apologize before I go any further, but I'll try to do it as a speaker. I am seeing all different kinds of ways, and all different kinds of projects. That's why I mentioned that I think I am a bouncer.

First of all I want to thank you all for being here. When I was growing up, I thought I didn't want to be in this kind of situation, because I didn't like to be involved with too many people when I was young. I would rather have somebody else be responsible for whatever I do, let them do the contacting. But, before I know it, the people would come over to ask, and ask.

Traditional knowledge – it is kind of big. Mine is made of what all I have gone through. But I will start off when I was young, because that's where I should begin. When I was young, we were kind of in a needy situation on the North Slope. Back in the 1940s, there was hardly anything that we could go to work. There was no other employment that we could make a living, other than the hunting. So, the Navy came for oil development, and they had their Arctic contractors. Our heating system in our homes were real in need back in those days. Wake up in the morning, the water in the kettle was just solid frozen. There was no heat in the house. It was the same temperature that was outside.

So the Navy came and wandered around, no rules, no red tapes back in those days. Tundra was open to anybody, whoever, for whatever they wanted to do. So, they set up a drill rig, and we in Point Barrow thought they can do anything because it give us the opportunity to go to work for them, from Barrow and from various other villages, from Wainwright, or wherever.

So, boy, that was a great time, when we have a job. Go to work, earn that dollar. I remember the first time that I had a bill in my pockets, I was very excited, and I think you all feel exactly that way when you are growing up. But anyway, the Navy brought that natural gas, heating oil, so really that's what the Navy has done for us. When I think about the old days, I always think about the Navy.

So, on traditional knowledge I always going to make myself available to whoever has questions, and I'm going to explain a little of the knowledge that I have. My father told me many things - told me many things. But I have seen plenty too. One thing I don't forget of what my father told me – that there are a lot of people feeling themselves higher than other people. That is something that I always remembered when they put me in a meeting like this, in front of a group. So sometimes, I remember not feel myself to be above other people. Something that I should keep in mind, and I hope you will find also. But sometimes it is hard to live level with the other people. We all know that better now, but there are some times when we need discipline.   If I have done something wrong, then I should go and do a better way.

So I know several things that we all understand. Work together, and share our thoughts, we have talked to you. Sometimes I may talk into a cassette player in my own language, in Eskimo, so people can transfer my words to paper. There was a tape that I recorded a couple of weeks ago. Playing it over again, it seemed like someone was talking to me, I think they understand it also. It seems like your language is telling you something of the best way in your life. I hope you understand what I'm talking about. So in order to think that I go through and I'm going to follow where I talk to myself on the tape. Maybe you have also, and I think we are moving in the right direction – we always have a direction in mind. Am I doing it right, going in the right direction?

Sometimes we go through that as we sat down and it makes me wonder, "Tomorrow there is something that I'm supposed to do". So you keep that in mind and you can figure out. Some ways are better ways, and impression. Sometimes impression before you think about it - sometimes time to study, and then there is a better way.   So we all understand that. So here we are today, yesterday and today, I think we are trying to understand each other, because there is something to tell me, I know that.

The knowledge that you have about "is that right?" – it is important to be out here. I've been out here. I'm glad that you ask for my name, I make it available to people. We have gone through many things. And you people have graduated from nice colleges, and have experience. So that is why you are here, to share your knowledge and your experience.

Advanced technologies. Sometimes I am happy to see people, to share their knowledge. When I was working with somebody, they ask the way to do something. I think that's where traditional knowledge is important – to be like a "bouncer". Sometimes we figure out some better way for tomorrow. Because you better plan and make yourself relax a little, and make sure there is a fire in the home.

We are having a good time, and I am glad that I have met you people. I call this lady a mother. It's always good to see a mother leading a group in the right direction. And we all need a leash. Understand that when I decide that I am going to lead myself alone, sometimes I go in the wrong direction. So here we are, thank you for leading us, always leading us in the right direction. I don't know what more I should give you people a bit more, but I know by my being here and your being here that you are looking forward for tomorrow, not just for tonight. Because we all need better way and understanding better, communication.   What are you going to do tomorrow? Tomorrow I'm going to I'm going to go down so and so. See if I am on the right direction for tomorrow's plan. We all need a bit of a direction from that person, and from that other person. In the right direction, no big problem.   But if you try to do it alone, you can't do that?

You already have a question.   How? We've got it all arranged. But before, have a round table and plan is all it takes. Better answers than to try to do it alone. Thank you for being here and for me being in front of you, and I hope next time you have a question, I always going to be available.   And I will say thank you this morning. The Lord will guide us and he will lead us in the right direction. So, God bless you, and thank you.

Implementation of Traditional Knowledge in EIS Analysis and Decision Making

Mike Burwell
Socioeconomic Specialist
Minerals Management Service, Alaska OCS Region

According to the native people of Alaska, Traditional Knowledge (TK) is practical, common sense information that is based on the teachings and experience passed down from elders. It includes an extensive and holistic understanding of the environment and the interrelationships of its various parts. These traditions provide a framework for determining how resources are used and shared.

In addition to that working definition for traditional knowledge, I'd like to give you three more definitions of TK that I like. The first is from Barry Lopez, the author of *Arctic Dreams*, who defines TK as "the past and particular knowledge garnered from hundreds of years of patient interrogating of the landscape." This is an interesting definition that doesn't rule anything out. A second alternative definition for TK is provided by Dr. Tom Albert, senior biologist from the North Slope Borough Wildlife Management Department, who defines TK as "information about the natural world from generations of observations by native people who could be killed if they acted on wrong information. With this in mind, there is a strong tendency for TK to lean toward the truth". Finally, Ellen Bielawski, an anthropologist and former director for Keepers of the Treasures Alaska, has said simply that TK is "practical strategies - what has worked, and what hasn't".

A major part of the MMS mandate to manage and lease offshore oil and gas resources on the U.S. Outer Continental Shelf (OCS) involves the Environmental Impact Statement (EIS) analysis process, where MMS staff such as myself describe the affected environment and assess the potential impacts from oil and gas lease/development actions on natural, biological, and sociocultural resources in the area. In particular, for the recent Beaufort Sea Planning Area Oil and Gas Lease Sale 144, the analysis focus was enlarged to include TK from native Alaskans in the EIS process. Natural science and biodiversity concerns addressed by MMS for leasing activities in the Alaskan arctic involve assessing impacts to wildlife resources, endangered and threatened species, bowhead whales, arctic peregrine falcons, spectacled and Steller's eiders, marine and coastal birds, marine mammals, ringed, bearded and spotted seals, walrus, polar bears, and beluga whales. Native subsistence harvest patterns and native cultural activities of the Inupiat were also assessed.

The MMS mandate comes from the OCS Lands Act, and the EIS analysis process calls for consultation with the state, Fish and Wildlife Service for endangered species, National Marine Fisheries Service for marine mammals and whale species, the Alaskan Whaling Commission, the North Slope Borough mayor's office and their planning department, as well as the various native governments, traditional councils, and the citizens of Barrow, Nuiqsut, and Kaktovik.

In early 1995, former MMS Alaska Regional Director Judy Gottlieb told MMS staff that Traditional Knowledge (TK) would be acknowledged and included in our EIS analysis process. Her motivation was twofold. First, there was President Clinton's Memorandum to Interior Agencies directing them to seek out more MOU's or MOA's promoting government-to-government relationships with Native tribes. Second, there was growing articulation of Alaska's North Slope native communities urging MMS to included Native knowledge in our EIS process.

In 1995, MMS met with the Alaska Native Science Commission, which was just forming at that time, and the U.S. Fish & Wildlife Service to ask their advice and views on TK issues and issues of incorporation. Later that summer during EIS workshops in Barrow, Nuiqsut and Kaktovik, MMS staff told the native communities of its commitment to include TK in the EIS process. At that time we solicited the help of local officials and elders to help us identify TK sources and experts, and TK reviewers. I was asked to identify published TK sources and to locate them for use by other MMS analysts. These published sources included village ethnographies, transcripts of NSB Elders Conferences, and published interviews. Collectively, these provided a rich source of Native testimony and observations. We also had a ready source of over 25 years of archived MMS hearing transcripts and meeting notes from earlier lease-sales that contained considerable native observations. We immediately went to these various sources and began to use them.

The process of incorporating TK into our review process is quite simple – we quote native speakers within the text of the EIS, and then we cite them by name in the bibliography. This helps resolve earlier concerns from native critics who claimed that although they were consulted, "what we say is not in the EIS". Their words are now put side by side with the opinions of Western scientists, with no attempt made to prove or justify one knowledge system over another. They were simply included together in the EIS. These sections were then peer reviewed by the North Slope Borough Wildlife Management Department, the Borough Mayor's Office, and TK experts that had been identified by the mayors of Nuiqsut and Kaktovik.

The direct inclusion of TK from the native community in a peer review of relevant sections of an EIS has led to the establishment of a unique and valuable dialogue between MMS and the people of the North Slope that continues today and will continue on into the future. This dialogue led to interagency/intergovernmental negotiations that included MMS, the State of Alaska, NMFS, NSB, AEWC and the oil industry. These negotiations culminated in an unprecedented set of mitigating measures that provided greater protection of subsistence whaling activities. These measures called for scientific peer review of monitoring plans and the development of a conflict resolution process. The entire EIS process and subsequent actions and negotiations were informed by the initial and ongoing inclusion of traditional native Alaskan knowledge - and the process is working.

The incorporation of TK into the Sale 144 EIS resulted in a number of spin-offs, including an Arctic Synthesis Meeting held in Anchorage in October 1995. At this meeting, whaling captains from Barrow, Nuiqsut and Kaktovik provided traditional data on whaling locations that was later used in the subsistence section of the EIS. An in-house workshop for MMS staff analysts was conducted by Canadian anthropologist Dr. Ellen Bielawski, a published expert on the epistemology of TK, and a pragmatist on the use of TK in environmental assessments. Canada has been a pioneer in the incorporation of TK, and I think that still to this day they are ahead of us in this regard.

A USDOI Traditional Knowledge Working Group was initiated in 1996, and although we have not been working in this area recently, we have met several times since the first meeting in January 1996 to discuss and formulate working definitions of TK, identify sources of TK, and to continue to refine the process of TK use. Members of the working group include MMS, NPS, BIA, BLM, NMFS, and other organizations. I believe that this was the first time that I was at a meeting with all my sister bureaus within the Department of the Interior to discuss these issues. There was really a high level of enthusiasm for working on this topic, and it was a very interesting series of meetings.
MMS has also developed a set of full color posters describing our TK incorporation process that was presented at a meeting of the Alaska Anthropological Association at Fairbanks in 1996. We were also invited to speak on TK at an annual meeting of the Native American Fish & Wildlife Society.

In March 1997, MMS sponsored an Arctic Seismic Synthesis and Mitigating Measures Workshop in Barrow to discuss the differences between traditional information and Western scientific data concerning the zone of influence of seismic activities on bowhead whales. This has been a point of contention for decades, and it remains so, but the idea was to sit down in one place and develop a dialogue. Native whalers and Western scientists came together to discuss the issue, and the whalers drafted a statement that provided the basis for us to develop a working guideline.

From here on, I'm going to give you an update of what has happened since our original process of incorporating TK began with Sale 144 in 1995. Since then, we have incorporated (or will be incorporating) TK into the following EIS's:

MMS Beaufort Sea Sale 170 (1998);
NPR-A Integrated Activity Plan (1999);
Liberty Development Project EIS (2000); and
Upcoming Beaufort Sea Sale 176.

I think it is fair to say that MMS is one of the first agencies to step through this doorway of incorporating TK. For that reason we were asked by Dames and Moore who was writing the Northstar EIS to talk to them about incorporating TK, so we have become a resource for other agencies. Recently we have created a web site with Alaska Native and Traditional Knowledge links (1999), and each of you here should have received a copy of a printout from the web site. And at the end of March we had a Beaufort Sea Information Update Meeting in Barrow at which the local whalers from across the Slope came and talked about their 1999 whaling season. This was largely a case of Western scientists providing information to the people of Barrow, but it was also the whalers giving information back.

One of the most significant things that has come out of this dialogue on TK is the establishment of MMS's OCS Regional Offshore Advisory Committee. The Advisory Committee provides a forum through which affected stakeholders can collectively and jointly make recommendations to MMS on preferred alternatives, mitigation, etc. The Advisory Committee was initiated specifically for Lease Sale 170, and continues for the upcoming Beaufort Sea Sale 176. Members include State and Federal agencies, industry, the environmental community, and local stakeholders, including representatives from whaling captains' associations, Native village governments, the Inupiat Community of the Arctic Slope (ICAS), and the AEWC.

Another way that TK is addressed in our process is through our Studies Program. One study that has been going on for a couple of years in Kaktovik is the Bowhead Whale Feeding Study in the Eastern Beaufort Sea. This is the first study that we have designed that truly involves native Kaktovik whalers in the study design itself, the data collection, and then the actual data analysis. It is an ongoing study, and I've been to Kaktovik a couple of times since the study began, and the community seems really interested and involved.

Another study is the Collection of Traditional Knowledge of the Alaskan North Slope. This study was awarded to the Ukpiakvik Inupiat Corporation in Barrow, a group that is near the heart of the regional TK archive. The objective of this study is to find out what TK sources are available because one of the first questions that Western scientists ask us is where do we find the TK to incorporate into our analyses. The Native criticism is that Western science is not listening to this type of knowledge, not paying attention to traditional ways of doing things. They are looking only at published papers, etc. So we are tying to find out what is available, what is published, what is unpublished, and determine what it is going to take to transfer that knowledge - to identify it, to index it, and archive it. Ultimately, we plan to establish a protocol that is designed by the Inupiat people themselves. They give us the information, and we incorporate that protocol into our analysis process. If we don't do that respectfully, then it is like we didn't do it at all, so basically we are asking them to write a protocol for us that deals with the respectful application of TK for our analysis process. My hope is that this will then become a prototype for other regions of the State.

A third TK study that is ongoing is the Subsistence Harvests and Oil Development Case Studies from Nuiqsut and Kaktovik. These studies involve interviews with local hunters about the continuity and change to subsistence activities. And there are a number of other initiatives that MMS is involved with.

MMS remains a beginner in this process; here are some of the suggestions that have been given to us by native leaders as to how we might better use TK in our decisions.

We need to make contact with more intermediaries--people who are firmly planted in both the conventional and traditional worlds. This involves finding people within the Inupiat communities familiar with both our culture and their culture, people like our last speaker, Kenneth Toovak.
We must work to improve communications skills; be prepared to communicate in Inupiaq. There are things that our science, and our projects, and our research will never be able to grasp because of the language barrier, and I'm as guilty of that as anybody. We now make sure that we always have a translator with us for any kind of meeting we conduct up there with native peoples.
We need to develop intercultural-awareness programs--so we can see how our respective cultural perceptions look at the world. I think it is the Arctic Slope Regional Corporation that has actually developed training of the Inupiaq culture for industry people working on the North Slope. Although I've never been to that training, I have seen the materials that they have developed, and it is very well put together. So I think that when we have opportunities to participate in those types of situations, we should do so.
We need to develop protocols for contact, involvement, and engagement between the two cultures. I guess that is how we develop a basic understanding of how people get together. Things as simple as how people speak – how we speak too fast, or how they speak too slowly, for example. I know that I have had to teach myself to consciously slow down when I'm on the North Slope when talking with the elders - things happen more slowly, and there is a lot more thought going into what is being said and done. These changes in behavior only come with experience.
We also need to develop demonstration projects that are cross-cultural, interdisciplinary, community-based, and that utilize more independent scientists. Although the Arctic might be one of the more intensely studied parts of the planet due to issues such as global warming, long-distance transport of contaminants, and so forth, how much of that information actually gets back to the people of Nuiqsut, Kaktovik, or Barrow at a level that matters to them, that speaks to them? It is likely that very little of this information gets to them, and this is an area that we can all improve on.

