NATIONAL PETROLEUM RESERVE IN ALASKA

DESIGN & CONSTRUCTION
OF THE
TUNALIK WELLSITE

HUSKY OIL NPR OPERATIONS, INC.
Prepared by: Dennis W. Mitchell

For the

U. S. GEOLOGICAL SURVEY
Office of the National Petroleum Reserve in Alaska
Department of the Interior
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INTRODUCTION

Naval Petroleum Reserve No. 4 was established by Executive order of President Harding in 1923 in order to protect a potential source of petroleum for strategic purposes. The name was changed to the National Petroleum Reserve in Alaska (NPRA) in 1977. The Reserve covers 23,000,000 acres in northern Alaska and extends south from the Beaufort and Chukchi Seas to the drainage divide in the Brooks Range and west from the Colville River to Icy Cape (Figure No. 1).

In 1944, the Navy began a large scale exploration program to assess the oil resource potential of the Reserve. The program began as a Naval Construction Batallion (Seabee) operation, but was changed to a civilian contract operation in 1946. During the first 2 years, in addition to the performance of some initial reconnaissance, the Seabees began construction of a camp and transportation facility infrastructure to support future activities. The gathering and interpretation of geological, geophysical and drilling data began in 1945. Drilling, geophysical and operations support activities were continued through 1953, at which time the program was closed out. During the 9 year program, nine small oil and/or gas fields were identified.

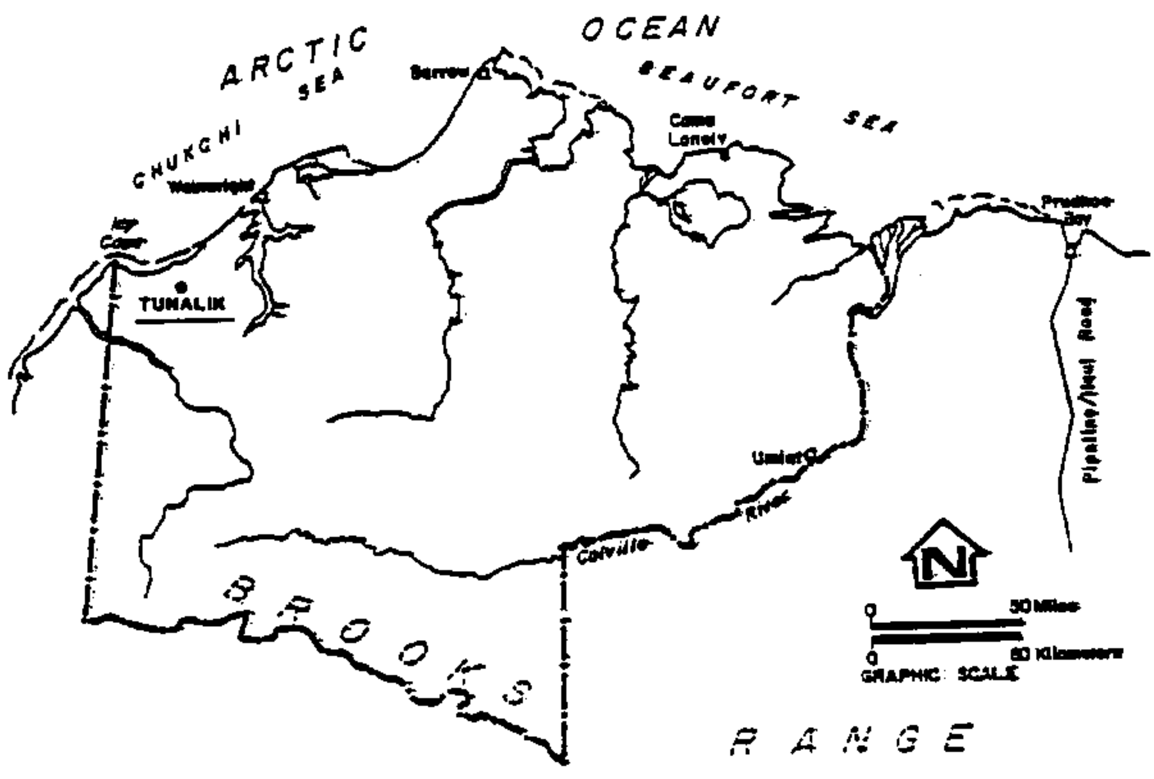

FIGURE NO. 1. LOCATION OF TUNALIK

In 1974, the U.S. Congress authorized and funded a new program to perform geophysical work and to drill exploratory wells in the Reserve. This program was originally under the jurisdiction of the Navy but was transferred to the Department of the Interior in June 1977. The responsibility for the program was assigned to the U. S. Geological Survey (USGS). The Navy contracted the operation to Husky Oil NPR Operations, Inc. (Husky) which acted as prime management contractor for the exploration program from 1975 until 1982. Under this contract, Husky and its subcontractors drilled 27 exploratory oil wells in NPRA.

TUNALIK WELL LOCATION AND DRILLING REQUIREMENTS

In the spring of 1977, the USGS directed Husky to develop plans to begin seven exploratory wells at specified locations the following winter. One of these wells, a 20,000-foot deep well named Tunalik Test Well No. 1, was located at latitude 70°12'21"N and longitude 161°04'09"W (Figure No. 1). This site is approximately 187 miles southwest of Camp Lonely, Husky's base of operations. Tunalik is also approximately 295 miles west of Prudhoe Bay, 221 miles northwest of the State owned airfield at Umiat and 131 miles southwest of Barrow.

Preliminary estimates indicated that roughly 330 days of drilling would be required to reach the projected 20,000-foot depth. Additional time would be required to construct the appropriate site facilities, mobilize and prepare the drilling rig, and, after completion of the well, to disassemble and demobilize the rig. Site preparation would require the construction of an approximately 300,000-square-foot drilling pad, installation of piling to support the rig, excavation of a reserve pit to contain spent drilling fluids, construction of an airstrip and road system and various other lesser items. Construction of these facilities would require mobilization of a construction crew and equipment to the site. Both the construction and drilling activities would also require a continuing supply of food, water, fuel, materials and personnel.

SITE CONDITIONS

The Tunalik wellsite was located within the Arctic Coastal Plain Physiographic Province about 7 miles inland of Kasegaluk Lagoon in an area with a ground elevation of about 135 feet. Preliminary reconnaissance and engineering surveys were carried out during the summer of 1977. This work was accomplished by crews based in the Husky camp at the Naval Arctic Research Laboratory (NARL) in Barrow. The crews traveled each day between the site and the NARL in helicopters.

The region surrounding the wellsite is characterized by very gently rolling terrain except adjacent to the predominantly northwesterly flowing streams where the relief is more pronounced. Surficial soils consist of organic silty sand or silt over most of the area. Relatively cleaner and coarser material, classified as sand and sandy gravel, was found to be present in limited quantities adjacent to several of the nearby streams.

