3.9 IGRUGAIVIK

3.9.1 Location and Site Description – Igrugaivik

This site is situated adjacent to the Kiniktuuraq site, lying inland about half a mile from the northwest edge of the Kiniktuuraq. It is located approximately 2 miles east of the existing Kivalina site. The site is bounded on the west by the main channel of the Wulik River, and by sloughs or ponds on the south and north sides.

The site is essentially flat in two abutting areas with a surface differential of about 3 ft. Reference the geotechnical report for a complete description of the site.

This site is very similar to the Kiniktuuraq site, dominated by low, arctic flora such as mosses, sedges and grass. The site does not have any trees or shrubs. Any site relief is marginal and strictly local. This site appears to be basically flat. The site features small tundra ponds scattered about its area, with a large pond located on the southeast corner and an elongated pond abutting the northwest side.

No ground truthing site visit was conducted under this contract. The material presented here is a compilation of data gathered from existing literature dating back to 1994.

3.9.2 Site Development – Igrugaivik

The fill depth over this site will vary depending on the type of subgrade soil it is placed on. We anticipate that gravel fill should be a minimum of 9 ft.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

Because the Wulik River flows past the north edge of the site, the face of the site fronting the river may have to be protected with armor rock to resist erosion from river flow.

Construction considerations for the Igrugaivik site can be referenced from R&M (2000 and 2002). Test borings were drilled in 1999 to investigate potential borrow material along the beach. Test borings were also drilled in 2002 to investigate potential borrow material underlying the Kivalina Lagoon.

R&M (2000 and 2002) states that foundation soils encountered were thaw-unstable, ice-rich fine-grained materials. Significant settlement should be expected if thawing occurs. Permafrost was encountered within all test borings. Many borings encountered considerable visible ice as stratified or distinctly oriented formations. Saline groundwater was encountered as far upstream along the Wulik River as the northwest portion of Igrugaivik.

R&M (2000 and 2002) suggests the use of pile foundations or a granular fill pad with a post-on-pad foundation to protect from settlement due to thawing of ice-rich soil. Post on pad foundation are for areas with little or no massive ice, and require periodic leveling. Another option would be insulated and/or refrigerated shallow foundations. This method is generally not used for ice-rich conditions and maintenance cost could be very high.

Roads within the site are recommended to have a 9 foot gravel thickness, while access roads may be 5 feet thick. R&M (2000 and 2002) states that embankments for roads and runways may also need to be protected from settlement due to permafrost degradation. An estimated embankment thickness of 9 feet may reduce the depth of thaw penetration into the ice-rich soil to nearly zero. Rigid board insulation or allowing for some settlement can reduce embankment thickness. The settlement would occur

mostly within the first few years of service. Culverts beneath the embankments are expected to settle due to permafrost degradation, and may need to be re-leveled periodically during the first few years of service. Insulation beneath the culverts may reduce the magnitude of settlement.

3.9.3 Infrastructure Development – Igrugaivik

3.9.3.1 Water – Igrugaivik

Based on the results of a geophysical survey conducted at the Igrugaivik site, Golder Associates (1997) found indications that a thaw bulb in floodplain and river terrace deposits near the bank of the Wulik River might provide an adequate year-round source of readily treatable groundwater. USACE (1998) proposed that a water supply system at this site consist of a well, pump house, water treatment building, relocation of an existing water storage tank from Kivalina, and an aboveground distribution system with forced circulation.

A test well drilled at the Igrugaivik site in May 2002, however, produced only saline groundwater. The saltwater was encountered in sand and gravel deposits at depths of 30 to 41 feet, which lay beneath a surficial permafrost layer (R&M 2002). R&M suggested the salts might be concentrating along the line of freezing/bonding at the edge of the permafrost. The source of the salt could be from a subsurface saltwater wedge effect, or from infiltration along the river during high tides or storm surges. Storm surge modeling indicates that maximum surge events can reach about 11 feet in elevation (1 foot above the highest elevation of the site) at Kivalina (USACE 1998). Further sampling of the river in various locations should be conducted to determine the extent of salt water intrusion. Additional test wells targeting potential thaw bulbs further up the river would need to be drilled in order to identify a non-saline supply of groundwater, with corresponding added costs for a longer piping distance. The location of any additional wells should take into account the inland reach of tides and storm surge.

The Igrugaivik site vicinity is covered by a number of small tundra ponds, none of which appear large enough to provide a sustainable surface water source. If a surface water source from the Wulik River were used for Igrugaivik, a collection, treatment, and distribution arrangement similar to the existing Kivalina site would be required. Water would be withdrawn through a hose and pipe transmission line placed in the river and pumped to a raw water storage tank. If the Wulik River could be tapped with an infiltration gallery year round, the transmission line would have to be heated with a glycol loop to avoid freezing.

If a year-round groundwater source is identified for Igrugaivik, R&M (2000 & 2002) and S&W (2004) suggest aboveground water utilities for the site, due to the potential for large differential settlement. The aboveground construction would thermally decouple the utilities from the subgrade and allow grade adjustments if necessary.

3.9.3.2 Wastewater – Igrugaivik

The unstable thaw conditions at the Kiniktuuraq site present a large problem for a sewage collection system.

Because of the flat terrain and permafrost at Igrugaivik, a vacuum collection system and above ground arctic pipe is recommended. USACE (1998) discusses that wastewater treatment could be accomplished by the development of a settlement lagoon at the 6 acre tundra pond near the proposed beach access road. Discharge of effluent after settlement of sludge could be directed to a

minor channel of the Wulik River by the pond.

Aboveground sewer utilities are suggested by R&M (2002) due to the potential for large differential settlement. Direct burial of settlement-sensitive gravity, pressure, or vacuum sewer systems might be risky due to the settlement potential.