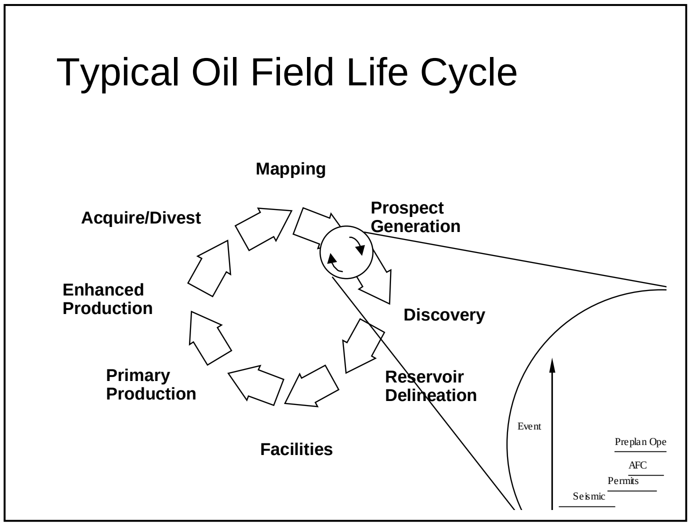
So in conclusion, I want to talk about some of the ideas that I think are important, some of the directions that I think we should go, and some of the things that we need to think about. Traditional knowledge is integrally linked to all of the issues discussed at this workshop. I realized this morning when I got up that I hadn't actually defined TK for my talk. This is because since I have been involved with it so intimately since 1995 that for me to provide a specific definition is difficult. But what is TK? It is what people say, it is what people do, it is what people are concerned about. The attention to traditional knowledge by Alaska Native communities is often part of a larger debate about trust and dignity. The native culture was there before our projects were there. The challenge is how to best combine knowledge from these different cultures? It is critical that MMS transcend the polarities and openly acknowledge the potential for traditional knowledge to genuinely expand the collective understanding of natural systems. It can be very difficult for a Western scientist to view TK as anything but anecdotal. There are many different scientific disciplines that must forge through this bias, and scientists must come to realize that sometimes TK is the only long-term observational data available. People have been looking at the ice and the climate and the caribou populations for generations, and that has great worth.

In order for conservation and development projects to successfully integrate traditional knowledge, agencies must strive for better communication and consultation, and learn how to form cooperative and collaborative partnerships with Native communities. Formal institutions for power sharing--such as promoting community-based research and ideas that come out of that research, co-management, and the adoption of resolute research ethics that formalize the consent, participation, and right to research results of the affected communities—must be forged as well. And finally, I think this unique union of Traditional Knowledge and Western Science will continue to transform the way scientific research, inquiry, and assessment is done in the Arctic.

Thank You.

Ice Road and Pad Technology – Industry Perspective

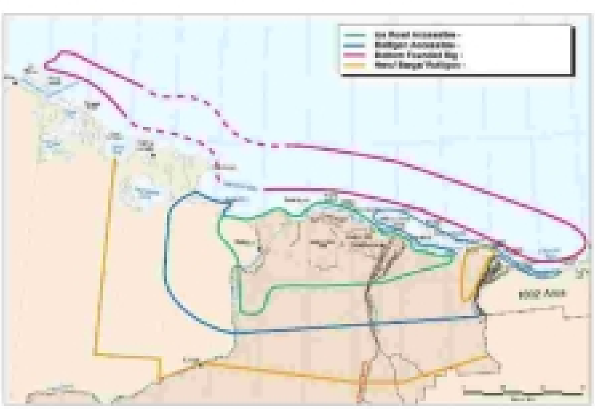
James Trantham
ARCO Alaska, Inc.



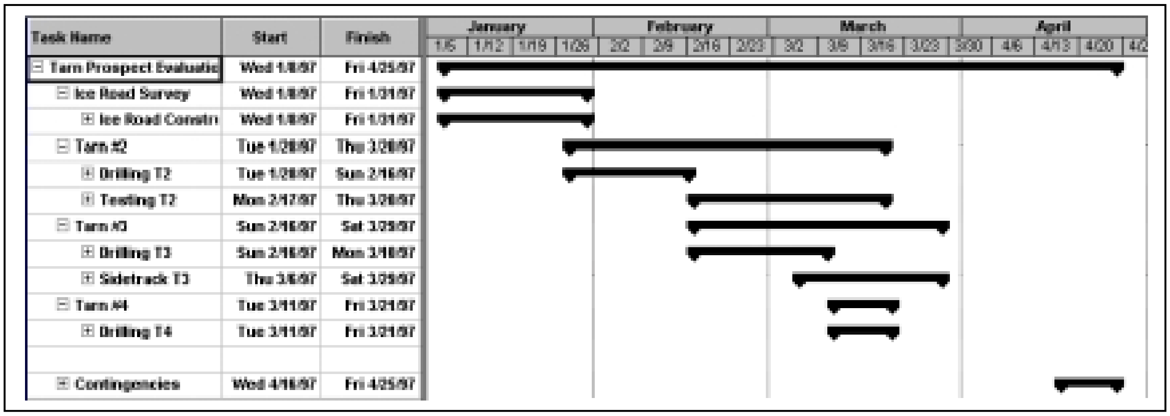
Thank you. The first thing I'm going to talk to you a little bit about ice roads in the scope of things. Then also I'll talk a little about past and present practices, some of the business drivers, some of the things we are working on to go forward, and give you a list of some of the people I work with, basically industry contacts, and then go forward from there. In the life of every oil field, you have to go through a generating process, hopefully discover something, and then go into reservoir delineation, put in your facilities, and go into primary production. After that you come in with enhanced production, and then usually you sell to another entity. In general up on the North Slope, to get from discovery to primary production in the past has taken about five years. We're continually looking at ways to decrease that cycle time.

Inside of this small circle is the discovery process iteration. We have projects where we go out and do seismic work on the tundra in winter, we go through a long permitting sequence, we apply for capital to spend money and preplan. In this execution phase, a very small part is ice roads. Then afterwards we recap and learn, and then come back next year and look for new prospects.

You might ask "why doe we even use ice roads"? Basically we need to utilize our conventional wheeled supply and logistics and rig fleet that you have on the slope that works the other nine months out of the year. Instead of having special equipment that you can use for only four months of the year, we try to utilize this other equipment when possible. The other alternatives are gravel roads and pads, and mobilization and support with rolligons or C-130 Hercules aircraft

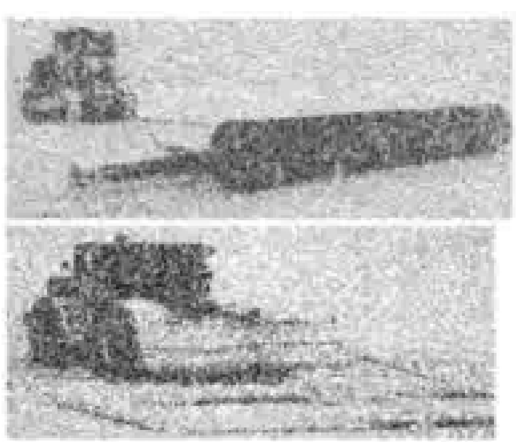


To get you oriented, this map shows the communities of Barrow and Nuiqsut on the Colville River, and also shows Prudhoe bay and the ANWR 1002 area. The green area on the map is where we use ice roads. This is outside of the infrastructure areas for Kuparuk and Prudhoe, and the new infrastructure we're starting to get at Alpine. The area at the top of the map is where we use bottom founded rigs or floaters for working out on the water. Also the blue area on the map show where we tend to use for rolligon support, and I'll show a picture of a rolligon here in a minute and explain that. And then when we go out to the farther boundaries of the map we get out to areas where we have to take rigs apart and haul them out using Hercules aircraft.



Task Name	Start	Finish
Tarn Prospect Evaluatio	Wed 1/8/97	Fri 4/25/97
Ice Road Survey	Wed 1/8/97	Fri 1/31/97
Ice Road Constr	Wed 1/8/97	Fri 1/31/97
Tarn #2	Tue 1/28/97	Thu 3/20/97
Drilling T2	Tue 1/28/97	Sun 2/16/97
Testing T2	Mon 2/17/97	Thu 3/20/97
Tarn #3	Sun 2/16/97	Sat 3/29/97
Drilling T3	Sun 2/16/97	Mon 3/10/97
Sidetrack T3	Thu 3/6/97	Sat 3/29/97
Tarn #4	Tue 3/11/97	Fri 3/21/97
Drilling T4	Tue 3/11/97	Fri 3/21/97
Contingencies	Wed 4/16/97	Fri 4/25/97

Here is a time line for a project that I did about three years ago in 1997. In this area it took us about a month to build the ice roads. It was about 15 miles of ice road south of the Kuparuk infrastructure. Once the ice road was built, we were able to drill three wells and we discovered the Tarn prospect.



In the 60s or 70s, we didn't add a lot of water – we didn't really build ice roads. We just packed snow and basically drove on this road that was very rough, built with caterpillars and trucks. Basically any time a truck went over it, you had to go back and roll over it again, because it just kind of squooshed the snow up. So it was really a high maintenance and probably not as safe a road as we have today.

In the 70s and 80s we started adding more water, starting close to the pads because there was so much traffic around the pads. Later, we started adding more water to the roads, and graders and snow blowers were introduced to ice road maintenance. In the mid 80s we actually started adding ice chips using a machine with a big pump that threw water up into the air where it turned into snow or ice chips and deposited on the road or pad where we would pack it down. After awhile we started actually mining ice chips from lakes to use in ice road construction, and then also at that time the first insulated pads were built at the Leffingwell where insulation and boards were placed on the tundra to support the rig. Then later that insulation foam was moved over to the KIC#1 well.

Here's a picture of an ice chipper mounted on a front-end loader. Basically it has a lot of teeth, and as it moves it chips ice out into the to middle of the road as it drives over it, and then loaders come behind and put the ice chips into dump trucks and haul them to where we need them.

Using best available technology to travel across tundra with minimal impact to the environment. Rolligons.

Current practices on the Slope include the use of all terrain vehicles (ATVs). There are various types, but the one that we use a lot is the rolligon. The wheel is about five or six feet tall, and it is pretty wide. The rolligon includes equipment that can actually put air in the tires as is being driven, and the psi. rating on these tires is anywhere from 3 psi. to 12 psi. As they are going up and down the tundra, the operators can actually change the air pressure in tires.

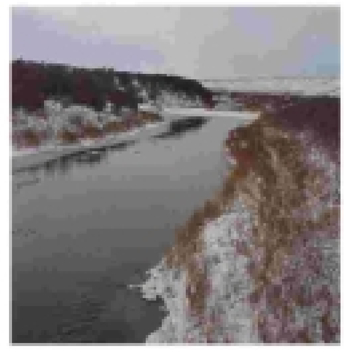
As you can imagine, the soils of the slope have a permafrost layer that is frozen from a depth of about 1600 feet to up to maybe a foot below the surface. This top portion of the permafrost is called the active layer, and it thaws in the summer and refreezes in the winter. As soon as you dump snow on top of the active layer, there is heat trapped in that top half-foot or so, so by packing the snow you remove the air and actually promote the freezing.   We do that from a rolligon, and then in time the trucks come down the middle of the road and squirt water out to the sides and start moving around on the ice road.

Inigok Test Well #1, 1979

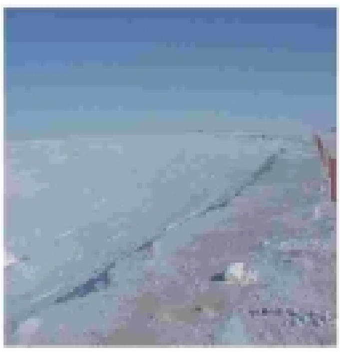
I want to show you where we've come over the past 20 years. This is the Inigok Test Well #1 that was drilled by Husky in 1979 that was quite a way from any existing infrastructure.   There was a road that came onto the pad, which was a gravel pad. Cuttings were dumped into a pile, and then into the reserve pit. There was also a flare pit.   Well, 20 years later, this is an area that had included an ice pad and ice road.

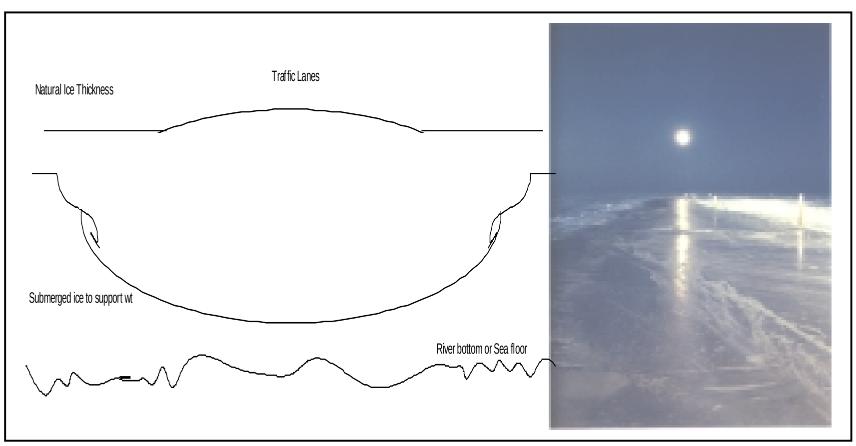
Meltwater South #1, 1999

This little mound is about the size of four of these tables put together, and is the cellar area where we dig it out at the start of the operation. Then once we abandon the operation, we abandon below ground and replace all that soil that was removed. Within five years or so, that pile of soil has all settled back down and is pretty much natural habitat.



Here is a picture of a project that we are doing today, there is actually a drilling rig on the other side of the ridge. This is the Ublutuoch Crossing, and it includes a zone with five to six foot tall willows, and is habitat for birds. The first picture was taken in about the August time frame. In the second picture, you are looking in about the same direction. You can see the ice road by the row of reflectors, and the most of the willows are covered naturally with snow. But here in the middle there is about 13 feet of ice that goes down to the bottom of the channel and is grounded. We are able to move about 1.2 million pounds of drilling rig across that bridge. That bridge in round numbers cost about $500,000, and took about three weeks of labor. You usually lay it in six-inch drifts.





Here is the cross section of an ice bridge if you can cut it in half and look into the ice bridge as you are going down the road. In the middle are the truck traffic lanes. We go out and we add maybe 100 to 150 ft of ice on both sides, and it's just like putting ice cubes into a glass of water, ten percent of it stays on top of the water while 90 percent of it goes down into the water. Throw in another ice cube and it sinks down the same way. What happens here is that as you add more and more ice on top, you create a bulb down in the bottom of the channel. This eventually creates a big enough structure that it will handle the weight that you design the road for. Sometimes they ground, but a lot of times they don't, and this could be over the bottom of the sea floor or a river bottom.

Ice roads are not the answer to everything we do up on the Slope - there are some limitations. The Meltwater South location that I showed you a few minutes ago could have gone another 5 to 10 miles south, but then there are not enough water sources to build an ice road. It costs too much money to haul water from the water sources. So you need water sources, and you need reasonable topography. Looking back at that Ublutuoch Crossing, if you had five of those crossings for a project, you really couldn't afford to do it.

The road quality is also important. You build the roads for what the loads are going to be. If the loads are too large, you won't be able to use the roads. The length of the road needed is also a factor, as the longer you take to get out to where you are going is just time taken away from your actual operation to drill. This runs into problems with season length.

Finally, there is what I call the Economy of Scale. When we find fields, even small fields on the North Slope, they need to be really large fields compared with fields in Texas or California. But they still have to be the right size for us to go out and drill.

So for Business Drivers, the main thing is that we maintain an environmental focus. We want to preserve the environment. We also want to reduce cycle time, and get the oil to the market sooner than our competitors. And the finding costs on the Slope need to be very competitive to attract capital, because the development costs on the North Slope are so very high compared to other places in the world.

So in the future we are going to be under pressure to maximize season length. To do this, we need to be looking at insulating pads, and we are also hoping to work with the agencies toward a tiered approach to tundra opening. We'd like to look at ways to increase bridge strengths with new kinds of materials. And we want to continue to monitor fish habitats. We have scientists come up to look at the lakes and tell us what we have. We also invite the local leaders from Nuiqsut or elsewhere. We are always monitoring the fish habitat. And there are the water recharge studies. We have a lot of reserve pits out on the Slope, and every year they fill up with water and we have to pump them out just so they won't overflow.