The primary vegetation type in the low areas is moist tundra comprised of a mosaic of plant communities typical of most of the coastal plain. In the higher and better drained areas, heath grasses, sedges and occasionally birch and willow were found. The entire area is underlain by continuous permafrost having an average annual thaw depth (active layer) of about 18 inches. The presence of permafrost is reflected by polygonal patterned ground, oriented lakes and occasionally by beaded streams.

Numerous lakes were found in the area. A large concentration of small lakes was located between 2 and 3 miles southwest of the wellsite. The several large lakes in the area were located between 3 and 6 miles northwest and west of the site.

Three potential borrow sites were identified during the summer. These varied between 5 and 12 miles from the wellsite. Borrow Site No. 1, located 5 miles west of the well was estimated to contain in excess of 400,000 cubic yards of sand and sandy gravel of marginal construction quality. Borrow Site No. 2, located about 9 miles north of the site was estimated to contain roughly 120,000 cubic yards of similar but less gravelly material. Finally, Borrow Site No. 3, located on a barrier island on the north side of Kasegaluk Lagoon was identified; however, numerous archeologically significant items were located in the immediate vicinity and this site was dropped from consideration.

A series of environmental investigations were also carried out during the summer. These included assessment of the plant, bird, fish and mammal populations in the general area, with particular emphasis on the specific areas which might be disturbed during construction. While numerous species were identified, no rare or endangered species were noted or expected to inhabit the area and the loss of potential habitat caused by construction of drill site facilities was judged to be minimal.

All potential operational areas were also surveyed by a joint BLM/USGS archeological team. With two exceptions, no archeological or historic sites were identified. Significant items were located at two of the proposed borrow areas. Two areas of proposed Borrow Site No. 3 were found to contain artifacts and this site was therefore dropped from consideration for use. Archaeological components were also identified at Borrow Site No. 1 by the BLM/USGS team. An excavation of the site was conducted by experienced personnel under the direct supervision of a BLM archeologist. BLM and USGS professional archeologists assumed the responsibility for analyzing the material obtained, publishing the results of these analyses and arranging for the archiving of the materials recovered. Borrow Site No. 1 was then approved for use.

SELECTION OF OVERALL DESIGN CONCEPT

Three basic factors affect the design of facilities constructed at a remote well location. These are the depth of the well, environmental considerations and economics. The depth of the well is the primary factor in determining the length of time which will be required on location. As previously noted, completion of a well includes mobilization to the location and construction of the wellsite facilities, mobilization of the rig and support equipment, drilling, testing and suspending or abandoning the well, and finally, demobilization of the rig and support equipment. If all this can be accomplished in approximately 170 days, or less, both environmental and economic considerations dictate that the well should be drilled in a single winter season. By electing this course of action, both the airstrip and road system can be constructed of ice. This is preferred environmentally, to the alternate of gravel construction because the facilities disappear during breakup. Ice construction is also less costly than gravel construction. Finally, for single winter use the drilling pad can be constructed with material obtained from the excavation of the reserve pit without concern about thaw-stability characteristics. By eliminating the need to develop a borrow source containing thaw-stable material, or the use of some type of insulation, environmental disturbance is minimized and costs reduced.

If a well cannot be completed in a single winter, two options exist. It can either be drilled on a year-round basis or drilled during two or more winter seasons, with all activities being suspended during the intervening summers. In the case of the Tunalik well, more than a single winter season would be required to reach the target depth. Each of the preceding two options were therefore investigated, and each found to have both advantages and disadvantages.

Multi-winter drilling is usually preferred from an environmental standpoint. By limiting drilling to winters only, most of the advantages of single winter drilling are gained; i.e., roads and airstrips constructed of ice, deletion of the requirements to develop large borrow areas which may add to environmental disturbance and minimized disturbance of the summer wildlife population. It is usually necessary, however, to mine some thaw-stable material to use as the upper few feet of the drilling pad thickness to provide a suitable surface on which to store the drilling equipment and materials during the summer. It is also necessary to rebuild the ice roads and ice airstrip each winter. The primary disadvantage of winter only drilling is the length of time required to complete the well. The drilling rig must be committed to a multi-winter well for two or more times as long as would be required for an all-season well. An estimated schedule for completing a well such as Tunalik on a multi-winter schedule is presented in Table 1.

As can be seen, a very tight three winter schedule exists for reaching a target depth which requires 330 days of drilling and the drilling rig itself is committed for approximately 840 days. Should delays in construction or drilling prevent the schedule from being met, a third 195 day long thaw season, and a fourth winter construction program would be required, adding over 200 days to the schedule before drilling could again be resumed.

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TABLE 1

ESTIMATED MULTI-WINTER SCHEDULE FOR A 20,000-FOOT-DEEP TEST WELL

1st Winter:	Initial Site Construction	45 days	
	Mobilization of Drilling Equipment	15 days	
	Rig-up	15 days	
	Drilling	85 days *	
	Suspension	10 days	
	Subtotal		170 days
1st Summer:	Standby		195 days
2nd Winter:	Site Reconstruction and Preparation to Reenter	25 days	
	Drilling	140 days *	
	Suspension	15 days	
	Subtotal:		170 days
2nd Summer:	Standby		195 days
3rd Winter:	Site Reconstruction and Preparation to Reenter	25 days	
	Drilling	105 days *	
	Testing (if required)	10 days	
	Abandonment	15 days	
	Demobilization	15 days	
	Subtotal:		170 days
	TOTAL:		900 days

*Total Drilling Days - 330

By comparison, an equivalent all-season well can be completed fairly quickly. An estimated schedule for the completion of a 20,000-foot-deep well such as Tunalik on an all-season basis is presented in Table 2.

As shown, only 520 days are required and the drilling rig is only committed for 400 days on an all-season basis when compared to an 855 day commitment on a multi-winter basis. Further, should an extra 20 to 30 days of drilling be required to complete the well (350 to 360 drilling days instead of 330), only 20 to 30 days are added to the all-season schedule. By comparison, 240 to 250 days would be added to the multi-winter schedule because of the need to include additional summer standby and winter site reconstruction periods. This time saving is one of the important advantages of all-season drilling.

TABLE 2

ESTIMATED ALL-SEASON SCHEDULE FOR A 20,000-FOOT-DEEP TEST WELL

1st Winter:	Initial Site Construction	120 days
	Mobilization of Drilling Equipment	15 days
	Rig-up	15 days
1st Summer & 2nd Winter:	Drilling	330 days
	Testing (if required)	10 days
	Abandonment	15 days
	Demobilization	15 days
	TOTAL	520 days

A second advantage of all-season drilling, when compared to multi-winter drilling, is reduced risk. When drilling exploratory wells, there is always the risk that unexpected and sometimes hazardous conditions will be encountered which may take months to control. This risk was particularly high at Tunalik because it was projected to be deeper than any well previously drilled on the North Slope. Should such a condition occur shortly before the scheduled suspension of a well, it may not be controllable before the ice airstrip and pad begin to melt and become unusable. If the site cannot be adequately supported, it is much more likely that the hazardous condition will not be controlled and could result in loss of the well and perhaps the rig or even lives.