- Ben Cleveland - Peak Oilfield Service Co.
- Beez Hazen - Northern Eng. & Scientific
- Bob Lewellen - Lewellen Arctic Research
- Bill Kuper - CATCO
- Dan Masterson - Sandwell Engineering
- Jim Palmeteer - SKW/Eskimos, Inc.
- Bill St. Lawrence - Polar Alpine

This is a list of the people I work with, if you are interested in contacting people to talk about ice roads and ice pads
I wanted to put ice roads in perspective for you. I've talked a little bit about practices,

the business drivers behind what we are doing, and where we're going in the future, and have given you a list of contacts. I also want you to go away with the message that topography and renewable water sources are important, that we need to cooperate between industry and agencies, and that we are continuously looking for better ways, through improved technologies

I want to leave you with this picture of a 3.4 million-pound production module in transit on an ice road to the Alpine site. This one happens to be on the sea ice. They crossed about 10 ice bridges and about 40 miles of ice roads, and all these roads and bridges will disappear in about two months.

Thank you.

Ice road and Pad Technology – Agency Perspective

Leon Lynch
Alaska Department of Natural Resources

I'd like to thank James for that excellent presentation, especially on the techniques for building ice roads. I'm going to try to discuss this in three specific areas. First, I'll give you an example of the historic transition from using gravel pads for exploration to using ice pads, and then discuss the Department of Natural Resources role of the North Slope, focusing mostly on our role in determining when to open and close the tundra. I'll include a few of the things that I think we need to work on, all the agencies and industry, to continue to move forward with this issue.

By way of orientation, the Black spider webbed area up there is the developed oil field, the Badami area is outlined in green, and the red line is the Alpine area. The first example I'm going to discuss is an exploration well drilled over here at the Nechelik No. 1 well, and also later in the discussion I'll be talking about another exploration well, the Red Dog well facility.

If we picture ourselves back in the 70s, going down this ice road and ending up at this drill rig, we'd find the rig on a gravel pad. If it were in a remote location, there might also be a gravel airstrip in the area. So there could be a potential loss of eight to ten acres of habitat, and if there was no oil found there, then there was really be no economic benefit for that habitat loss.

This is an example of an old oilfield exploration pad Getty State #1 and its interesting to see not only that the gravel pad was left behind, but here is an old tundra road, which was kind of a historic way of access prior to gravel roads and ice roads. As you can see that although it is probably thirty of forty years old, you can still see the dramatic change in habitat.

This next photo is of the V-200 well that was drilled just last year off an ice pad, and as you can see there is really no impact at all from the activities.

The Nechelik No. 1 well was drilled in 1981, and to try to give you a background of the transition from gravel to ice. Sohio came in with a plan to drill that well, and they had a traditional gravel pad that was to be utilized. But it was in the Colville River delta, which is an extremely valuable habitat, and some of the agencies were concerned and tried to push Sohio into considering using an ice pad. They provided economic incentive for that when they refused to allow uses of nearby gravel sources to build the pad, and instead requested Sohio to haul gravel 40 miles from the Kuparuk gravel mine site. That's a haul distance of 40 miles for 30,000 cubic yards of gravel, so there was a definite economic incentive to switch over and make that transition to ice pads

I'd like to move on now to the Department of Natural Resources' historic role on the North Slope. In the 1970s, it was pretty evident to everyone that the Slope was a very sensitive area, and that were plenty of examples of tundra damage throughout the Slope. So, the Department responded by passing regulations making the Slope a special land use designation. One result of that is that activities that were generally allowed on other state lands now required a permit, such as off road travel. In these permits some of the common stipulations included:

ice roads and ice pads had to be built so that they were thick enough to protect the vegetative mat;
vehicles shall be operated so that there will be no damage to the vegetative mat;
all rehabilitation shall be to the satisfaction of the commissioner of the DNR; and
DNR or the other applicable land manager shall determine what the travel openings and closures shall be based on snow cover and frost depth.

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The standard that we use for opening tundra for off road activities is 12 inches of frost and 6 inches of snow. When this occurs, there is a general opening for all vehicles to operate on the SlopeThe way we determine that is shown here by my coworker Gary Schultz. What we do is go around to different parts of the Slope and physically pound a probe into the ground to see what the frost depth is. This is a little deceiving, because you are usually doing this in the dark of night, in November or December, not on a sunny day like this. We feel that this is a very labor-intensive way for determining frost depth, but we also feel that it is very accurate, because you can really physically feel when you break from a frozen area into a thawed area.

The opening dates have in general allowed for about a six-month season, starting in November and December. Everything was moving quite well until recently. During the last few seasons, exploration activities went from a six-month season to about a three and a half-month season. This has had a tremendous impact, not only on the industry, but also on my agency. BP's response to the short season was a White Paper that they issued in 1997 outlining some ways that we might be able to extend the season. James touched on this a little bit, regarding the pre-packing of the trails. If you were to remove the insulative properties of the snow by pre-packing, the frost level will be driven down quicker. If you then take water and put it on the pre-packed trail, it would drive it down even faster than that.

As an example, the Red Dog well was drilled in the winter of 1998-1999, and these same techniques were employed there. The general travel opening didn't occur until January 14, but by the first week in January all the roads and pads for that project were already completed. The white paper was followed up by two conferences that ARCO hosted in 1999 to discuss the possible use of a graduated system of opening. With such a system, instead of waiting for 12 inches of frost, some vehicles that were lighter weight and lower ground pressure could actually operate on the slope with six or eight inches of frost. That would become important for vehicles like loaders that are used in ice road construction. If loaders can begin construction of ice roads prior to the general opening, ice roads could be completed earlier in the winter. And quite frankly that is one of our goals, because the sooner industry can get out there safely, without damage to the tundra, the sooner they can complete the project, and the sooner they are back in the springtime, before breakup becomes a concern.

I'd like to conclude by talking about three items that I think are important to discuss to keep this issue moving forward. The first is that the National Science Foundation is planning to conduct a cumulative impact study on the North Slope. The Department has asked that ice roads and ice pads be included in the study. Right now we might feel that ice construction and use is a benign activity, but that's not everyone's opinion. We'd like to take this issue out of the legal arena and put it into the scientific arena, and we feel that this is the opportunity to do that.

The second item involves possible changes to the Alaska Coastal Management Program. Currently in that program, ice roads can be phased if they are for exploration activities, but if they're not for exploration activities, if they are for a development project, the ice roads cannot be phased. We plan to change the statute so that both exploration and development ice roads can be phased.

Finally, this is an old photo of summer tundra travel from back in the 70s. When it was determined which vehicles could be used out on the tundra, it was a multi-agency, multidisciplinary effort to determine what vehicles can go out and operate safely. I think that if we are going to make a change from a standard 12 inches of frost, 6 inches of snow, to a graduated system, then we need the have the same kind of rigorous field testing to prove that we have an adequate level of protection. We might not have as much fun as this guy did because we'll be doing our testing in the wintertime, but I really feel that it is important, and I look forward to doing that with Phillips or whoever wants to organize it.

With that I conclude my remarks, and I thank you.

Pipelines and Caribou Crossings – Industry Perspective

Mike Joyce
ARCO Alaska, Inc.

NOTE – THE FOLLOWING IS A SUMMARY OF MR. JOYCE'S PRESENTATION. A COMPLETE MANUSCRIPT OF HIS TALK HAS NOT YET BEEN MADE AVAILABLE.

We've talked about all the hardware, and we know how we've come a great way over 25 years of getting the hardware tweaked, all to the benefit of the critters, all geared toward saving the critters or their habitat. So now we're going to start talking about the critters themselves directly. Our challenge, Dick and I, is to take this very exciting topic of caribou, and to try to extend 25 years or more of lessons into a short communication. That is what we are here for, to talk about lessons we want to share of some of the things that we have learned in over 25 years of constant study of trying to figure out how we are interacting with the caribou, and how they are responding to our mitigation, and do better – a better way for tomorrow - do better at the next location, in the Colville Delta or out in NPRA.

I see many people in this room that know the 25-year history with caribou. So you know that if ever you are in a gathering and the topic is starting to get a tad boring, and you'd really like to spice things up, all you have to do is mention caribou. It doesn't really matter what your position is on caribou, you just need to bring up caribou and topic heats up immediately. This has been a very complex topic, it has been a challenge for us to try and study it and to make sense out of what that data has told us. I'm going to focus on the Kuparuk field, and if we go back to where we first realized that there was this new herd in the early 70s called the Central Arctic Herd (CAH), we found that the first population estimate was about 3000 animals. What we have done is to have watched that herd grow over twenty years or so from a population of 3000 to about 20,000 animals. And at the same time we have plopped a 40-pad oil field down in the middle of where that caribou herd does its thing, and used to do its thing, with about 160 miles of road, and hundreds of vehicles running back and forth in all directions at all times of the day.

So our challenge has been to try and figure out how to understand what our influence is having on their migration patterns, their traditional use, they have a very strong traditional use, but this herd as you remember has been growing rapidly. That traditional use has a high of degree of annual variability sprinkled in. When we start to think that maybe we are beginning to understand something that is going on, then the CAH loves to throw us a little curve and makes it a little puzzle, so that maybe the traditional use isn't quite what we understood it to be. So its been a very difficult topic. It has created lots of debate, but in looking forward at some of the old hands that have read this for 25 years or longer, I think this is a great opportunity to gather some of these lessons learned and share them with you.

So I wanted to start by going back and looking at some history. I think lessons learned always come back to history. And Dick said that if I would bring the pictures, he would follow up and correct me when I might not cover what that picture was all about. So, as scientists, Dick and I and all the rest of us, our contractors, Alaska Biological Research, Steve and Rick are here, as we have all tried to understand this topic, remember something Michele told us yesterday. The Governor's "Do it Right" was the first issue of her three-pronged tier of what is important – it is sound science. So caribou, we always need to remember, to come back to the data. What are the data telling us about what we think we understand about what they are doing?

Our goal is to have "happy caribou" - let them do what they want to do, completely undisturbed. We've got critters bedded down, with some steel pipe and infrastructure in the background. So our goal is always "happy caribou". One of the first issues we had to deal with was putting pipe, and roads and traffic in the middle of movement patterns. Can you imagine a young grad student being sent to the North Slope and told he has to sit in a tower and track the actual movement of every individual caribou? The result would be a complex distribution map, spaghetti diagram that would show the movement patterns and how the caribou interacted with roads and pipelines when they encountered them. You'd like to see nice straight lines that run across it, but we don't have straight lines - we have a whole mass of confusion. In the early days, the late 70s to the early 80s, pipelines were right on the ground, gravel roads were right next to the pipelines, and caribou had no visual window to see if there was free range on the other side of that limit. There was a lot of wandering and confusion in the distribution patterns.

In looking at this problem in some detail, it wasn't the gravel fill itself or the roads that caused the problems - caribou are used to going up and down riverbanks - so gravel wasn't an issue. The problem was the combination of this low pipe right next to the road, and as the animals come up to this limit, they had visual blockage. We then started looking at building sidewalks for them over the pipelines - gravel ramps, caribou ramps. We built and studied several different designs in the late 70s, early 80s, and what we found often was that caribou would use the ramps sometimes, but they would not travel along the linear feature to search for a ramp. And often, they would cross right next to the ramps, without actually using the ramp. But the ramps were used to some degree, and we decided that these ramps can be beneficial in key areas: If you can figure out what some of the preferred crossing locations were, ramps can be a benefit, but they are not used in selective and search fashion.

The other area that we started to focus on was the pipeline. In the early days, the pipe was right on the tundra surface. The welders hated to get down on their knees, and they hated to have to build scaffolding. The welders loved to work at belt-high or chest-high levels, which often meant that the bottom of the pipe was too low for good passage. We started looking at putting pipe up at a level of five feet in the early 80s, and found that the caribou had good passage success under that taller platform. So a new standard was created - a minimum of five feet to the bottom of the pipe. So for linear features, pipelines in particular, from the early or mid-70s to the early to mid-80s we began to keep that pipe up off the tundra, and also to separate the pipe from the road. Instead of putting the pipe right next to the road, we started to provide some distance between the pipe and the road. This came about from a crude understanding and use of ice roads as a development technique. Instead of having a gravel pad for construction of the pipelines, you can build these pipelines from ice roads, providing the distance needed to help the caribou get though.

The next focus was traffic. Pipes were okay, using the right design and orientation. The gravel road itself was not the problem. It became clear to us that traffic was the prime stress in causing caribou to abort any attempt to cross a linear feature. There were lots of trucks around, so traffic became the focus, and we studied traffic a bunch.   We can't control traffic. But if we provide caribou with plenty of space, they can get under the pipeline, check out the traffic wait for the traffic if they need to, and then pass.   So we've got a lot of work to do in trying to manage our traffic during the caribou season, when the caribou are actually present.

The other issue we were very concerned about was again is let them get to where they want to go under any seasonal activity, and the other component then was making sure they maintain a healthy population and net production, and calving has to occur at the spot that is beneficial, with minimal predators, good forage, and low snow cover. So there are traditional patterns that are used for calving. This was a slide that was put together based some 1981 through 1986 data across the whole Beaufort Sea. So we're looking at the CAH calving distribution, again information that came from the early 80s, during that rapid growth phase when the Kuparuk field was starting to be built in about 1981, and rapidly through a massive expansion, basically through the first three phases of Kuparuk were all being built during this time frame. I'd like to focus on some colors. During the 1981 through 1986 time frame, this (first slide in the series) shows what we estimated the calving distributions to be. During that 5 year period of time, we had calving in the red zone every year, and then decreasing in the other color zones from four of the five years down to one.

As we continue to collect data, I want talk about some of the data we have collected on calving distribution running from about 1993 through 1999. From the 80s through the 90s, we have seen a shift in calving in the Kuparuk area. The bulk of it does occur to the south of the field and some to the west of the field. That is not an abandonment of calving in Milne and Kuparuk - they still do have some that occurs, so we're not talking about abandonment of calving occurring inside the oil field. We've seen over a 20-year period a shift of where the bulk of the calving occurs.

So the next question is "why"? And even more important, "so what"? We don't know those answers. Maybe Dick has some views on either the "why" or the "so what". For the "why" part, there are all kinds of variables that influence caribou behavior from year to year - weather, snow, and predators, all of those things that cause stress within an area like Kuparuk during that 20 year period when we were developing that supporting pad complex.

The "so what" part, we do have some data that can help us try to get a feeling for whether we do have a real problem. Remember, our goal healthy caribou populations - happy caribou. The number of calves being dropped every year per 100 cows, from the late 1970s through last year, shows a lot of between-year variability. But when you compare what is happening with the CAH with other herds and other ungulate species, there is actually a fair amount of commonality in terms of down years. But in just looking at the recent past, we have had about four years or so of pretty good production. The caribou are still having calves, and they are having them over a wider distribution. Some of the calving is occurring in the Kuparuk field, but a lot of it is occurring south of the Kuparuk field.

The other component of "are they happy and healthy?" is how that population is doing. In 1972, when it was first recognized that the CAH was a discrete group, there were only and estimated 3000 animals in the herd. Over the 25-year period, that herd has grown significantly and we're at about 20,000 or so in number. We did see a rather significant decline in the mid 90s, and it is not clear what the cause of this decline was. We do know that there were a couple of hard winters at that point. We also know by looking at ungulates across the North Slope, that other caribou herds showed declines at about the same time. So this may have been weather induced from those harsh winters, it is not clear.   If only we could stop and ask the caribou what their feeling of all this was, and what causes the variability.

Which brings me to maybe the most important lesson I'd like to share with you. A disciplined wildlife scientist, trying to figure out what the results are in terms of cause and effect, a couple of years of data doesn't help you answer those questions. We've been studying this caribou herd for over 25 years, and we still have questions about what is happening with this herd. It has taken this cooperative program working with the agencies, working with the North Slope Borough residents and the village community residents, and some very powerful consultants with a lot of experience to try to get to the point where we think we are starting to understand what is going on. This is a discipline needs constant attention and surveillance and monitoring. Scientists always get into it with the budget people because we never have enough data. This caribou herd is the perfect example of how important this continuous record of monitoring has been terms of trying to help us do better for tomorrow in understanding how to make sure that our presence and our influence is keeping a happy caribou herd. Population numbers are another quantity that you can look at to help answer that "so what" part of the question as to whether the calving distribution has shifted. I believe that the population is healthy, so I don't know that oilfield stress has caused any serious population-level disturbance at this point.

I would like to just briefly touch on one thing. We've talked about the fact that we also have learned behavior, habituation going on. I'd like to share some quick examples. Caribou need to go to the coastal plain for insect relief. They are harassed early by insects, and its very important to move to avoid this. A learned behavior that we have seen over time is that our gravel fill provides secondary insect relief benefit to them.   You see a lot of caribou in the oilfields standing on the gravel pads with their noses down in the gravel to protect them from the insects harassment early in the season. They have learned that there are fewer insects up on this gravel fill. It simulates coastal beach areas or gravel bars that they normally use for insect relief. So there is a learned behavior going on. Remember that the herd was growing in the mid-1980s, so there are four or five generations or more of caribou that have grown up with Kupauk. They've grown up with pads and pipelines and traffic, and there is a learned behavior and an adaptation, and I think there is some influence in what we currently see in terms of cause and effect on the caribou populations.

So lessons learned are keep your pipe up off the tundra, try to minimize where you put roads and try to not run them perpendicular to caribou direction - try to go parallel as best you can, keep traffic down, control it during calving season. Ramps can be beneficial in key locations, but probably most important is giving them space between pipes and roads. I'd like to let Dick follow up on a lot of this, so thank you.

Pipelines and Caribou Crossings – Agency Perspective

Dick Shideler
Alaska Department of Fish and Game

NOTE – THE FOLLOWING IS A SUMMARY OF MR. SHIDELER'S PRESENTATION. A COMPLETE MANUSCRIPT OF HIS TALK HAS NOT YET BEEN MADE AVAILABLE.

I had originally planned on concluding my talk by presenting the Department of Fish and Game Management Responsibility, but Mike did such a good summary that I guess I should start with it. I would summarize our philosophy regarding caribou management on the North Slope as this:

Because the Department is ultimately accountable to the public for the welfare of the Central Arctic Herd, we must scrutinize any influences on its sustainable viability, and make appropriate recommendations to land management agencies and to those making political decisions. Those recommendations are of necessity sometimes based on fuzzy results or trends rather than absolute evidence. The challenge is to ensure that the agencies, industry, and the public use the best available evidence to ensure that our collective decisions keep the welfare of the herd in mind.

The point I want to make from our perspective is that when it is all said and done we *all* have a responsibility in terms of what happens caribou, although the Department of Fish and Game is the actual management authority. When things happen with any population of animals, whether it is caribou or another species, for which we have management authority, we're going to be concerned about it, and we are going to scrutinize any kind of major change in the environment of that population. Certainly siting an oilfield into the area occupied by the Central Arctic Herd of caribou comes under that standard.

Regardless of the shared responsibility, I should point out that whenever something does go bad with respect to one of these species, we are ultimately the management authority responsible. And we are going to be the ones who are directly accountable to the public and who are going to have to make management recommendations. That doesn't mean we don't all share the responsibility - we're just the ones left holding the bag when problems arise. By necessity, we are going to be a little more conservative toward or protective of the animals than maybe others might. That doesn't indicate whether one side is right or wrong, but that is kind of the position we feel we must take.

I'd like to start out discussing the issue of caribou calving. One of the things we feel we really need is thorough predevelopment studies - but only recently have we really good before and after data. But for caribou calving, the bottom line is that response of the caribou to the roads and facilities really does complicate what our mitigation options are for future oil fields. If they are so very reactive, it is essentially unrealistic to expect that an oil field the size of Kuparuk or Prudhoe would shut down all traffic during calving, and in fact this might not be effective anyway. So we have to look at other options.

Mike pointed out that we have had a shift in proportional caribou habitat use. There has always has been some calving occurring in the hills south of Kuparuk, up through an area known as the Itkillik Hills. I can remember doing calving surveys with Ray Cameron in the mid-80s during heavy snow years on the coast, and we had a little more calving down in the southern parts of the field, south of Kuparuk. So some of the observed shift is probably related to snow conditions down on the coast.

We do not feel that the caribou can't physically get to the calving area. There is an impediment to ewes crossing the pipeline and roads, but it really has more to do with their behavioral response. On the east side of the Sag River where there is not yet any oil development other than the Bedami site, it can be used as a semi-control of what has been happening on the west side of the River where we have not seen a shift in calving of the magnitude we have seen on the east side. We have to remember that some caribou herds, like the Beverly Herd for example, will go through major shifts in calving area almost annually. On the other hand, herds like the Western Arctic Herd hasn't significantly changed its calving area in recent years, although its population has grown from 65,000 to almost a half a million animals in the last 25 to 30 years. The Teshekpuk Herd hasn't changed much either. From a biologist's standpoint, trying to integrate all of this conflicting information is difficult. The bottom line, and Mike as already alluded to this, is that we may never know why some of these trends occur.

So the real question is "what does it mean"? or "so what", as Mike put it. A lot of information is based more on modeling than on real data, and we are dealing more with inference than fact, but some of the modeling suggests that forage availability might be an important factor. The nutritional value of foliage might be better in Kuparuk, and the caribou are being selective in terms of their feeding. But modeling also suggests that it may not make any difference in what happens with the herd until there is a really severe environmental stress like a dramatic change in the weather, we really don't know.

Increased predation has probably been more hypothesized as a factor for the Porcupine Herd area, as there is evidence of their shifting their calving area. Certainly, grizzly bear densities are a bit higher in the Itkillik Hills area than along the coast, and we have collared bears in the area. Data from these collared bears indicate that the home regions of these bears are often overlapping both areas. However, what we do see as we progress southward farther is that grizzly bear density and wolf density both increase, with the highest density of grizzly bears and wolves in the foothills area. Wolves up until now have probably not been a factor in this herd, as trapping from the villages up there does a pretty good job of keeping the wolves down. We've seen quite a few wolves just in working with the grizzly bear population again in the hills, and there have even been a few reported down along the coast, but most of the wolf activity is found in the calving area during the winter. So I don't think really that predation at this point is a major effect. As for golden eagles, I think that there are more than we used to see, both along the coast and in the hills. So, I'm not sure what we can conclude from all of this in terms of predation on calving, but we feel that we really need to keep track of things, and there may be a negative aspect to that displacement. We'll have to see if we have a change in weather patterns over the next ten years of so, maybe that will help answer some of the questions of population fluctuations.

I also want to mention summer mosquito season, and I'll make the distinction between mosquito and fly season even though they overlap for part of the summer. I think that most people would agree that access to that coastal area for the CAH is really critical. They don't have a lot of mountains, and they therefore don't have the alternatives in habitats that the other herds have. It is therefore really important that they able to get to the coast. When the mosquitoes are bad down to the south, caribou move northward, up into the continuum of air temperature and wind where mosquito harassment abates and they can start feeding again. Sometimes they move way up to the coast, but sometimes they don't go that far. However, most of the movements observed early in the development days were strongly north-south along the major tributaries. More recently, their movements have become more of an "end run" around the densely developed areas.

Well, what does this mean? The movements themselves don't mean that much to caribou because they are so efficient at walking that the effect on their energetics are not significant. Really the only change is a minor loss of foraging time, and there is a question as to whether that is critical or not for these long movements. The real key might be to make sure that they get back to the south to feed as soon as they can. And, as Mike pointed out, caribou also respond strongly to traffic, probably just as a normal response of a prey animal to their predators, so any time you have traffic in conjunction with any kind of obstruction, that is going to create problems.

I'll speak a little about the separation of roads and pipelines. I think that Mike's mitigation list is a pretty good one, and we agree that all of those types of things work. As Mike pointed out, there are certain situations where ramps may work better than just pipe separator or a high pipe by itself, and those include some of the intersections where the caribou essentially get themselves into a corner. So in terms of designing pipelines or oil fields, if you can minimize those kinds of things you are better off. Ramps are probably of some use in these situations, but there is still a residual question because you don't have success in getting caribou in large groups under mosquito harassment to cross than we do with some of the smaller herds.

Unlike the case of the calving, we do feel that there has been habituation with caribou. The Central Arctic caribou over the course of oilfield development have lessened their reactivity to structures during mosquito season. I wouldn't say that they have habituated as far as calving is concerned, but they are definitely habituated during mosquito season.

During the fly season you get a lot of caribou movement onto the pads. This also occurs during certain parts of the mosquito season, but the caribou are definitely attracted to the taller roads for insect relief. What are the long-term consequences or benefits of this?

In general, I think we can conclude that the CAH has habituated to the activity in the Kuparuk area in general, and that the mitigation measures we have applied there can be used in designing future oil fields. However, we also conclude that there has been an effect of human activity in Kuparuk in terms of caribou calving. This is still being investigated. We hypothesize that if any substantial effect occurs, it might not show up until the population is really stressed, probably mostly by weather or some other factors. We have to be careful how we extrapolate from what we've done in the CAH to some of the other herds where the conditions may not be the same both in terms of human development and in terms of their habitat.

Thank you.

Wetland Surface Flow and Stream Crossings

Mac McLean
Alaska Department of Fish and Game

There are three caveats that I want to lay out before I get into this presentation. Number one is to apologize to the entire industry, which has no counterpart making a presentation here - if there is a bias to my presentation, I apologize. Second, although I've been involved in many of the more controversial cross-drainage discussions and permitting decisions on the North Slope, my primary responsibilities have been on the statewide-level, and more recently working with BC, the Pacific Northwest, and California in trying to develop culvert design guidelines. Finally, most of this talk is going to focus on stream crossings of fish-bearing waters, and to a lesser extent on basic surface runoff, which is more directly the responsibility of DEC and the Army Corps of Engineers. That said, what I'd like to do is run through some of the major impacts associated with cross drainage structures on the North Slope, the leading causes of failure as ascertained over the years, the lessons that we've learned over the last 30 years, and some of the future directions that I think we are probably going to be moving toward.

Obviously, culverts can create barriers to fish passage. A prime example in this picture is a culvert battery that was installed with either a combination of being undersized and/or a failure to provide sufficient outlet scour protection. As you can see, what has happened is a degradation of the stream back to about here, it has dropped the downstream thalweg elevation, the outlet has become perched, and outwash gravel has formed a berm right downstream of the culverts. At low water, water percolates or french drains through these berms, and they are barriers to fish. The second thing that can happen, as you may note here in the picture, is that is often is standard practice to block the inlet and outlet to these pipes with plywood or some other structure during the winter months to try to keep snowdrifts out of them. This is done so they do not ice up, and are free to flow during breakup. Sometimes the plywood barriers are not removed prior to breakup. In those cases, the plywood becomes the barrier.

Improper design and installation can also cause upstream ponding of the surface flow if it is inadequately sized. This picture is an example of a pipe crossing an area where water was impounded upstream from a culvert battery during the springtime.

Improper design and installation can also cause changes in channel morphology, as the difference both immediately upstream and further upstream of the culvert in this photo depict.

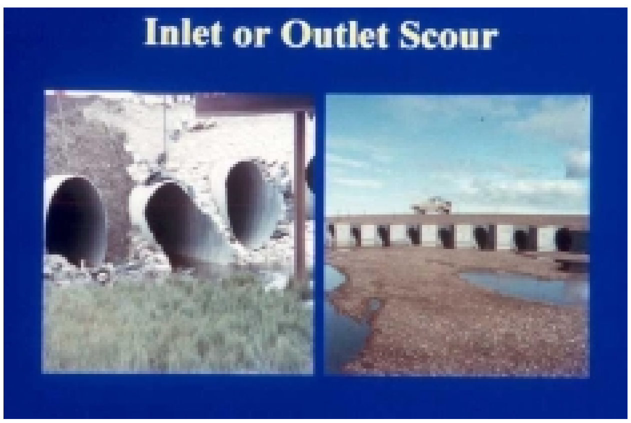
These problems can cause significant changes in maintenance costs. One typical thing is that any flooding can cause erosion of the protection that you have put on the culvert battery. This requires annual maintenance. Improper cleaning activities in springtime can cause damage. As you can see, the culverts have been bent and twisted here. If there is sufficient damage, these culverts will have to be replaced. Another thing that is associated with maintenance is the need for ice protection. You don't have a free flood plain channel anymore, and some degree of ice protection is going to be needed to protect the structure and the roads from ice.

This increases life-cycle costs, and can lead to road failures and operational downtime.

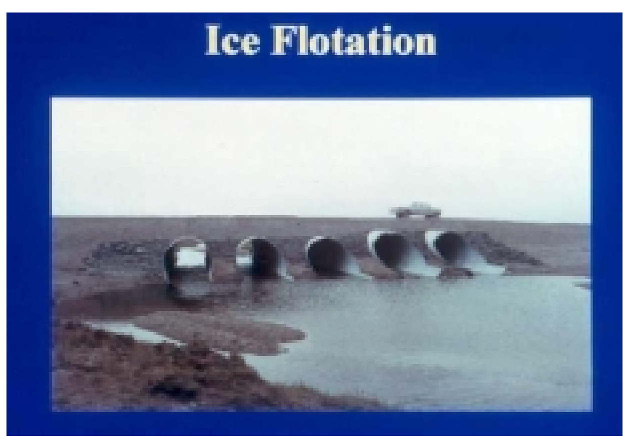
So what causes structural failures? The most obvious causes on the North Slope is under-sizing of the structure for the basin hydrology. One of the most difficult things to do on the

Slope is to try to determine what the drainage area is. It is flat, with very little relief, little structure, and many, many wetland bogs. What exactly is the drainage area? You can't ascertain it on the map, and it's hard to ascertain in the field. Mistakes here in the design and in the sizing can cause significant problems down the road in terms of maintenance blowout. So at best you're going to have to figure it by guesswork, and if you are going to have to guess, it is better to err on the safe side and use a bigger culvert than you think is required.

A second factor is incorrect location of the stream channel during winter construction. Because of off-road equipment transport restrictions, most of the new development occurs during wintertime operation. Trying to find channels in the wintertime in low spots and depressions when snowpack is drifting is at best an imprecise activity. How would you know where the channel is? The only way around this is to do summer staking, and to go back and install it at the same location. You're not going to find it otherwise.



Inlet or outlet scour is a typical cause of structural failure. And again this is caused by using culverts of inadequate size. Ways tried in the past to prevent scour have included sandbagging and use of scour nets. These may work for a short period of time, but inevitably you will get degradation of the fabric, and you may get ice ripping the fabric. Eventually, it will need to be replaced. The most successful technique that we have observed are the metal headwall structures that you see If this were a small to medium size drainage, these would be the most effective.



Ice flotation is another cause of structural failure. This occurs when water depth either increases dramatically on the inlet side, or ice depth increases on the inlet side. Because of the differential pressures created, this can cause an upward bending of the end of the pipe. One of the ways that this can be prevented if it is a small, non-fish bearing drainage is to use rigid, steel-wall pipes. There is no evidence of ice damage to steel-wall pipes. You can also miter the inlet, provide a vertical headwall, or you can counteract the lifting force by attaching the culvert to a concrete weight. Here is an example of a mitered inlet that helps to counteract some of those lifting forces.

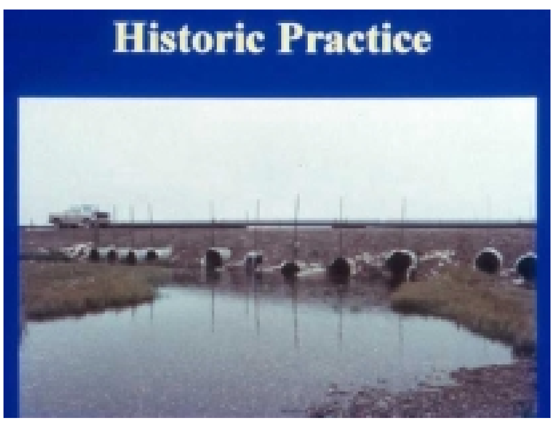
And finally, geo-technical and thaw settlement can be a major problem. Most of these soils are ice-rich permafrost, and as I indicated, a lot of the construction occurs during the wintertime. One of the things that is clear is that to avoid adverse settlement you're either going to have to maintain the permafrost in the frozen condition, or you're going to have to replace it with thaw-stable bedding material beneath the culvert, or a combination of both. This is what is typically happening now.