There is also a risk associated with suspending and later reentering a well. In some cases drilling cannot be resumed at the depth at which the well was suspended. Unstable conditions in the open hole in an inactive well can result in complete filling or bridging over much of the hole by sloughing. Also, particularly in permafrost areas, inactive wells can have extensive casing collapse which will also block reentry.

There are, however, two main disadvantages of all-season drilling. These are environmental considerations and cost. From an environmental standpoint, larger areas are disturbed in obtaining material for and constructing the required thaw-stable facilities. In addition, the over-summering wildlife population may be adversely impacted. Finally, the cost of constructing an all-season wellsite can be considerable higher than that of completing a multi-winter wellsite. Depending on site specific conditions, the construction of an all-season facility can cost between $10 million and $20 million. By comparison, the initial construction cost of a multi-winter well can be estimated at roughly $2 million. To this must be added those costs which would be incurred in suspending the well each spring, holding the rig on standby for the summer, reconstructing the site in the fall and reentering the well. These items taken together can amount to roughly $2.5 million for each summer. When added together, initial construction and two subsequent summers can cost roughly $7 million.

For the Tunalik well, it was decided that the reductions in required time and the reduction in risk outweighed the additional cost and a decision was made to drill the well on an all-season basis. In addition, it was decided that Tunalik was not located in an extremely environmentally sensitive area and that by taking proper precautions the environmental impact of all-season drilling could be reduced to an acceptable level.

SELECTION OF CIVIL CONSTRUCTION DESIGN

Once the decision had been made to drill on an all-season basis, the next step in the design process was to select an overall civil design concept for the Tunalik site within which the detailed design would be developed. The overall goal was to design facilities capable of supporting drilling activities through the thaw season with minimal environmental impact.

Except beneath large bodies of water, the entire NPRA is underlain by continuous permafrost. In addition, the vast majority of the permafrost soils found within the NPRA are not thaw stable. Thawing of these soils usually results in significant settlement, deformation of the surface, and the liberation of sufficient melt water to create extremely weak soil conditions. Most facilities constructed in permafrost areas disturb the natural thermal balance and, unless special precautions are taken, thaw the underlying soils.

Prevention of thaw penetration beneath structural embankments has usually been accomplished either by constructing very thick fill sections or by incorporating an insulating media within the embankment.

Thick gravel embankments have been used in Alaska on numerous occasions to prevent thaw of permafrost soils. The required thickness of such gravel fills on the North Slope, range between about 5 feet near the coast and 7 feet near the Brooks Range. The thickness of such fills is designed to be greater than the annual thaw depth. The depth of annual thaw is a function of numerous conditions, including the local climate and the thermal properties of the fill material. Thawing induced by the fill cannot be fully contained within the fill itself. Some thaw beneath the outside edges of the fill is to be expected because of the lesser fill thicknesses at the toe of the slopes. This normally leads to settlement of the edges of the fill accompanied by some slumping and perhaps ponding of water at the toe.

As an alternative to thick fill embankments thermo-insulating media has been used within embankments in Alaska for many years. By incorporating a thin layer of material which is a very good insulator, the overall thickness of fill can be substantially reduced, and the depth of annual thaw still contained within the embankment except, as noted previously, at the toes.

An insulated embankment cross section is presented in Figure No. 2. In the typical case, a thin leveling course is placed over the existing ground to provide a flat and smooth surface on which the insulation is placed.

The insulation is then covered by another lift of fill. This second lift of fill serves two functions. First, it keeps the insulation in place so it will not move or blow away. Secondly, it protects the insulation from crushing or other damage by distributing surface loading over a large area.

The decision whether to use a thick embankment or an insulated embankment is affected by both environmental and economic factors. Depending on circumstances, either type can be environmentally superior and either can be the less expensive alternative.

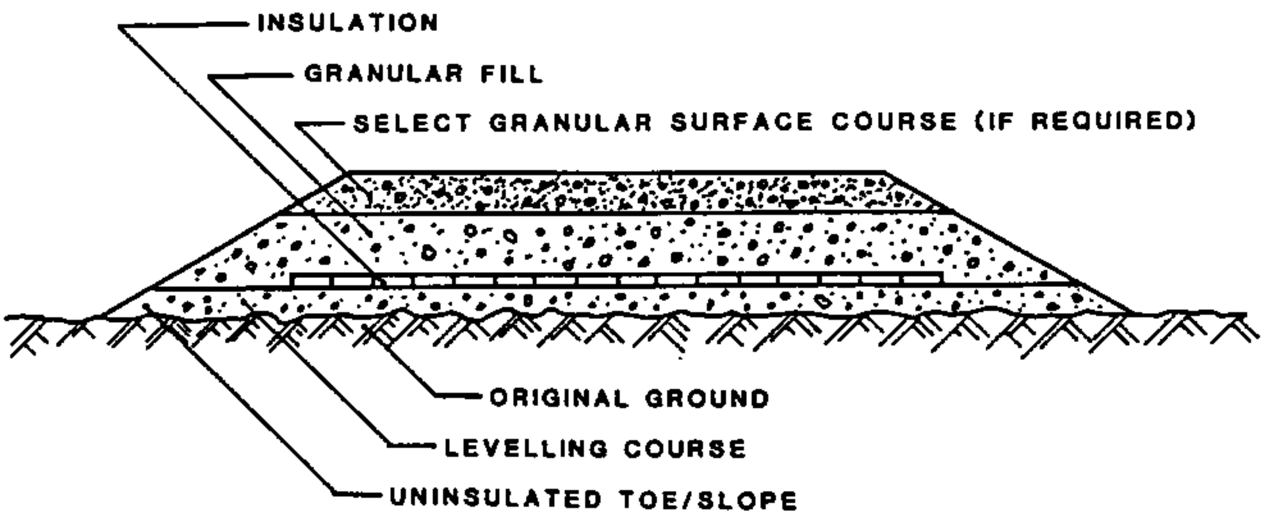

FIGURE NO. 2. TYPICAL INSULATED EMBANKMENT

In the case of runway construction, use of an insulated embankment is more environmentally acceptable than a thick fill because of the reduction in the required quantity of material. Construction of a 2-foot-thick insulated gravel runway, 170 feet wide and 5200 feet long, requires approximately 70,000 cubic yards of fill. By comparison, a similarly sized 5-foot-thick runway requires approximately 180,000 cubic yards of fill and, if 7 feet thick, requires about 260,000 cubic yards. By substantially reducing the quantity of borrow material which must be mined, a reduction in environmental disturbance can be realized. This is particularly beneficial in remote areas where borrow sites usually occur in previously undisturbed areas. Occasionally, however, use of synthetic insulation within an embankment is less environmentally acceptable than constructing a thicker fill section. This was the case at one wellsite constructed by Husky in the NPRA. At the J. W. Dalton Test Well No. 1 site, the drilling pad was located within several hundred feet of the Beaufort Sea coastline, in an area characterized by a receding shoreline. At this location, the risk that the receding shore would eventually reach the drilling pad was high. If this were to occur, erosion of the pad itself would uncover the insulation and result in its pollution of the surrounding area. It was decided, therefore, to use a thicker fill section instead of an insulated fill at the Dalton wellsite. From an environmental standpoint, keeping the insulation contained within the fill over the long term is a concern regardless of the location. This results in essentially permanent facilities.