So, are we starting from scratch? No. Fortunately, what we have learned over the past 30 years has been put together into a design manual. This is one that was put together by G.N. McDonald in 1994 through a contract with BP Exploration, and under a DEC grant. It pretty much summarizes the state of knowledge in terms of how to calculate discharges, and the hydrology of most of these small coastal plain streams. This document is in a large part built on a companion document that was done earlier by Fish and Game, the University of Alaska-Fairbanks, and the Alaska Department of Transportation and Public Facilities that came out in 1991. This is a new approach to fish passage through cross drainage structure design that instead of just looking at velocities, integrates the forces of velocity, which is profile drag, with gradient forces, and virtual mass forces, to take a look at the combined impact of all of these forces on fish.

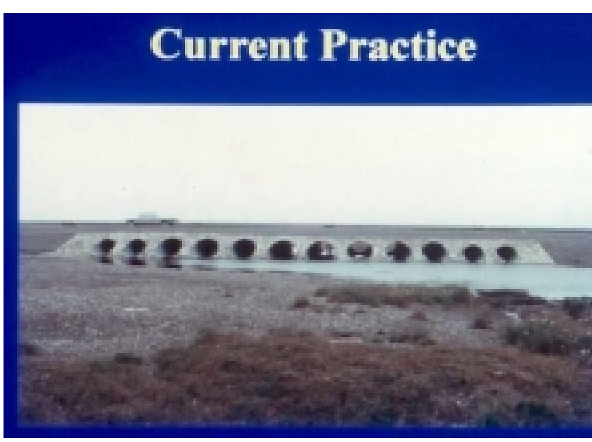
Where are we headed from here? The U.S. Forest Service has issued contracts to integrate the ADF&G/UAF/ADOT&PF design manual with the new fish crossing design manual they are developing. This means that the power/energy type concept that we have in this manual will be integrated with their more traditional velocity approach for designing of fish passage. Traditional engineering hydrological analysis tools like the Federal Highway Administration's HY-8 also will be integrated into the new computer software to provide a more complete package for evaluating culverts for fish passage. This is due out later this year. So I think that this is an exciting thing, the combination of these two documents into what is pretty much a stand-alone document and design software for most of these drainages.

So what have we learned from all of this? One of the things we have learned is that early coordination with resource agencies is critical. Many of the pipes that initially went into the oil field complex in the 70s went into streams that hadn't been surveyed. In some cases permits weren't required. Many of those pipes had to be retrofitted later to allow fish to pass through the drainages. For proposed new operations, we would like to know the plans in advance, so that we or a contractor have an opportunity to get out into the field to do an advance identification to determine what the fish passage needs are, what species are present, what time of the year they are using the pipe. Obviously whenever possible, final design should avoid fish spawning and over wintering habitat. Again early consultation allows us to make that determination and make changes in alignment when it is still possible to do so.

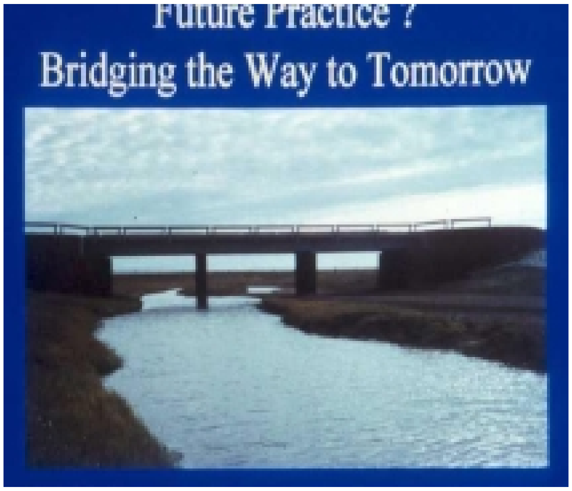
One of the things that I really want to encourage at this point is that for the medium to larger fish-bearing streams, history has shown us that culvert batteries are probably not the way to go. As the oil field has developed and matured, it has become obvious that the transportation infrastructure is there to stay. So I think that the lesson to be learned is that we need to start thinking about not only the up-front costs for a specific project, but the life cycle costs as well. What is it costing us to do the annual maintenance? What is it costing us to replace pipes? What is it costing us when we have road failures in terms of down time? And what are the tradeoffs of culverts versus bridging the structures, particularly for the larger streams? When the North Slope oil and gas fields were young, and new fields had yet to be discovered and developed, there was a clear desire to minimize up front costs. However, at this juncture, after 30 years of development and with new fields opening, it is clear that the future looks pretty bright for quite some time to come. With a longer service life that increases life-cycle maintenance costs, my advice is to focus on bridges as the preferred alternative.



So to wrap it up, in the 70s this picture depicts the state-of-art - lots and lots of small culverts and major culvert batteries.



Current practices use more refined batteries, larger pipes, more sophisticated scour protection.



In the future – perhaps our next challenge, is more bridging.

I thank you.

Gravel Mining and Site Rehabilitation

Steve Taylor
BP Exploration (Alaska) Inc.

(MATERIAL NOT AVAILABLE)

North Slope Gravel Mines: Rehabilitation for Fish Habitat Where we've been and where we go from here

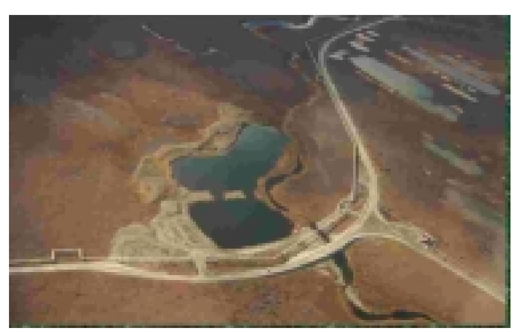
William Morris
Alaska Department of Fish and Game

As Mr. Taylor said, I'm going to talk to you today about rehabilitation of some of these gravel extraction sites. Specifically, I'm going to talk about how the state historically dealt with gravel removal and gravel needs for construction purposes, and I'll go through the progression from the early 70s to what we're doing today to rehabilitate and design these sites.

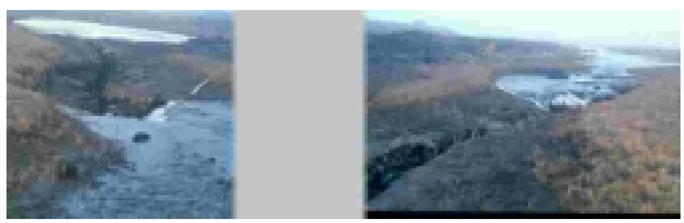
Basically, in the early 1970s, gravel removal focused on in-river or river margin gravel scraping. It soon became obvious that there was a hydrological impact to rivers from this practice - isolated pools would be left in the spring following gravel removal, which occurred mostly during the winter. So during breakup, isolated pools would be left behind in gravel-scraped areas, creating a problem with fish entrapment. Mr. Taylor also mentioned water use, a lot of water is needed on the Slope. Winter use of water from deep pools in the river certainly has the potential for reducing fish overwintering habitat, which is extremely limited in the Arctic, and can result in fish kills. The potential for fish kills has been avoided by essentially moving away from winter water use from rivers. With summer and winter water use, there were problems with actually sucking fish out of the water. Use of screened intake structures has reduced the occurrence of such events significantly.

This is an example of gravel scraping in the Sag River in the mid-70s. In the mid to late 70s, after the state became interested or noticed the potential impacts from this activity, gravel extraction sites were moved away from the rivers and moved to upland sites. This largely removed the hydrologic impacts to rivers. As I mentioned, winter water use especially was moved out of rivers and was conducted in non-fish bearing waters and some of the gravel mine sites that were available. However, now that we've moved to upland gravel sites, this left the problem of having numerous large pits ranging from 45 to 60 feet deep.

Mr. Taylor showed you some pictures of some sites that hadn't been rehabilitated yet, basically deep gravel mines. This is an example, Kuparuk B-Pit, of a deep site that already has been flooded. And this is another example, Mine Site Put 27, and I'll talk about both of these sites in more detail.



So in the mid-1980s, what happened was that the B-Pit site actually flooded on its own. As you can see it was close to a creek, and it just naturally flooded. Originally that was a concern. However, it became obvious that with limited deep water available for fish overwintering habitat, an occurrence like this actually offers great potential for increased fish habitat, specifically overwintering habitat. So at this point there were a couple of other sites that had flooded naturally, so we started a fairly intensive monitoring program to look at fish use and colonization of different mine sites. Based on this research, we also started to move some of the gravel extraction activities back to the rivers. This would not involve gravel scraping where it would leave isolated pools of water after breakup, but there would actually be a deep excavation of the river channel. This has benefits again by increasing fish overwintering habitat within the river itself as well as increasing the availability of domestic and construction water for the Slope that could be removed without impacting overwintering habitat of fish. This also decreases the oilfield footprint, and decreases the impact to wetlands because you do not take that active layer of tundra off to access the gravel.



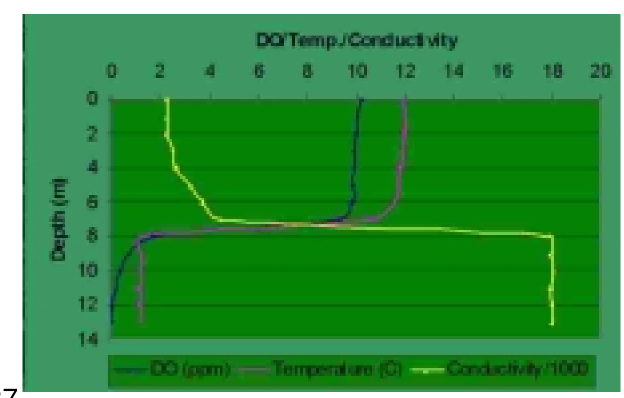
Originally, when we decided to start connecting sites to river systems, there were some concerns. When a creek is connected to a pit, a large deep trough is will likely be cut, through head cutting, as the water flows from the creek to the bottom of the gravel site 30 to 60 feet below. This occurred in the Kuparuk River Unit when D-Pit was being flooded. There was about a 50 to 60 foot head between the creek bottom and the bottom of the pit. So when it started to flood, it started to cut through the tundra, and the end result was a fairly large trough running into the mine site. Originally that was a big concern. However once fully flooded, water levels stabilized, and it actually appeared to create additional fish habitat, and stabilized the trough by eventually filling it in with water and eventually with sloughing fill material.

So what we started doing was trying to monitor fish colonization and use at these sites as soon as they were filled with water and connected to the river or creek system. This is B Pit, right at breakup, where we try to catch certain species as they move in to these systems in the spring. We sample the systems throughout the season, to try to pick up species that move in later on. The species that end up utilizing these sites, as you would expect, are the species that are most prevalent in the drainage that we connect them to.   Broad whitefish from B Pit, is a species that tends to move up these small tundra systems in the spring, and they look for a link between lake systems. They are one of the first species to show up early in the year, and in B Pit, which has been flooded for quite awhile, we believe we have a resident population of broad whitefish, and we actually plan for the next couple of years to try to determine that.

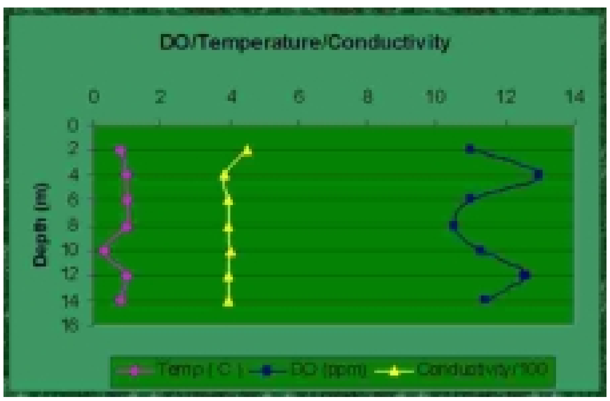
We have also used these sites to do experimental fish transplants. Carl Hemming (ADF&G Biologist, retired) started a population of Arctic grayling at this particular site in 1989.   From this we have been able assess the site's ability to sustain the population of fish. It also provides recreational access to the public that is employed in the oil fields, a catch-and-release fishery primarily, and a lot of employees use it.

This is a photograph of a fairly extensive wetland complex upstream from a newly-rehabilitated mine site. This system is very productive, and it runs downstream into the mine site itself, and then from the mine site it continues to the Sagavanirktok River, which has very high fish diversity. The year after the site flooded we immediately found juvenile Arctic grayling, indicating that the grayling were moving up the system from the Sagavanirktok River, spawning in the wetland complex above the pit. Age-0 Arctic grayling were captured in the fall as well, indicating upstream spawning was successful. This also indicates that the juvenile fish were moving down from the system and into this pit, where, presumably, these fish will spend the winter. This is an important aspect of this site especially for juvenile Arctic graying, as this is the fish age class that generally experiences the highest mortality usually associated with their inability to find suitable overwintering habitat. Now these fish naturally funnel down into what is really a perfect overwintering site. And given this site's proximity to the Sag River, several other fish species began using the site quickly including, Dolly Varden, Broad Whitefish, and Least Cisco.

We've also been conducting water quality measurements at all of these sites basically from the time they were flooded through now. This is Mine Site Put 27 during the open water season. This site is relatively close to the Beaufort coast and is connected to the Putuligayuk River.   What I want you to



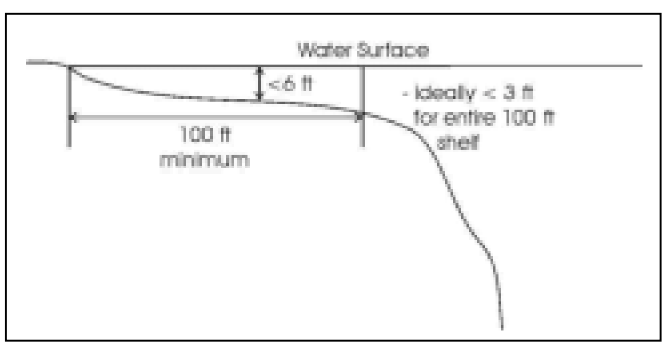
notice here is the yellow line for conductivity, which can be used as an indicator of salinity, basically the higher salinity is, the higher the conductivity will be. What we have found here is that as conductivity increases, the other parameters dissolved oxygen and temperature go the opposite way, so dissolved oxygen goes way down and temperature goes way down. And the point here is that you can see that there are two layers of water, this upper layer to about 2 or 3 m deep that has relatively low conductivity, it has good DO, almost at saturation, and fairly warm temperatures. The bottom layer of this mine site is extremely cold, has high salinity and has no dissolved oxygen. This is the result of salt water actually coming up the Putuligayuk River and entering the mine site. At this point there is such a strong chemical and temperature gradient that there is probably not much you can do about that. However, broad whitefish have used this area along with another excavated area in the Putuligayuk River for several years in a row, for overwintering. So there are fish living in the site still.



As a comparison, this is a similar plot for D Pit in the Kuparuk River unit. You can see one layer of well mixed water, high dissolved oxygen, steady temperature, and relatively low conductivity, and it is out of the influence of saline water.

Most recently our focus has been on concurrent rehabilitation of gravel mine sources. What we attempt to do is to have the desirable characteristics built into the mine sites while the mine sites are still being excavated. What we're looking for is a littoral zone, a shallow area along the margins of the pit which promote aquatic vegetation growth and fish food organism production. The littoral zone also provides areas for increased waterfowl use, nesting islands and loafing areas can be built into these shallow lake margins.

We try to get a minimum of about a 100 foot shelf on the edges of these sites, that have less than 6 feet of water, and preferably less that 3 feet of water to really foster good aquatic plant growth. And then, however fast the pit walls drop down into the deep water portion is fine, that provides the water for fish overwintering and water use in the oil field.



So basically, just to wrap things up, rehabilitated mine sites have the potential to be beneficial to fish, predominantly for fish overwintering habitat, and also for waterfowl habitat. However, gravel extraction site selection is very important. In order to maximize the benefit from the site, we want to make sure that sites are rehabilitated for uses they are best suited for. If you are in an area with a high potential for saline intrusion, maybe the best rehabilitated use for that site might not be to connect it to that river for fish habitat. Because as we've seen, over time, those sites may become very saline and not be very useful for fish. Maybe those would be better to flood and use for waterfowl habitat. Depending on what kind of system you hook these sites up to, you're going to have different fish species diversity. And of course there are systems that just don't have fish in them, and we've gone in and stocked some of those to provide recreational opportunities for people who work on the Slope. Where we are now, as I mentioned, is rehabilitation concurrent with gravel extraction. What we're trying to do now is to have the smaller gravel pits smaller gravel use areas rehabilitated as they are finished so that you have multiple smaller sites being rehabilitated so that you can realize the benefits from these sites in a shorter period of time.

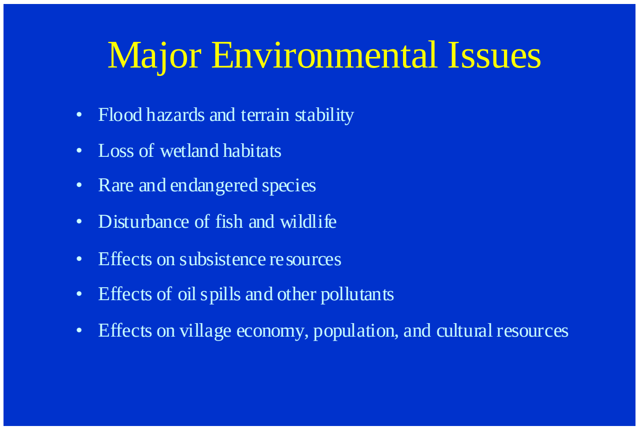
Thank you

Habitat Mapping, Geobotanical Classifications, and Geographic Information Systems

Steve Murphy
Alaska Biological Research

One of the advantages of going late on the program is that I can try to tie together some of the themes that we have been hearing for the last two days. For those of you who keep up with conservation biology and wildlife management, you've probably heard a lot of rhetoric in recent years about ecosystem management. At times it is presented as a novel concept, but if you have ever read "A Sand County Almanac", by Aldo Leopold , you know that this concept is well established well over a half a century ago. What is new, however, is that we now have tools available to us that allow us to integrate physical and biological ecosystem management information on multiple spatial scales, and to use the resulting information to make informed management decisions. So I think that ecosystem management has gone from a theoretical concept to a real practice, and there is perhaps no better example of this than the work that has recently been done in the Colville River Delta in support of the Alpine Development Project.

You have seen the Alpine project from a couple of different speakers here, but this slide shows the Colville Delta, which drains approximately 60 percent of the North Slope watershed. The picture shows the western edge of the Kuparuk oil field, and shows the Alpine pipeline, and the Alpine development area on the Delta, as well as what is referred to as the transportation corridor. The village of Nuiqsit is also shown. Keep in mind the shape of the yellow perimeter on this map, because it will be seen on some thematic maps of Alpine, so it will make more sense to you. Most of you know the story of the Alpine development. Following exploration, delineation, and testing in 1991 to 1995, ARCO and Anadarko decided to develop the Alpine oil field underlying the Colville River delta. Recognizing the ecological importance of the Delta, ARCO initiated studies in 1992 to provide baseline information for project planning and design. This has long been known to be an extremely productive area. As a basis for comparison, I think that most biologists familiar with the North Slope would say that the area is much more diverse and much more productive than the ANWR 1002 area. It is a really an important and unique habitat feature on the North Slope



There are large lakes and ponds throughout, there are river channels, and then there is extensive wetland areas that combine to be one of the most productive water bird areas that we know of in the Arctic. ARCO initiated its study in 1992 to provide baseline information for project planning and design. An important point here is that ARCO began extensive environmental studies at a regional scale five years prior to the decision to proceed with this development. In addition they consulted with resource agencies and the native community in Nuiqsut, prior to the implementation of wildlife studies to gain a clear understanding of what issues would be most prominent if and when they applied for permits to develop the field. In those early consultations, a number of prominent issues were identified. I think Mike Joyce of ARCO deserves a lot of credit here. He was very proactive in soliciting agency input and input from native stakeholders in the region to identify exactly to do to--using Commissioner Brown's terminology, "do it right."

Interestingly, along with some of resource agencies, we had just finished the Lisburne development monitoring studies a couple of years earlier, and one of the complaints about our program, which was a well funded and rigorous program, was that there was no predevelopment environmental baseline. So Mike went back to the same people to ask them what it would take to "do it right"? What did they want to see in terms of information if this area is going to be developed? So for Alpine, we had agency input into the design of the research, we had input from the village of Nuiqsut, and that has gone a long way toward determining just exactly what we were going to be doing on the Delta.

The Colville Delta long has been recognized as one of the most productive regions for fish and wildlife on the Arctic coast of Alaska.   The area is important for breeding of tundra swans, brant, yellow billed loons, and greater white-fronted geese. Arctic cisco and broad whitefish overwinter on the Delta, and they support both the subsistence fishery and the only commercial fishery on the North Slope.   Caribou from both the Central Arctic and the Teshepuk Lake herds use the Delta, and the area's fish and wildlife resources for the subsistence economy and culture of the local residents in and around the village of Nuiqsut.

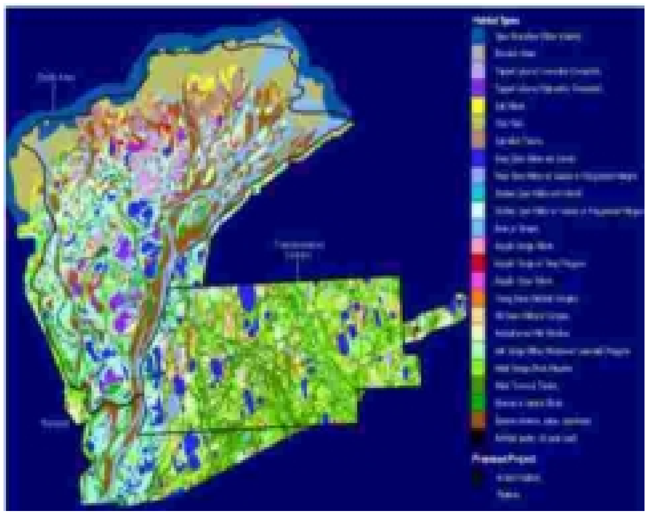
So the challenge for us is to figure out exactly what we need to be doing in the field in our studies to answer the questions that come up and address the concerns. This is an overview of the studies that ABR and some of the other consultants have undertaken in the Delta. The area does drain some 60% of the North Slope watershed, so you can imagine what the floodwaters are like there during spring breakup. It is important to know from an engineering perspective whether areas where they might put facilities become flooded out. They also need to know the stability of the terrain. This is a dynamic environment with meandering river channels, and it is important to know whether the places you put pipelines, gravel pads and facilities are going to have erosion problems twenty years from now. And then, of course, there are all of the issues regarding fish and wildlife habitat that we had to pull together information for to address the topics of concern.

I'm going to start out with a fairly complicated slide. Across the top you see several of the different habitat types that we encounter on the Colville Delta. In the center, we see a profile of what the Delta would look like in cross section. And what we are trying to look at here is what is the depositional environment, what is the ice environment, and how does that effect the stability, how does it effect the surface forms, how does it effect vegetation, which really reflects what is happening with soils and with the land form. Vegetation is usually the key to how the wildlife are going to be using the area.
Down on the bottom we have soil cores, and what we were looking for in these soil cores were some indication of the flooding activity and the depositional environment which helps us to predict where floods are going to occur. The top line is the 25 to 200 year flood level, then we have the five to 25 year flood, and the one to two year flood we have nearly every year. This is important information to understand just exactly what the dynamics of the hydrology of the Delta were, and how that effects all of the other physical and biological processes.

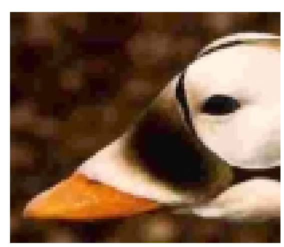
So what we did initially was to map out "terrain units". We had several different ways to classify the landscapes, and "terrain units was just one of them, which is basically what the depositional environment is. We also looked at the surface forms,

which is a reflection primarily of ice processes, and then we also looked at vegetation itself. We had a number of vegetation classes identified – this figure doesn't reflect them all because the color contrast is not very good, but essentially we had 23 units, 16 land forms, and 18 vegetation types. With these various combinations, we wound up with 195 ecological land classes. We then recombined these land classes and analyzed a set of 24 wildlife habitats.

Ryan Lance showed this slide yesterday of the 24 wildlife habitats. The take home message here is that we have quite a mosaic of habitats, and you're going to see differential use of these habitats of wildlife. And that is what we are trying to do – identify and characterize the most important areas of this landscape for fish and wildlife.



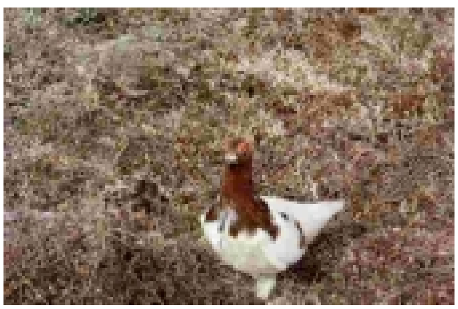
After we have a map like that from our GIS database, it is very easy for us to calculate areas. And so here is a list of the 24 habitat types identified in the Delta transportation corridor, and the relative percentages of each of the 24 habitat types that occur in the delta. So we know instantly whether it is a rare habitat or it is a common habitat, and we combine this with the wildlife data. If you have a habitat that is used by a lot of species in high densities, and it is rare, then you know that you have a pretty valuable habitat. On the other hand, if you have a common habitat that isn't preferred by any birds and mammals, you know that you have something that is not as important in terms of project planning.



As I mentioned, the wildlife studies started in 1992, and we had five years of baseline going before the decision to develop was made, and we also have data for each one of the subsequent years, so we are up to about nine years of data to this point. Rick Johnson is going to go into more detail on the bird studies, but I will give you an overview of what some of the most important species are, and why we are studying them. The spectacled eider which is a protected under the Endangered Species Act, and which has received a lot of attention from resource agencies. It is critical for anybody developing anything on the North Slope to get site clearance to first find out if these birds are nesting there. Well, finding spectacled eider nests is not very easy because the female eider is not nearly as easy to see as the male eider. As a result, we spend a lot of time marching around the tundra trying to find these nests over broad areas. It is very labor intensive and very time consuming work.

Tundra swans as I mentioned use the Delta extensively. They are considered by a lot of people to be good indicators of the health of the environment. They are easy to survey by airplane because they are big and white, and so we have a big database on swans, and it is one we definitely want to get a baseline on to look at what happens to the population over time. It is also an important species for deciding facility siting.

There are also geese on the North Slope that are important for subsistence, and they are also protected under migratory waterfowl treaties, so they also receive a lot of attention from the resource agencies.



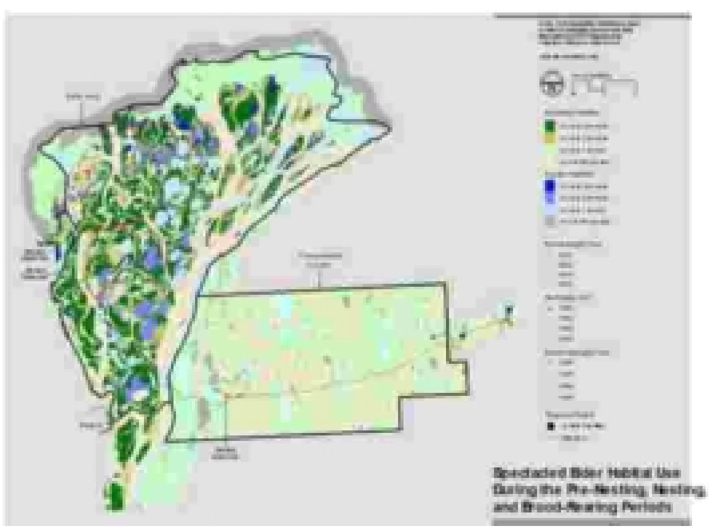
Then we have some of the more resident types of species, ptarmigans for example, is once again a subsistence species. It is important for us to look not only at the high profile birds that show up in the lower 48 during the winter, but to also look at some birds that are important to the local residents. We also looked at some birds that are not consumed by anyone – they are just part of the landscape - like golden plover. There is a lot of interest of protecting habitat for these migratory birds, and we looked at 50 species of birds and a suite of mammal species to figure out what is happening with each population prior to the development, which helps us assess how to proceed with development, and then how to look at post-development impacts.

Arctic foxes – we will hear about them in more detail from the next speakers, but they are important for us to keep track of. We've got a good running tally of where all their dens are, and it is important to know whether they increase as the result of the development. And of course caribou are really important. I won't go into a lot of detail about caribou, because the Colville Delta is not one of the hot spots for caribou. It is close to where they calve, but they generally do not calve on the Delta itself, although there is some calving activity in the transportation corridor.

So this is the list of species that we looked at, and when we get data, it is not only from ABR sightings, but it is also a lot of work from Fish and Game and the Fish and Wildlife Service for both polar gears and grizzly bears. So we have a pretty big area hear around the Delta where bear sightings and bear dens are being recorded. Interestingly, while most of the polar bear dens are near the coast, there are a couple of them that were actually in or close to the transportation corridors. That is important to know because they are protected under the Marine Mammals Protection Act, and its also good to like to know where they are when you are doing winter work out there. After we digitize all of this information, we use the habitat map in conjunction with the wildlife sightings to determine the most important habitat areas.

At this point, we again went back to the resource agencies with our database, and asked them what information was important for them to know about the Alpine development and its effects. We looked at the regional importance of five endangered or high profile species, overall diversity (i.e., which habitats are supporting the greatest number of birds and mammals?), and subsistence species (i.e., what habitats are used by species important for subsistence?). So, having 50 bird species and a dozen mammal species, there are a number of ways to look at the area.

Using spectacled eiders during pre-nesting as an example, there is just handful of habitat that they use. We've got the number of sitings by habitat, and we know the availability of each habitat type. We then performed a couple of different analyses to determine whether these birds are preferring, avoiding, or just using the habitat at a level that is equal to its availability. Monte Carlo simulations turned out to be the best way to get quantitative measures with a confidence interval to test the hypothesis of whether the habitat is preferred or avoided. We then used these results to construct a fairly simple map.


Spectacled Eider Habitat Use During the Pre-Nesting, Nesting, and Brood-Rearing Periods

For this map, we combined the nesting, pre-nesting and brood rearing data, and we color coded the maps to show which areas were used during all three of these periods in both terrestrial habitat and aquatic habitat. So the dark green and the dark blue are the hot spots for the eiders.

So here is a simple thematic map that we can use for information transfer, because one of the elements of the NEPA process is that you are supposed to instill your information to a nonbiological audience – it has to be accessible to a to a nonbiological audience. So this is one of the ways we can pull this data into something that is fairly accessible. We can simply show them the map and say that these are the hot spots for spectacled eiders. And we can do the same thing, for the subsistence species, caribou, or whatever people want to look at we can take these data and produce these thematic maps. If we go back to Commissioner Brown's statements about sound science, prudent management and public input, I think this plays into all of these. There is sound science on the bottom of this – it provides some of the answers to the people making management decisions about what the effects of an action might be, and I think it is reasonably accessible, at least as compared with some of the stuff that the scientists produce that people without technical background can understand.

What we can do with out GIS system is to slice out the habitats that might be consumed either by being covered by gravel or as a buffer, and can calculate very precisely what habitats will be lost. And from that you can determine what effect the action will have on the species. For example, if you're particularly worried about threatened and endangered species, one route may be worse or better for spectacled eiders, for example.

This is also a way that we can communicate with the engineers, which is something that has been kind of elusive over the years. We have a common spatial database with the engineers. We are sharing their drawings. They have access to our hydrology maps, our terrain maps. And we have access these various alternatives. And these were changing almost on a weekly basis, and the beauty of having this in a GIS database is that we can just turn the crank and say "OK, well they moved it. Let's do the exercise again and figure out how much habitat is lost by that particular scenario". And that really helps us to make these impact predictions.