In addition to these environmental issues, economic factors are also considered in selecting between the use of a thick or insulated fill. In conjunction with a direct comparison of the cost of the insulation (in place) with the cost of the extra gravel required for the thick design, several other factors should be considered. Speed of construction is one such factor. In most cases, several inches of insulation can be placed more quickly than several feet of gravel. This results in a reduction of support and other indirect job costs. For fills constructed during the winter, spring maintenance costs are also reduced by use of an insulated design because the insulation limits thaw to the surface course and, by decoupling it from the cold ground, allows it to thaw quickly. It can, therefore, be completely compacted and stabilized while the thaw in an uninsulated fill is still progressing.

For the Tunalik wellsite, the choice was not clear cut. It was decided, however, that because the available fill material was only marginally thaw stable that the amount of thaw should be minimized and it would be best to proceed with development of an insulated design. Styrofoam insulation manufactured by Dow Chemical Co. was chosen for use at Tunalik. This material was readily available in the large quantities required and was known to have performed satisfactorily on other projects in Alaska. Styrofoam is commonly manufactured in 2-foot-wide by 8-foot-long boards of varing thickness although other sizes are available. The boards are also manufactured in various grades corresponding to the insulation's mechanical strength. Two standard grades, called HI-60 and HI-35, were selected for use at Tunalik. The HI-60, a grade which will not be crushed to less than 90% of its original thickness by loads equal to 60 psi, was selected for use in the airfield. The HI-35, which could only withstand a load of 35 psi without being crushed to less than 90% of its original thickness, was selected for use in the road and drilling pad.

The final layout of the Tunalik wellsite is presented in Figure No. 3. The all-season facilities consisted of the drilling pad including fuel, reserve and flare pits, an airstrip consisting of a runway, taxiway and aircraft apron, and an access road connecting the pad and airstrip. Temporary facilities used to support construction of the all-season facilities, included two ice airstrips and a series of 32-foot-wide ice roads totalling about 8 miles in length.

Many of the design details discussed in the following sections of this report were developed with the assistance of the U. S. Army Cold Regions Research and Engineering Laboratory (CRREL). CRREL was retained by the USGS to assist as a consultant. Additional assistance was provided by the U. S. Army Engineer Waterways Experiment Station, also under an agreement with the USGS.

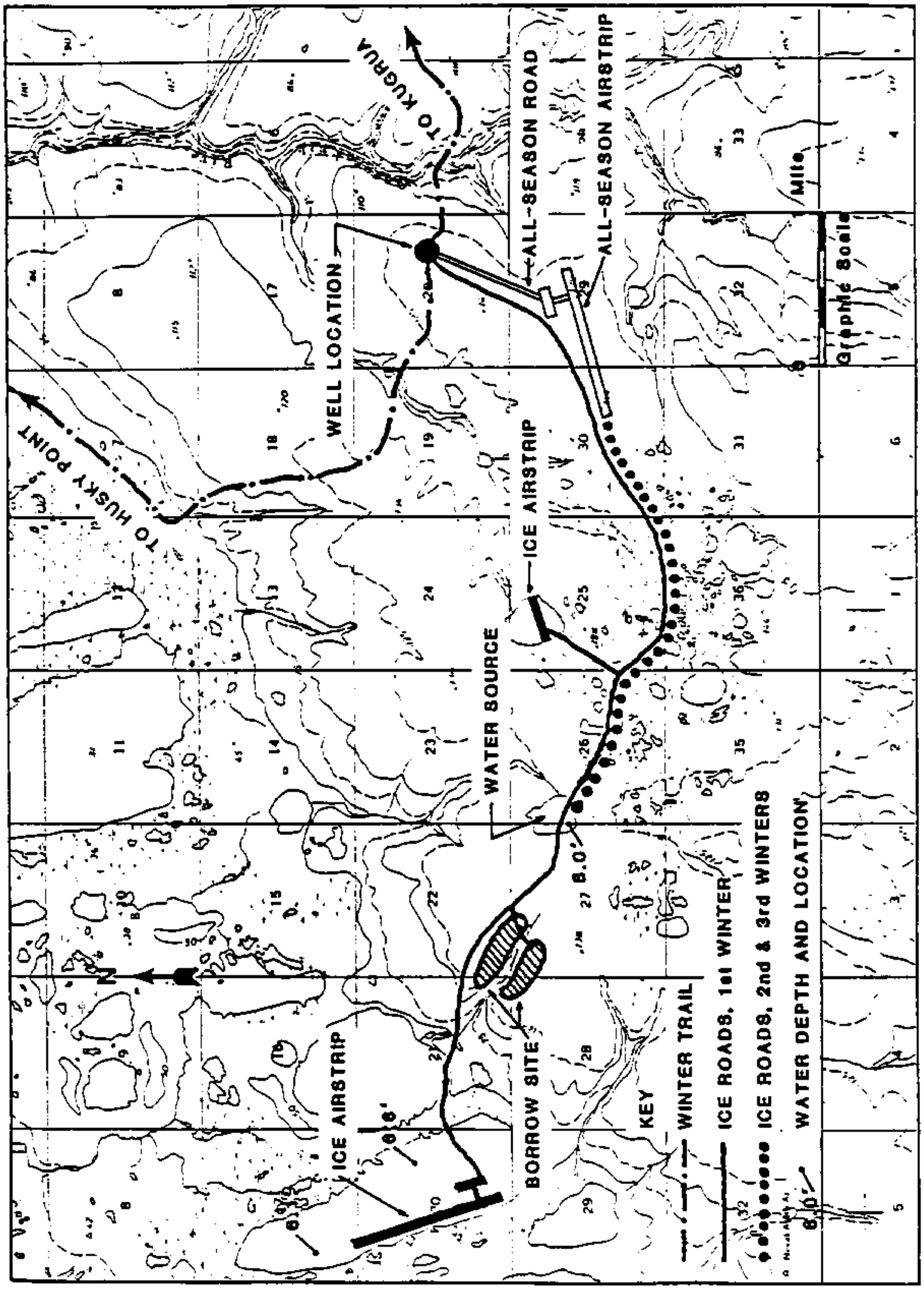

FIGURE NO. 3. LAYOUT OF TUNALIK WELLSITE

The Tunalik drilling pad was designed to accommodate the drilling rig, drilling camp, materials storage, operation of support equipment and to provide containment for fuel, spent drilling fluids and the safe burning of any hydrocarbons produced during testing. Husky's Drilling Department requested that the pad have a flat surface of about 300,000 square feet. In addition, they estimated that approximately 4 million gallons of water and spent drilling fluids would be discharged into the reserve pit. Project stipulations required that this volume be contained within the excavated portion of the reserve pit. Project stipulations also required that bulk fuel storage be contained in a diked and lined enclosure capable of holding 150% of the maximum amount of fuel stored, or within double wall fuel tanks. Since fuel bladders were proposed for use at Tunalik, a fuel pit was included in the pad design. The pad design also included a flare pit to facilitate the safe and environmentally acceptable burning of any hydrocarbons produced during well tests.