In summary, these baseline studies and the development of GIS database aid in the evaluation of land capabilities and potential project impacts. These evaluations result in thematic maps that facilitate communication among developers, agency personnel and the public. For environmental impact analysis, this spatially explicit ecological data in a GIS database provide a common means for evaluating a wide range of potential impacts associated with oil development, including precise measurements of land classes effected by various design alternatives for gravel pads and roads, airstrips and pipelines. Acquisition of multiple years of both physical and biological data greatly increases the reliability of the information.

Thank you.

Practices and Technologies Designed to Protect Bears and Foxes

Dick Shideler
Alaska Department of Fish and Game

NOTE – THE FOLLOWING IS A SUMMARY OF MR. SHIDELER'S PRESENTATION. A COMPLETE MANUSCRIPT OF HIS TALK HAS NOT YET BEEN MADE AVAILABLE.

I've been asked to talk about three different species – grizzly bear, polar bear, and foxes. A lot of people actually were surprised to learn that we do have grizzly bears this far north – in fact the North Slope is actually the farthest north distribution of grizzly bears in North America. Of course there are also polar bears, which a lot of people are also surprised to learn visit the oilfields. In fact Steve Taylor showed you the map of polar bear dens, showing that they actually den farther inland than that, up to 40 km inland in some places. They have been spotted recently 50 miles in from the coast, so most of the oil development, or areas that are looking at oil development, are potentially within both polar bear and grizzly bear ranges. I was also asked to talk about foxes - both arctic foxes and red foxes. However, most of my talk will deal with bears, especially the importance of food and garbage management, which also have direct relevance to foxes.

When you develop an oilfield, you not only potentially provide stable food sources for bears if you don't handle garbage properly, but you can also inadvertently create denning locations. This artificial habitat enhancement, especially for foxes, allows them to den in close proximity to that stable food source. How much effect this has on growth of fox populations is unknown. I'll show a series of slides that illustrates some of the things that we have done on the North Slope and how these actions have impacted bears and foxes.

First of all, don't intentionally provide food for bears, and I think that the industry has done a really good job about stopping the intentional feeding of bears in the oilfield. We've only really had a couple of cases in recent years where we suspect bears have been fed intentionally, but we couldn't confirm it. This isn't much of a problem these days primarily because regulations have changed prohibiting this, and industry has really emphasized the point.

The bigger problem is the unintentional provision of food for bears and fox. Here is an example where a bear walked onto the crew bus and got into about week's worth of lunch garbage that was on board in a plastic bag. Bears are really good at finding food, and in this case she just walked onto the crew bus to get the food. Dumpsters used to be a big problem on the Slope in terms of providing unintentional food sources for bear and fox. Within the past year, however, the existing oilfields have gone exclusively to a bear-proof and fox-proof dumpster system, and hopefully this will be a thing of the past.

The North Slope Borough landfill at Prudhoe has long been a problem, but the landfill is now being fenced. Garbage management operations have really changed over the years. I think we are still going to see bears and foxes getting into the landfill again this summer to a certain extent. But with the electric fences installed that are being installed, hopefully this problem will also go away, so that these species will no longer have access to human food.

What we call “garbage bears”, or “food-conditioned bears” are bears that we know have gotten into garbage over the years. Many of these problem bears eventually are killed legally under “Defense of Life and Property” (DLP) circumstances. In almost all cases, these garbage bears have been weaned in the oil field where they were protected by firearm restrictions, left the oil field for some period of time. Eventually they wind up in one of the local villages, either Nuiqsut or Kaktovic, where they were shot by residents under DLP situations, or else they wander down the haul road and get shot by hunters. Recent estimates is that if not for these DLP kills, we would have about 28 garbage bears wandering around in the oil field, all food conditioned because they were the cubs of food-conditioned bears. This has been a real bad situation because we are creating the problem by providing an easy food source to the bears. We are now trying to break this cycle by eliminating the food source.

We have also recommend that the industry adopt a Bear Interaction Plan Program, which we started implementing in 1988 or 1989. This has been a voluntary program, but almost all of the companies that go through any kind of permit review process have adopted it. Primarily these Plans involve exploration activities, but some of the new production areas like Alpine and Bedami have prepared Bear Interaction Plans. These provide ways to design your site so that you can reduce bear problems. For example, recommendations are provided as to where and how facilities should be located to reduce areas where snow drifts accumulate, providing locations for bears to hide. This is even more important in the case of polar bears, as they are present year round. Basically, the Plans help you to design your facility to offer maximum visibility. Lighting is also an important consideration. Perhaps the key component, however, is training. Virtually all oilfield employees now go through both polar bear and grizzly bear training programs to alert them as to what they should or should not be doing and the possible consequences.

In terms of monitoring, ARCO, BP and the North Slope Borough have funded our grizzly bear project since 1991, and we also enlist Security personnel and others around the oil fields to look for bears with ear tags and to report when and where they see these tagged bears. There are also procedures that have been developed for off-site work. If you are going to send crews out, you are going to have water truck drivers and all sorts of other people out there during the exploration process as well as for the permanent facilities and for oilfield development in general.

I mentioned earlier, orientation of facilities is important, as is the implementation of physical barriers. Steve Taylor showed you slide of a typical facility that is elevated up off of the pad. This type of design may be great from an engineering standpoint, but it also provides potential places for bears can hang out. We recommend construction of some type of barrier such as skirting around the base of the building to keep animals from hiding beneath the building. This has to be done in a way that doesn't result in creating drifts under the facilities, but it can be done. It is also important to construct doors and windows in a way that will reduce the possibility that bears can gain entry to the buildings.

Simple, common sense things like not placing a dumpster near a stairwell can be important. The bears quickly learn that the North Slope dumpsters are their target of choice. If there is no barrier to the stairwell, the bear can literally walk up it. It is often easy to remove the dumpster so bears are not attracted to areas near where people are, and this is the type or recommendations we would make in a Bear Interaction Plan. If you are familiar with Prudhoe, the Central Gas Conditioning Plant there is a four-story building. One heavy mosquito day there was a female polar bear resting up on the little platform on the third story stairwell. Someone wanted to open the door from the inside, and couldn't figure out why the door wouldn't open. He looked out the window and saw the bear. At exploration facilities, barriers can be erected by simply running a chain link fence around the whole camp. If there is no attractant in the camp, this will be enough to keep grizzly or polar bears from hanging out there.

Waste management of many different types is still one of the main problems, and attractants can be lots of different things. They don't have to be things you normally think of as garbage, because bears are also attracted to things like sanitary wastes from cleaning up the rooms. These wastes should also be treated as garbage rather than as plain paper waste, and placed in bear-proof containers. Bears have been attracted to sewer gray water lines, and they have been known to actually go under buildings, tear up lines, and trace them back to the kitchen area. This is a problem primarily in the smaller camps, but can even occur in a major facility. Break room trash out in the shacks at some of the work sites is also a common problem. And finally, antifreeze and petroleum products can also be attractants to bears, and these materials may deadly to bears, just as can be to cats and dogs.

Once you have a bear problem, there are a number of different types of potential solutions. Some of these, such as structural changes, we have already talked about. But we also have to make some cultural changes. For a long time we have told people to take their garbage and put it in the nearest garbage bag instead of dropping it on the ground. Although in certain respects that may be a good idea, if the garbage bag eventually winds up in the back of a pickup truck instead of in a bear-proof container, you've just traded one problem for a potentially more serious one by creating a bear attractant. So we need to start reprogramming people to realize that there is really only one type of container where all the garbage goes - a bear-proof and fox-proof container.

Another issue involving bears that is not related to facilities and garbage management is the increased use of 3D seismic in exploration. One of the great things about winter exploration and winter construction, of course, is that you can reduce the impacts on a lot of tundra species. However, this is not necessarily a benefit to all species. What happens is you saturate an area with 3D seismic tests in the presence of denning polar bears or grizzly bears? We've actually had a couple of close calls resulting from disturbed bears. We have a radio-collared bear population, so we provide denning locations for the bears we know about to the industry, and they subsequently avoid these locations

What has happened with seismic exploration over the years is that we have taken a half-mile radius out of the pattern to avoid bear dens. With 3D seismic, when you take out a half-mile radius out, you lose data for a circle a mile across. So the seismic folks have asked for a variance where surface structures can be used to reduce impacts. As a result, we are now experimenting with a system where we alter the shape of the area. In one case, there was a den we were avoiding that was located on a pingo that was elevated maybe 20 or 30 feet above the tundra surface, which is a lot of elevation in this part of the North Slope. We concluded that disturbance on the back side of the pingo would be less than that on the front side due to the topography. We avoided the front of the pingo, and made the exclusion area more elliptical.

A lot of times there is a single seismic sweep through an area, but in some cases these bears may be subjected to two or three seismic runs over a period of time. If you're familiar with the Kenai fatality that occurred recently during a 3-D seismic program, we concluded that the bear had had a lot of disturbance from repeated seismic activities before he came out and killed the unfortunate worker. This is something that I think we need to look at in future, especially when we move to new oil fields where we're not going to have collared bears. Fish and Wildlife Service, as you may have heard, is working on a system to detect polar bear dens using forward-looking infrared technology and habitat characterization. We're doing a similar thing using a different approach.

Practices and Technologies Designed to Protect Birds

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INTRODUCTION

More than 20 years have passed since the first production well began pumping oil in Prudhoe Bay. Over the intervening years, our understanding of the impacts of oil development on birds and the mitigation practices to avoid and minimize those impacts have progressed substantially. In this brief description of the practices used to protect birds, I first review the development issues that potentially effect the bird communities in oilfields on the Arctic Coastal Plain, then the species of birds that receive most attention, and finally research and monitoring methods that guide effective mitigation.

DEVELOPMENT ISSUES

The issues on the Arctic Coastal Plain are general and probably are germane to development elsewhere, but I am going to address specific issues on the coastal plain, which is a breeding area for a diverse assemblage of long-distant migrants and a few resident species. For a full discussion of development impacts and mitigation measures at a recently developed oilfield, I refer readers to the Alpine Project Environmental Evaluation Document (ARCO 1997). The following list of issues pertain to most oilfield developments:

habitat loss or modification, either long- or short-term, usually results from placement of gravel pads and roads, airstrips, pipelines and powerlines, and other infrastructure;

disturbance from noise, vehicles, aircraft, predators, or people may change habitat use, affect behavior, decrease nest attendance, increase risk of predation, and increase energetic costs. People and predators usually elicit the greatest disturbance responses from birds;

death and injury from bird collisions with vehicles and structures such as powerlines claim an unknown number of birds. A growing concern is the potential for collisions of migrating flocks of birds, particularly eiders, that fly along the coast. In fog or conditions of reduced visibility, birds sometimes collide with buildings, towers, and powerlines. Such collisions are infrequent but can kill large numbers of birds in single incidents;

predation is a major factor limiting the productivity of ground nesting birds on the coastal plain. Arctic and red foxes, brown bears, Glaucous Gulls, Common

Ravens, and several spp. of jaegers are endemic to the coastal plain and prey on birds and their eggs. Nesting colonies of brant on the Colville Delta of over 1,000 nests have suffered near complete failure from a single bear and similar failures have occurred from bears and arctic foxes at Howe Island, a brant and snow goose colony on the Sagavanirktok River Delta. Foxes, bears, gulls, and ravens are attracted to human food sources, which are available when waste management is ineffective;

hydrocarbons and byproducts of oil production potentially can contaminate birds and cause death, injury, decreased productivity, or reduced health; and

marine oilspills can be devastating to bird life depending on the location, timing, volume, and containment of a spill. Marine spills are a major concern for offshore oil development.

Not all species of birds that occur on the coastal plain receive the same attention when it comes to oilfield development. Two species are federally listed threatened species—Steller’s Eiders and Spectacled Eiders—that require special clearance before new facilities can be constructed. There are several species that are rare locally (i.e., do not breed in all the available habitat): Yellow-billed Loons, Bar-tailed Godwits, and Peregrine Falcons. Species that are known or suspected to have declining populations, either regionally or globally, are granted more protection than other species, and this list changes as our knowledge improves: Brant, King Eiders, Oldsquaws, Red-throated Loons, and Buff-breasted Sandpipers. Finally, there are species that are protected because they have special subsistence or economic values: Tundra Swans, Greater White-fronted Geese, and Snow Geese.

PRACTICES

The specific practices and technologies employed for bird research and protection are somewhat dependent on the stage of oil development. The most effective protection for birds and wildlife in general is to incorporate baseline information on distribution, abundance, and habitat use into the design and location of oilfield facilities. A recent example of this strategy is the Alpine development project, which used seven years of baseline studies on the Colville River Delta (Smith et al. 1993, 1994; Johnson 1995, Johnson et al. 1996, 1997, 1998, 1999a) as technical data to identify preferred habitats and specific nest and brood-rearing sites for the species of concern in the area. Using GIS and habitat modeling techniques (see Murphy 2000, in this proceeding; Johnson et al. 1999a), baseline data on site specific use were analyzed to map habitat preferences for individual species and the species data were then integrated into maps of species diversity for different sets of species (e.g., rare species, subsistence species) (ARCO 1997). Through this process specific areas and habitats are identified that may be considered more sensitive to oilfield development. Pads and roads locations can be modified then to avoid or minimize their incursion into valuable bird habitats and specific use areas. Baseline data on the regional distribution, abundance, and habitat use for large showy species are usually collected during surveys from aircraft timed for important periods in the breeding cycle of birds. Site specific surveys are conducted in the proposed location of the oilfield and support facilities for nests and broods of species that are difficult to see from the air are conducted with intensive ground-based searches (Johnson et al. 1999a, 1999b).

Although the above techniques are employed prior to development in the planning stages, they also may be employed, along with other techniques, during the construction and operational stages of oilfield development to identify responses of birds. A brief and incomplete description of some of these other techniques follows. Radio and satellite telemetry are used to follow movements of individual birds within oilfields (to identify nesting and brood-rearing areas as well as bird movements relative to facilities) and beyond (to identify molting, staging, and wintering areas) (TERA 1996). Capture and banding of Brant and Snow Geese are conducted to identify migration routes, staging and wintering areas, and estimate survival rates (Anderson et al. 1999). Radar is used to identify flight paths and flight elevations of migrating birds in places where structures could lead to collisions (Day et al. 1998). Time-lapse photographs or videotapes are used to monitor the effects of disturbance and predation at nest sites (Anderson et al. 1999, Johnson et al. 1999b). Temperature sensors implanted in artificial eggs are used to monitor nesting behavior as part of disturbance studies in oilfields (Anderson et al. 1999, Johnson et al. 1999b). All these techniques are most effective at measuring oilfield impacts when they are conducted before and after construction in both affected and reference sites (Stewart-Oaten et al. 1986), but a number of techniques can be effectively used in paired plot and blocked designs or in gradient analyses after construction or operation has begun (Murphy and Anderson 1993, TERA 1993, Ellis and Schneider 1997). Studies of bird responses to development have provided invaluable information that can be applied to minimize potential impacts in oilfields.

Another effective practice to protect nesting birds is the reduction of disturbance and predation. Seasonal restrictions on aircraft, vehicles, noise, and people on foot in nesting and brood-rearing areas help maintain avian productivity. Winter construction, particularly of roads, pads, and pipes, eliminates much of the disturbance related to heavy equipment. Maintaining minimum flight altitudes is an effective measure to reduce aircraft disturbance. The level of predation can be controlled with effective waste and food management. Eliminating the availability of human food to predators reduces the attraction of predators to oilfields and thus reduces the level of predation on birds and their nests.

Research is an essential element in the array of practices used to protect and maintain the bird community in the vicinity of oilfields. Continued research and monitoring into habitat selection, the effects of disturbance, and new approaches to mitigation are needed to improve our ability to protect birds and to search for cost-effective management practices. More species are likely to come under concern as global and regional modifications in habitat and climate cause populations to decline. Regardless of where problems occur in a species range, protection of species with declining populations will be a necessity on their breeding grounds.