The layout of the Tunalik drilling pad is presented in Figure No. 4. The drilling rig, Parco No. 95, was supported by 200 slurried-in-place wood piles. Most of the piles were installed to a depth of 25 feet below finished grade. The 17 piles closest to the well bore were set to a depth of about 45 feet below finished grade.

Drilling operations generate a large amount of heat. Several steps were taken to assure that the drilling rig would be adequately supported for the entire drilling period. Hot fluids circulating within the well are a primary source of heat and can melt the permafrost soils. Design details were developed to minimize the effect of this heat source on the piles supporting the drilling rig. As previously noted, those piles closest to the well were installed to deeper depths than the remaining piles. Heavy steel beams were used to span between these deep set piling to distribute the load to adjacent piles if one began to settle because of thawing of the permafrost. In other areas, 12-inch x 12-inch timbers were used to span between the piles and support the rig. A 6-inch-thickness of Styrofoam insulation was applied to the sides and bottom of the cellar box. A 6-inch-thick layer of insulation was also applied on the outside of the conductor pipe to a depth of 45 feet below the floor of the cellar box. The purpose of this insulation was to retard radial heat flow from the wellbore.

Other heat sources associated with the drilling rig are its engines, generators and the large quantities of water which are used to wash the rig floors and drilling pipe. To retard heat flow into the permafrost from these sources, a 6-inch-thick layer of Styrofoam insulation was used under the rig. This insulation was composed of three layers of 2-inch-thick insulation boards buried about 2 feet below the pad surface. The insulation was placed at a 2% slope and covered with an impermeable plastic liner to direct the flow of water towards the reserve pit.

As can be seen in Figure No. 4, synthetic insulation was only used in the pad under the rig, the camp area and the primary operation areas for equipment. Except for under the drilling camp, the insulation was protected from crushing by covering the insulation with 2 feet of granular fill. Loads imposed on the surface insulation under the camp were

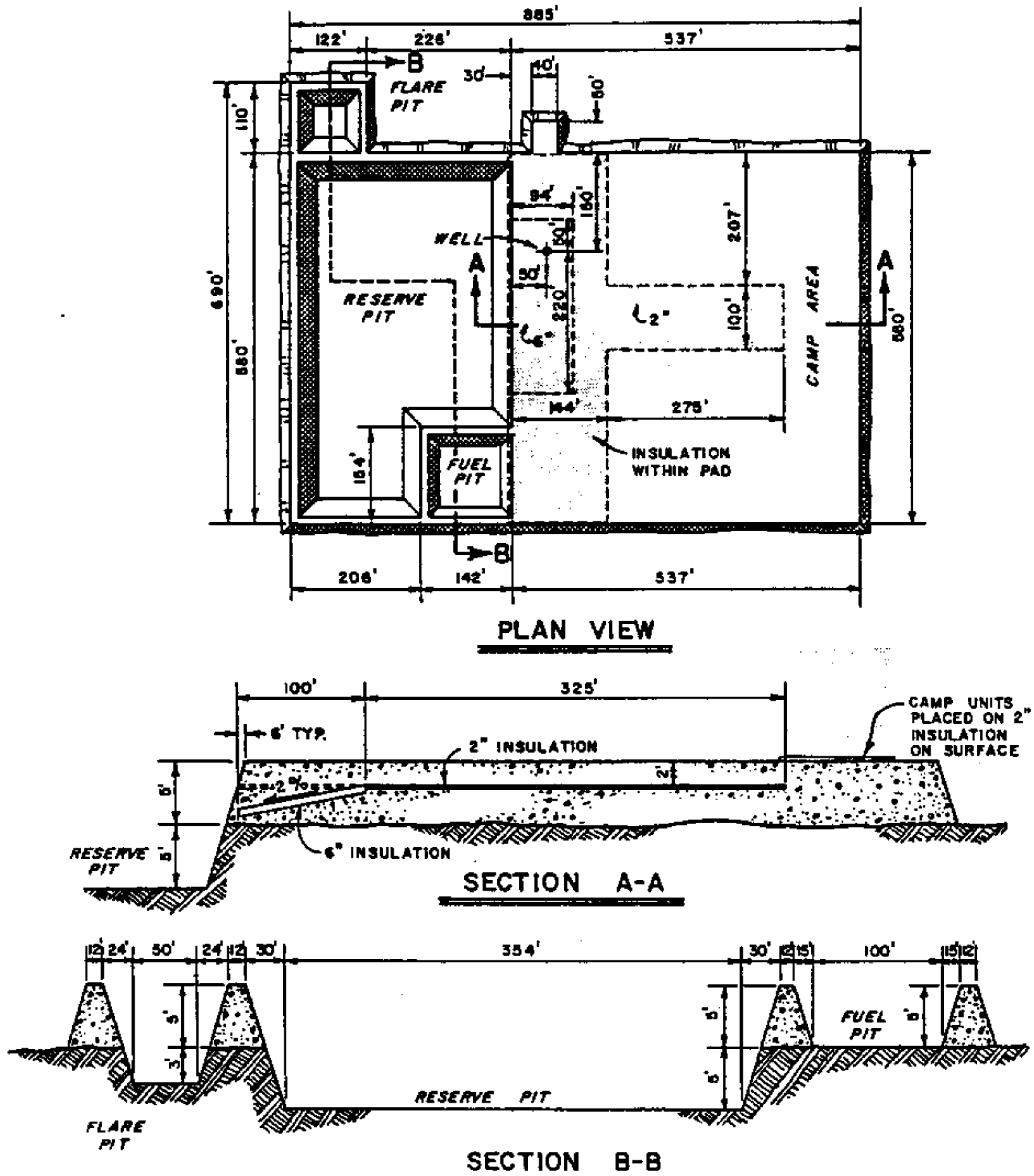

FIGURE NO. 4. TUNALIK DRILLING PAD

distributed over the insulation by use of timbers. Finally, the majority of the pad fill was obtained from the reserve pit excavation. The upper layer of fill was obtained from the borrow source.

DESIGN DETAILS - AIRSTRIP

The airstrip was considered the most critical aspect of the entire site design. It was essential that the airstrip remained operational throughout the summer so that drilling operations could continue uninterrupted.

The runway, taxiway and apron were laid out as shown in Figure No. 5. The runway alignment was oriented in a northeast-southwest direction roughly parallel to the prevailing wind direction. Material obtained from a borrow site approximately 5 miles west of the airstrip was used as fill for the lower portion of the runway and for the all-season access road. A 2-inch thickness of Styrofoam insulation was used to keep the airstrip subgrade fill frozen throughout the summer. The total thickness was made up of a single layer of 2-inch-thick board stock, placed so that all joints were tight. The insulation, placed 18 inches below the final surface elevations, sloped down to the northeast at less than a 0.5% grade. To promote drainage of the surface courses, the insulation also sloped away from the runway centerline at a 1.5% grade. The insulated portion of the runway was 158 feet wide and 5,050 feet long. Plans called for an additional 21 feet of uninsulated shoulder on each side of the runway and 200-foot-long overruns at each end of the runway.

The insulation was first to be covered with an impermeable plastic sheeting and then a 12-inch-thick layer of thaw-stable gravel. Finally a 6-inch-thick surface course of thaw-stable gravel was to be placed and compacted.

A compromise, designed to both reduce cost and risk, was reached in regard to the relative thickness of the insulation and its gravel covering. A thermal analysis performed by CRREL indicated that 2 inches of insulation was the minimum required to prevent thaw of the underlying soils, except near the end of an unusually warm summer. The use of 2½ or 3 inches of insulation would be more conservative. In addition, studies performed at the Waterways Experimental Station (WES) indicated that some crushing of the insulation might occur because of aircraft wheel loads if the thickness of the gravel surface course was less than 18 inches. At Tunalik, it was decided, based on the estimated costs of the insulation and gravel, to use the 2 inch minimum insulation thickness and a full 18-inch gravel thickness. At Tunalik the gravel haul was from a source about 5 miles distant. By comparison, at the Inigok wellsite, being designed at the same time and for which both CRREL and WES made identical recommendations, it was decided to use 3 inches of insulation and only 15 inches of cover. At Inigok, the thaw-stable cover gravel had to be hauled 38 miles to the site. This made it cost effective to increase the insulation thickness and reduce the quantity of gravel cover required. The extra insulation thickness at Inigok left some allowance for any crushing of the Styrofoam which might be caused by a combination of heavy traffic loads and thin gravel cover.

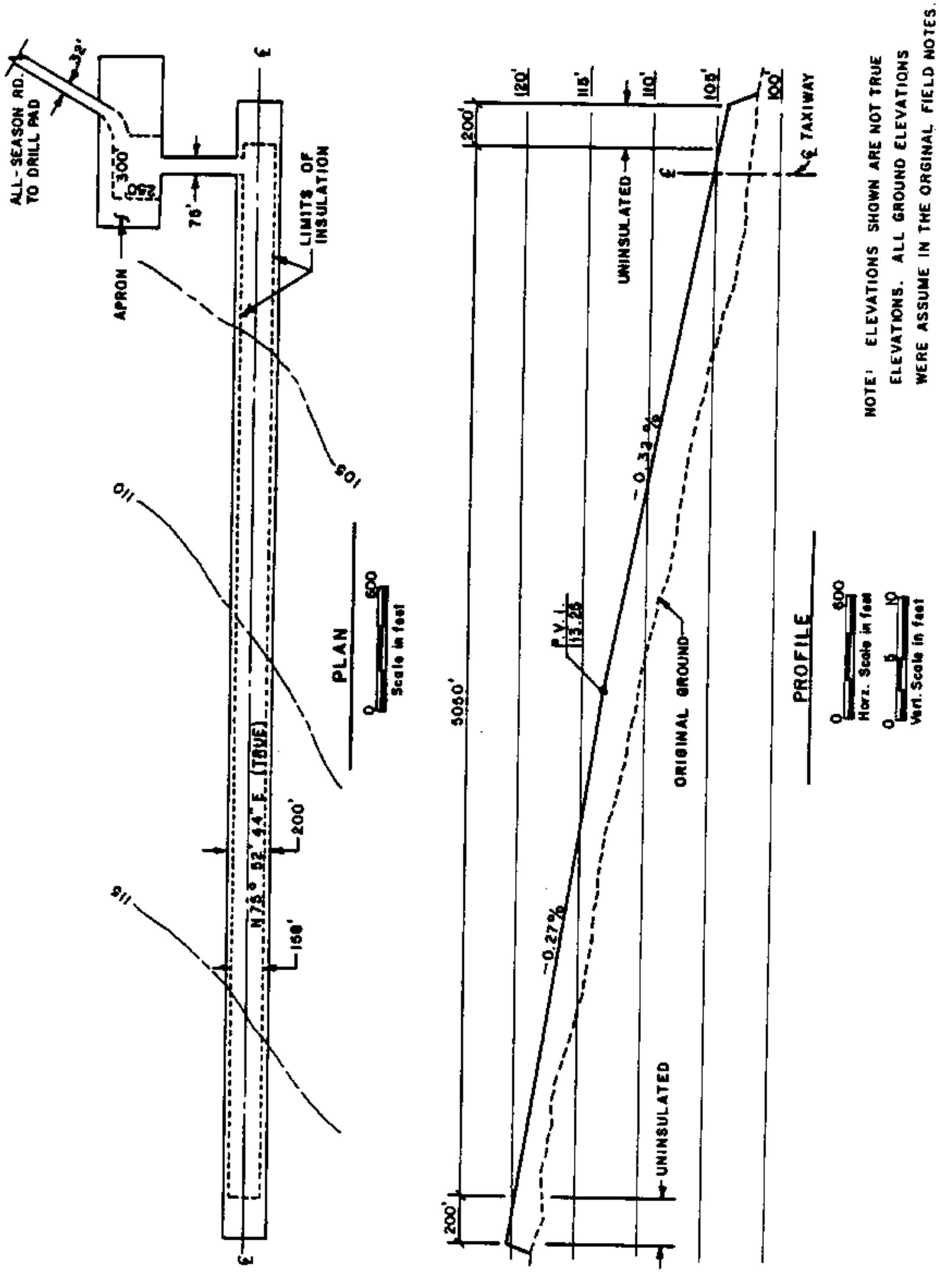

FIGURE NO. 5. TUNALIK ALL-SEASON AIRSTRIP

The same basic runway design was used for the taxiway and central portion of the aircraft parking apron. The taxiway was 400 feet long and only 75 feet wide. The entire parking and storage apron measured 820 feet by 300 feet. Only the central 250-foot by 300-foot section adjacent to the taxiway was insulated.