Conclusions

The most effective protection of avian communities during oil and gas development is through the design and siting of projects. Baseline data on species abundance and distribution can be integrated into a habitat evaluation through GIS that can take into account multiple rare, sensitive, or socially valued resources. These tools make it possible for development to avoid specific nest sites as well as habitat that has a high potential for use.

Another important protection is an effective mitigation program to minimize the attraction of predators and the impacts of disturbance. Controlling the availability of human food to foxes, bears, gulls, and ravens is essential to maintaining a healthy productive community of breeding birds in a developed area. Minimizing disturbance through managing aircraft, vehicle, and pedestrian traffic during the nesting season and during the brood-rearing season in specific habitats allows the birds opportunities to produce young without additional stress.

Research and monitoring into habitat selection, the effects of disturbance, and effective approaches to mitigation continue to be needed to supply information for bird management and protection. More species are likely to decline from global or regional modifications in populations and habitat, and these species will need protection on their breeding grounds.

Finally, the cost of proactive strategies—collecting baseline data, effective design and siting of projects, effective mitigation programs, and continued research—might seem expensive. But it may be cost effective when we consider the costs of increased oversight and regulation by resource agencies, lawsuits and injunctions, missed construction seasons and deadlines, and delayed production. The Alpine oilfield and Tarn development in Kuparuk are examples of new development where this strategy has worked.

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NOTE: FOOTNOTES BELOW BELONG TO VAN TUYN PRESENTATION

[i] State of Alaska, Department of Environmental Conservation, 1996 Water Quality Assessment Report, (August 1996), p. 6.

[ii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, Vol. IV, ch. 10, p. 10-2.

[iii] U.S. Department of the Interior, Northeast National Petroleum-Reserve Alaska Draft Integrated Activity Plan/Environmental Impact Statement, (December 1997), p. III-A-5.

[iv] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, Vol. IV, ch. 10, p. 10-2.

[v] Alaska Department of Natural Resources, Proposed Oil and Gas Lease Sale 86 Central Beaufort Sea - Preliminary Finding of the Director Volume I, (January 28, 1997), p. 2-12.

[vi] A unit is a combination of existing leases that the lessees and the State of Alaska (or Minerals Management Service for federal offshore lands) agree should be combined into one unit to promote optimal development without unnecessary duplication of infrastructure.

[vii] Anchorage Daily News, "$55 million bid for oil leases," June 25, 1998, p. F-1.

[viii] Anchorage Daily News, "BP, Arco win 87% of NPR-A oil leases," May 6, 1999.

[ix] State of Alaska, Department of Natural Resources, Historical and Projected Oil and Gas Consumption, (1997), p. 19, and Table 4, p. 27.

[x] Anchorage Daily News, "New deposits found on Slope," June 18, 1998, p. F-1.

[xi] U.S. Department of Energy, Alaska Oil and Gas: Energy Wealth or Vanishing Opportunity, (1991), Table 2-5.

[xii] Christian Science Monitor, "Quest to wring more oil from Alaska North Slope," October 8, 1996, p. 4. Oil company estimates are even higher. Anchorage Daily News, "Tarn prospect becomes worthy 'satellite," January 5, 1997, p. A-5 (1 billion estimate); Alaska Oil & Gas Reporter, "Meet Alaska: BP sees more oil on the slope: BP's Richard L. Olver sees another 5 billion barrels, not counting ANWR," February 19, 1996, p. 13.

[xiii] Anchorage Daily News, "Brighter future foreseen for North Slope," January 5, 1997, p. A-1.

[xiv] Anchorage Daily News, "Advisors see Alaska's oil output rising," March 30, 1995, p. A-1; Alaska Oil & Gas Reporter, "Industry Outlook: Cambridge Energy Research says Alaska production will increase again," February 17, 1997, p. 15. BP and other industry documents, submitted as part of sworn testimony to the Alaska Oil and Gas Commission for Prudhoe Bay hearings, May 16, 1995, projected production to the year 2040. Attachments to Richard A. Fineberg's rebuttal testimony to "Summary Critique" of James E. Eason, August 28, 1995.

[xv] State of Alaska, Department of Natural Resources, Historical and Projected Oil and Gas Consumption, (May 1998), Table 1, p. 4. The state lists 46 separate oil and gas fields.

[xvi] U.S. Department of the Interior, Fish & Wildlife Service, Final Environmental Impact Statement And Preliminary Final Regulations: Proposed Oil & Gas Exploration With The Coastal Plain Of The Arctic National Wildlife Refuge, Alaska, (1983), p. II-10.

[xvii] U.S. Department of the Interior, Fish & Wildlife Service Memorandum from Botanist, Arctic National Wildlife Refuge to Refuge Manager (April 3, 1998).

[xviii] Petroleum News - Alaska, "North Slope Borough denies permit," June 22 - July 26, 1998, p. A-2.

[xix] Anchorage Daily News, "The Sound of Oil," in We Alaskans, May 17, 1998, p. F-6.

[xx] U.S. Department of the Interior, Fish and Wildlife Service Memorandum from Botanist, Arctic National Wildlife Refuge to Refuge Manager (April 3, 1998), p. 2.

[xxi] State of Alaska, Department of Natural Resources, Division of Oil and Gas, Final Finding of the Director Regarding Oil and Gas Lease Sale 75A Colville River Exempt, June 22, 1993, p. 41 (citing AOGC 1992 Report).

[xxii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998),Volume IV, § 10.2.2, p. 10-2.

[xxiii] Greenpeace, Oil in Arctic Waters: The Untold Story Of Offshore Drilling In Alaska, (1993), pp. 68.

[xxiv] U.S. Army Corps of Engineers Alaska District, Final Environmental Impact Statement Prudhoe Bay Oil Field Water flood Project, Prudhoe bay Alaska, (October 1980),Vol. 1, p. 3-60.

[xxv] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. IV-A-11.

[xxvi] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume II, Table 3-2.

[xxvii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume II, Table 3-3. Water volume needs for water injection or flooding with either treated seawater or treated produced waters range from two barrels of water per barrel of oil produced to 170% of total produced fluids. *Ibid*., p. 3-45.

[xxviii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998),Volume II, p. 3-8.

[xxix] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. IV-A-11.

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[xxxi] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume II, p. 3-22.

[xxxii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume II, pp. 4-31 - 32 (map showing active permitted onshore water withdrawal sites).

[xxxiii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998),Volume IV, § 10.2.2, p. 10-2.

[xxxiv] U.S. Fish and Wildlife Service, Comparison of actual and predicted impacts of the Trans-Alaska Pipeline System and Prudhoe Bay oil fields on the North Slope of Alaska, (1987) draft report prepared by Fairbanks Fish & Wildlife Enhancement Office.

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[xxxvi] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. III-C-55.

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[xxxviii] R. Meehan, Oil Development in Northern Alaska, prepared for U.S. EPA (Corvallis, Oregon, 1988), p. 35.

[xxxix] U.S. Department of Interior, Minerals Management Service, NPR-A Symposium Proceedings: Science, Traditional Knowledge, and the Resources of the Northeast Planning Area of the National Petroleum Reserve - Alaska, April 16-18, 1997, Anchorage, Alaska, p. 1-12 (remarks of Beez Hazen, P.E., Northern Engineering & Scientific entitled "Use of Ice Roads and Ice Pads for Alaskan Arctic Oil Exploration Projects").

[xl] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), p. II-93.

[xli] U.S. Department of the Interior Proposed Trans-Alaska Pipeline - Introduction and Summary, (1972) Volume I, pp. 55-56.

[xlii] U.S. Fish and Wildlife Service, Comparison of actual and predicted impacts of the Trans-Alaska Pipeline System and Prudhoe Bay oil fields on the North Slope of Alaska, (1987) draft report prepared by Fairbanks Fish & Wildlife Enhancement Office, Table 2, p. 12.

[xliii] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. III-C-57.

[xliv] Ibid.

[xlv] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, pp. III-C-59 - 60.

[xlvi] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. III-C-57-58.

[xlvii] State of Alaska, Department of Natural Resources, Final Best Interest Finding, Lease Sale 75A, June 22, 1993, p. 41.

[xlviii] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, pp. III-C-57 - 58.

[xlix] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998),Volume IV, § 10.2.2, p. 10-2.

[l] BP Exploration (Alaska) Inc., Fact Sheet - Produced Water, No.98-15 ("six gathering centers/flow stations in the Prudhoe Bay field separate crude oil from produced water and natural gas"); R. Meehan, Oil Development in Northern Alaska, prepared for U.S. EPA (Corvallis, Oregon, 1988), p. 32.

[li] ARCO, Supplement to Annual Report, (1985), cited by NRDC et al., Tracking Arctic Oil: Background Technical Report, (1991), p. 4.

[lii] State of Alaska, Department of Natural Resources Oil and Gas lease Sale 87 North Slope Areawide Final Finding of the Director, (march 17, 1998), Vol. I, ch. 4, p. 4-5 (four to five thousand workers). See also, BP Exploration (Alaska) Inc., Fact Sheet - Environmental Setting, No. 98-1 (2500 employees); U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. III-C-4 (6.000 North Slope oil-industry workers in 1992); State of Alaska, North Slope Borough, Solid Waste Management Plan, (April 1996), § 10.3.1, p. 10-4 ("The number of employees at Prudhoe Bay/Kuparuk was estimated at 6,235 in 1994 from state Workmen's Compensation filings ... the estimated resident population of SA-10 is put at approximately 3,100.").

[liii] U.S. Department of the Interior, Proposed Trans-Alaska Pipeline Introduction and Summary (EIS Volume 1, (1972), p. 50. In fact, the TAPS EIS's description of the proposed major federal "action" was restricted to permitting for construction of TAPS. Ibid., p. i-a.

[liv] U.S. Department of the Interior, Proposed Trans-Alaska Pipeline Introduction and Summary (EIS Volume 4, (1972), Figure 5, p. 264.

[lv] State of Alaska, Department of Natural Resources, Proposed Oil and Gas Lease Sale 86 Central Beaufort Sea, Preliminary Finding of the Director, Volume 1, January 28, 1997, p. 2-14, Table 2.1. Dates of discovery and production startup and estimated original economically recoverable oil reserves given in the table for major fields are from *ibid*.

[lvi] State of Alaska, North Slope Borough, Solid Waste Management Plan, (April 1996), § 10.3.1, p. 10-4.

[lvii] State of Alaska, North Slope Borough, Solid Waste Management Plan, (April 1996), § 10.3.1, p. 10-5.

[lviii] State of Alaska, North Slope Borough, Oxbow Landfill - Annual Reports, (1996, 1997).

[lix] BP Exploration (Alaska) Inc., Fact Sheet - Solid & Hazardous Waste, No.98-18

[lx] State of Alaska, Department of Environmental Conservation, "Environmental information relative to air and water quality, solid waste disposal and oil spill contingencies for the Arctic National Wildlife Refuge," (1986) North Slope District Office, Fairbanks, 65 pp., source cited by Mueller, K.A., "Toxicity and water quality of natural water bodies, reserve pits and selected sites at North Slope, Alaska, Oilfields" (1986), U.S. Fish & Wildlife Service, Ecological Services, Fairbanks, NAES-TR-92-01, p.2.

[lxi] State of Alaska, Department of Environmental Conservation, Oil and Gas Waste Management Issue and Recommendations for the Arctic National Wildlife Refuge, Appendix I, (1990), p.59.

[lxii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume III, Table 5.4-7.

[lxiii] EPA Office of Air Quality Planning and Standards, AIRSWeb at http://www.epa.gov:6703/airwdcd/ow Source Count Report (August 21, 1998) for State of Washington Nitrogen Dioxide Air Pollution Sources.

[lxiv] EPA AIRSWeb http://www.epa.gov:6703/airwdcd/ow (August 21, 1998) Source Ranking Report Alaska Carbon MoNOxide Air Pollution Sources (Anchorage total 38,500 tons per year).

[lxv] See Radian Corporation, Air Toxics Technical Assistance for the State of Alaska, Final Report, (March 1987) (estimated toxic emissions from oil field activities).

[lxvi] U.S. Department of Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan Environmental Impact Statement, (August 1998), Volume 1, p. IV-H-5.

[lxvii] U.S. Army Engineer District, Alaska, Draft Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project, (June 1998), Volume IV, § 10.4, p. 10-20.

[lxviii] State of Alaska, Department of Environmental Conservation, Oil and Gas Waste Management Issues and Recommendations for the Arctic National Wildlife Refuge, (1990, Juneau), Table 3.1-1, p. 43-A.

[lxix] State of Alaska, Department of Natural Resources, Final Best Interest Finding, Lease Sale 75A, June 22, 1993, p. 42.

[lxx] State of Alaska, Department of Environmental Conservation, Oil and Gas Waste Management Issues and Recommendations for the Arctic National Wildlife Refuge, (1990, Juneau), Table 3.1-5, p. 43-D.

[lxxi] State of Alaska Department of Environmental Conservation, 1997 Oil Spill Database.

[lxxii] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement, (August 1998), Vol. 1, p. IV-A-34. See also, State of Alaska, Department of Environmental Conservation, 1997 Oil Spill Database.

[lxxiii] State of Alaska, Department of Environmental Conservation, Alaska Water Quality Assessment, (1990). Section 305(b) Report to EPA, p. 40. State of Alaska, Department of Environmental Conservation, Information Sheet for Reserve Pit Discharge Permit, (1985), cited by NRDC, et al., Tracking Arctic Oil: Background Technical Document, (1991), p. 12.

[lxxiv] U.S. Department of the Interior, Bureau of Land Management, Northeast National Petroleum Reserve-Alaska Draft Integrated Activity Plan/Environmental Impact Statement, (December 1997), Table IV.G-1, p. IV-G-1. The table was not reprinted in the final EIS.

[lxxv] In BP's illegal disposal at the Endicott field, Class I wastes--engine oil, paints, solvents, etc.--were mixed with Class II wastes and injected into a Class II well. The injection records for this well were then altered to hide the disposal of the illegal wastes.

[lxxvi] Anchorage Daily News, "Pollution's price tag: $1 million," May 1, 1998, p. A1; ibid., "Enviro crimes," May 6, 1998, p. B-6.

[lxxvii] Section 8002(m) of RCRA, 40 U.S.C. Section 6982(m). For more details on this exemption see NRDC, et al., Tracking Arctic Oil: Background Technical Document, (1991), p. 25.

[lxxviii] 53 Fed. Reg. 11 (Jan. 4, 1988) (report to Congress); 53 Fed. Reg. 25446 (July 6, 1988) (regulatory determination).

[lxxix] See 40 CFR § 261.4(b)(5) (1990).

[lxxx] New York Times, "The Nation's Pollution: Who Emits What, and Where," October 13, 1991, p. F10.

[lxxxi] Emergency Planning and Community Right to Know Act, Section 313, Title III, Superfund Amendments and Reauthorization Act of 1986, 42 USC § 11023.

[lxxxii] Offshore Magazine 57(5), "Activity review of US regulatory, legislative issues," May 1, 1997.

[lxxxiii] LR 19 (1997).

[lxxxiv] 42 USC § 7545(i).

[lxxxv] 42 USC § 7545(i)(4).

[lxxxvi] 61 F.R. No. 161, pp. 42812-17 (August 19, 1996).

[lxxxvii] Anchorage Daily News, "Tesoro expands presence," February 18, 1997, p. A-1.

[lxxxviii] Informal Attorney General Opinion, File No. 993-94-0102 (October 11, 1996), p.5 and n. 8.

[lxxxix] Two page letter from the Alaska Chapter of the International Association of Drilling Contractors to ADEC's Commissioner, May 1, 1998.

[xc] An ADNR Division of Oil and Gas official suggested that an example of a "significant new" piece of information would be the discovery of a new, threatened species of wildlife. Personal conversation with ADNR's Ken Boyd and Trustees for Alaska staff attorney.

[xci] State of Alaska, Office of the Governor, News Release 98-105, (May 4, 1998), "Knowles Vetoes Bill That Weakens Air Quality."

[xcii] Section 3 of House CS for CSSB No. 231 (FIN) am H (brf sup maj pfld S) (May 10, 1998)