The design also called for installation of a runway lighting system. The system included edge, threshold and taxiway lights, runway end illumination lights (REIL), and vertical angle slope indicator lights (VASI). Equipment installed included a non-directional radio navigation beacon, and a weather shack to accommodate an airport manager who also was a certified weather observer. A generator was provided to power all airport electrical systems.

DESIGN DETAILS - ROAD

An all-season road was required to connect the drilling pad with the airstrip. The road design was similar to but less conservative than the airstrip design. The finished design called for the road to have a 32-foot top width and to be about 3/4-mile long. The subgrade, to be constructed of the locally available sandy fill, was varied in thickness to provide a relatively uniform grade and shape. The subgrade was to be covered with a single 2-inch thickness of Styrofoam insulation which was in turn to be covered with a 15-inch thickness of pit run material and a 6-inch thick select surface course. A weaker and less expensive grade of Styrofoam was specified for the road than for the airstrip.

SITE CONSTRUCTION

During early September 1977, two Arctic Slope/Alaska General (AS/AG) Cat-trains were transported by barge to an abandoned DEW-Line site named LIZ-C. This coastal site, approximately 51 miles southwest of Barrow, was to be the staging area for construction of four wellsites during the winter of 1977-1978. These sites were South Meade Test Well No. 1, Kugrua Test Well No. 1, Maguriak Test Well No. 1 and Tunalik Test Well No. 1. Maguriak was subsequently dropped from the program. It was then planned that each Cat-train would be used to construct one site and then proceed to Tunalik where both trains would be used.

One of the two Cat-trains, called "F-train", completed work at the Kugrua wellsite in early January 1978 and began preparations for the 71-mile overland mobilization to Tunalik. "C-train", the second Cat-train, completed construction of the South Meade site in early January and was mobilized 51 miles overland to Kugrua, arriving there on January 11, 1978.

On January 5, 1978, prior to departure of either construction train, a 10-man crew and some equipment departed Kugrua and began the move to Tunalik. The purpose of this advance train was to establish a safe crossing of the Kuk River for the main construction trains. The vicinity of the Kuk River crossing is shown in Fig. 6. What is called the Kuk River is in reality a large tidal inlet which extends approximately 36 miles inland from the Chukchi Sea at Wainwright and is between 2 and 3 miles wide for most of its length. The site selected for the crossing included several islands which substantially reduced the over-ice length of the trail to traverse the river.

This advance crew arrived at the crossing on January 7, and found the brackish natural ice ranging between 3 and 4 feet in thickness. This thickness was judged to be insufficient to safely support the heavier units of the main Cat-trains and preparations were made to spread fresh water over the existing ice to increase its thickness. A layer of wooden timbers were incorporated in the fresh water ice to increase its strength. Work began by clearing a 2,000-foot-long ice airstrip on a nearby lake so that the crew could be resupplied with food and fuel by fixed wing aircraft.

Work on the crossing was severely hampered by the weather. High velocity winds and blowing snow restricted the crews ability to make significant progress. In addition, above zero temperatures slowed the rate at which the ice thickness could be artificially increased.

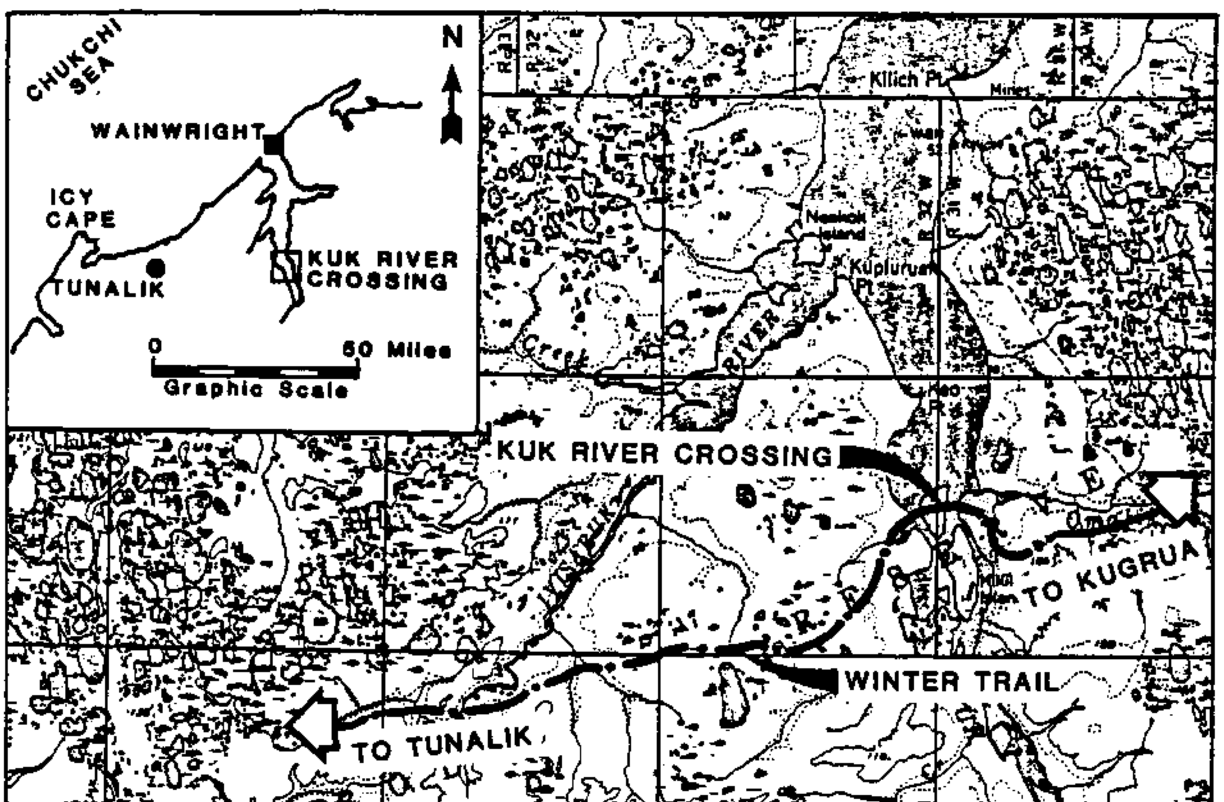

FIGURE NO. 6. KUK RIVER CROSSING

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C-train left Kugrua on January 12 and arrived at the Kuk River on January 15 to assist in the construction of the ice bridge. With the crossing construction nearing completion, F-train departed Kugrua on January 29 and C-train crossed the river the following day. F-train crossed the river on February 3, 1978 and both trains were at the Tunalik wellsite by February 4, 1978.

During the first week of construction efforts were concentrated on the ice roads and ice airstrips. A 150-foot-wide and 5,000-foot-long ice runway was cleared near the western shore of a 2-mile-long lake located about 6.5 miles west of the wellsite. This ice airstrip was designed to accommodate large aircraft such as the C-130 Hercules which would provide the heavy airlift support to the construction site. A shorter, 150-foot by 2,000-foot runway was also constructed. This runway, called the "Otter Strip" because it was to be primarily used by Twin Otter type aircraft, was located on a lake about 2.5 miles west of the well location. A Twin Otter aircraft was stationed at Tunalik to provide transportation during medical emergencies and to assist in the regular transportation of materials and personnel.

By mid-February, the ice airstrips were operational. Work had also begun on the reserve pit and borrow pit excavations. The ice roads were usable and the first loads of borrow material had been hauled from the borrow site to the all-season runway.

Activity at Tunalik peaked during March. Throughout the month approximately 150 people were on-site. In addition to the personnel employed by AS/AG, the prime construction subcontractor, the site population included several other subcontractors. These other contractors included an engineering/surveying firm which provided two 4-person survey crews and up to eight site inspectors, a transportation contractor which provided aircrews for the site's aircraft, and the runway operation contract which provided two airport manager/weather observers. The crews completed construction of the runway base course and began placement of the insulation and its gravel cover on March 11, 1978. By the end of March the site was reporting the following completion percentages:

Mobilization	100%
All-season Airstrip	74% overall
Airstrip Insulation	89%
All-season Road	58%
All-season Pad	91% overall
Reserve Pit	99%
Rig-support Piling	75%

The all-season airstrip construction was completed on April 16, 1978 except for stabiliation and compaction. The best borrow material available had been used as the fill over the airstrip insulation since satisfactory performance of the airfield was critical. Material of lesser quality, but the best remaining, was used to cover the road and pad insulation. Road construction was completed on April 25 and all site construction was essentially completed by the first of May.

On May 4 and 5, 1978, one of the two Tunalik construction Cat-trains (F-train) was mobilized overland from the wellsite to "Husky Point", a previously unnamed point of land on Kasegaluk Lagoon approximately 2 miles southwest of Nokotlak Point. This staging area, 7 miles north of Tunalik, was used to further demobilize F-train by barge during the summer and as a barge unloading point for the drilling rig.

By May 7, 1978 most of C-train had also been demobilized. That portion demobilized was transported by C-130 Hercules aircraft to the Lake Betty staging area approximately 163 miles southeast of Tunalik. This was in preparation for construction of another wellsite the following winter. That portion of C-train left behind at Tunalik was used to house and support a small maintenance crew engaged in site cleanup and stabilization of the pad, road and airstrip.

DRILLING

It was originally planned that Parker Rig 95, a National 130 would complete drilling Kugrua Test Well No. 1 in the spring of 1978 and be mobilized by air to Tunalik in early May. Because of difficult drilling conditions, however, the Kugrua well was not completed until May 29, 1978, one week after Kugrua's ice airstrip was declared unusable because of warm weather. Since the rig could no longer be airlifted to Tunalik it was moved by Catco Rolligon to LIZ-C on the coast and prepared for barge transport to Husky Point during the summer. The barge move was accomplished during the first week of September and the drilling rig, camp and support equipment was moved to the wellsite by Rolligons during the period between October 11 and 21, 1978.

Throughout the summer a small construction crew had been working at Tunalik compacting and stabilizing the runway, road and pad surfaces. In late October, additional construction personnel were brought to the site and construction of a 3-mile-long ice road to a 8 foot deep winter water source lake was started. This construction was completed during the second week of November and the Tunalik well was spudded on November 10, 1978. During February 1979, the construction equipment still at Tunalik was airlifted to Lake Betty and rejoined C-train.

During the month of April 1979, while drilling at approximately 12,550-feet the Tunalik well encountered high pressure fluids which began to flow into the well. Conventional well control procedures were complicated by heavy sloughing of the open hole. Attempts to control the well continued throughout April and May. Full control was finally established and drilling resumed on June 13, 1979. Sixty-five days had been spent controlling the well.

Drilling reached a total depth of 20,335 feet. After testing and abandonment procedures the drilling rig was released on January 7, 1980. A total of 424 days of drilling had been required. The drilling rig was then disassembled and prepared for air transport to another well location. The rig move, requiring 152 C-130 Hercules loads was completed on February 12, 1980 and the Tunalik site was vacated. The Tunalik wellsite facilities, particularly the all-season airstrip, continue to be used as a staging point for additional operations in the area.

SUMMARY AND CONCLUSION

An all-season airstrip, all-season drilling pad and an all-season connecting road were constructed during the winter of 1977-1978 to support year-round drilling operations at Tunalik Test Well No. 1. The design of these facilities incorporated the use of Styrofoam insulation which reduced the quantity of thaw-stable granular material required for the construction work. In order to support winter construction of the facilities, two ice airstrips and approximately 8 miles of ice roads were constructed. During the winters of 1978-79 and 1979-80, 3 miles of ice road were constructed each winter to provide the drillers with access to a suitable winter water source lake. The cost of constructing the all-season facilities approached $15,000,000. Approximately $1,100,000 of this total was for the purchase and delivery of the Styrofoam insulation.

Although circumstances will vary from location to location and from well to well, it is believed that the construction of all-season facilities at the Tunalik location was justified when compared to multi-winter drilling. In hindsight, because of the well control problems which were encountered, it is estimated that four winters would have been required to complete this well on a multi-winter basis. It is also noted that the well control problem occurred in the spring and was not resolved until after an ice airstrip would have become unserviceable, which would have complicated a difficult and potentially dangerous situation. It is, of course, impossible to know if problems would have been encountered reentering the Tunalik well if it had been drilled on a multi-winter schedule.

An additional advantage gained by construction of this all-season site was continued access to the remote area with fixed wing aircraft. The Tunalik runway and apron provided a logistics support point for numerous summer and winter programs after drilling was completed. The costs of these programs were reduced by the transfer of supplies to the site by fixed wing aircraft instead of helicopters.

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9. Husky Oil NPR Operations, Inc., On-Tundra Ice Airstrips, Prepared by Dennis W. Mitchell, Anchorage, Alaska, 1983

OTHER REFERENCES

10. Burns, Cecil D., Traffic Tests of Expedient Airfield Construction Concepts for Possible Application in the National Petroleum Reserve Alaska (NPRA), Technical Report GL-79-2, Waterways Experimental Station, Vicksburg, Mississippi, 1979.

APPENDIX I

TUNALIK CONSTRUCTION CONTRACTOR EQUIPMENT INVENTORY

36	each	Construction Camp Trailers (sleepers, wash houses, kitchen/dining, office and generator units)
10	each	Caterpillar Tractors
6	each	Loaders
14	each	End Dump Trucks with Trailers
7	each	Delta All-terrain Vehicles
2	each	Tucker Sno-cats
10	each	Pickups/Carryalls
2	each	Graders
3	each	Water/Fuel Tankers