R&M (2000 and 2002) mentions that massive ice wedges and large differential settlement would affect sewage lagoons. High lagoon dikes need to be constructed to account for settlement or periodically regraded as necessary to avoid causing a membrane liner to rupture. In an unlined lagoon, a piping type of failure could occur along lenses or wedges of massive ice. A sewage lagoon constructed with earthen dikes should be sited in an area without massive ice if possible, or a tundra pond could be used. Septic tanks and a package treatment plant would also eliminate some of the potential problems with a constructed lagoon.

USACE (1998) proposed a sludge disposal site by the road near the proposed sewage treatment lagoon.

3.9.3.3 Solid Waste – Igrugaivik

S&W (2004) assumed that the site is underlain by potentially highly thaw-unstable soils based on its 2004 site investigation. Since at least 9 feet of gravel would be required to preserve the thermal regime under the proposed town site, construction of a solid waste landfill would be difficult and expensive.

3.9.3.4 Fuel – Igrugaivik

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.9.3.5 Heating – Igrugaivik

The information in 3.2.7 Heating applies equally to all sites.

3.9.3.6 Electricity – Igrugaivik

The information in 3.2.8 Electricity applies equally to all sites.

3.9.4 Access – Igrugaivik

The Igrugaivik site, like the Simiq site, provides only one direct avenue of access. This site is surrounded by muskeg type soils that are saturated, thermally unstable and provide poor structural support for vehicles, including four-wheelers. Access from the main channel is the most direct access to the site.

A road will need to be constructed to provide year-round access to this site. The best route appears to be to the southwest along the Wulik River, across the Kiniktuuraq site to the sand spit on the south side of the Singauk Inlet near the river's mouth. While this one mile long route presents additional design problems over a straight route to the Chukchi Sea along a southwest course, it benefits from accessing the south end of the lagoon, where a protected barge landing can be constructed. Bridges would have to be constructed and culverts installed to cross channels and streams along the route. This is the same route as described in the USACE (1998) study. A total of 1.3 miles of road (west to the Singauk Entrance and east to a potential runway location) is required.

It is important to note that to stabilize the sand spit comprising the south side of the Singauk Inlet, the spit may have to be armored against wave and storm erosion on all sides.

We have not been able to discover any existing data regarding the depth of the south end of the lagoon. The action of the flow of the Wulik River in conjunction with the tidal influences on the Singauk Inlet

make the entrance to the lagoon and flow channels at the south end difficult to determine. To understand what engineering considerations are necessary at the south end of the lagoon, a study specific to the river and tide actions may have to be conducted if this site is selected as the preferred new village location.

It is possible for boats to navigate up the channel of the Wulik River to access the west side of the Igrugaivik site. This would provide an additional boat tie-up point near the village.

3.9.4.1 Access for Subsistence Activities – Igrugaivik

Access to the lagoon, rivers, and the Chukchi Sea for hunting sea mammals and fishing should be at the proposed barge landing site. The location of the site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible.

The 1 mile road from the northwest end of the site to the lagoon may allow foot and vehicle traffic to easily access the barge and boat staging pads and the lagoon.

Beach access from the Igrugaivik site may be either by foot or four-wheeler over the muskeg to the southwest of the site or by the road from the village pad to the south end of the lagoon, and then west to the south side of the Singauk Inlet. Access to the beach on the north side of the inlet may be by boat from the lagoon only.

Subsistence activities such as gathering berries and greens and small game hunting can be easily performed from the site by foot or on four-wheeler. The wet, unstable nature of the terrain may make travel by four-wheeler slow. The very high cost of constructing roads across the muskeg may require that roads from the village be limited to an access to the airstrip and solid waste dump facility and barge landing. It is anticipated that this road may be at least 1.3 miles long.

3.9.4.2 Goods & Supplies – Igrugaivik

A road to the beach is the most likely access to the barge landing. At the barge landing site, a one acre staging area should be constructed to enable loading and unloading of the barge. This staging area should allow the community to stage the materials and ferry them to the new village.

The location of an airstrip is unknown at this time. Additional information should be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. Until a suitable location is found, the community should use the existing airstrip and ferry goods across the lagoon to utilize the new village access road.

The USACE (1998) study describes a 4,000 ft long runway site northwest of the site. No distance is given, but for the purposes of a cost estimate for this study we have located it about 1 mile east of the east end of the site. If the solid waste dumpsite is located along the gravel road to the barge landing, it should easily be outside the 10,000 ft runway exclusion zone (see Figure 12).

3.9.4.3 Air Transportation – Igrugaivik

The December, 1997 letter from ADOT&PF to Dr. Orson Smith, USACE Project Manager regarding location and logistics for a new runway indicates that ADOT&PF feels the Igrugaivik site has moderate ability to support a new airstrip. The letter cites ice-rich soils, potential foundation degradation, possible river erosion and heavy reliance on river resources for foundation material.

Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. For the purposes of this study,

we have selected a location approximately 1 mile east of the site on a low ridge. A new airport should be constructed prior to occupancy of the new village site. Refer to Section 3.1 for general recommendations.

3.9.4.4 Roads & Streets within Community – Igrugaivik

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The poor soil conditions and unstable thermal regime of the Igrugaivik site may necessitate the construction of a thick gravel pad to protect the existing conditions. This pad should also serve to raise the new village above the level of the anticipated storm surge.

3.9.4.5 Roads Outside the Community – Igrugaivik

The location of the Igrugaivik site and the soil conditions of the terrain surrounding it make road construction difficult and expensive. It is anticipated that there should be as few roads as possible outside the village to access the new airstrip, solid waste facility and lagoon boat moorage area. Preferably, two or more of these facilities should be located along the same road, to reduce the amount of road development necessary. A total of 2.3 miles of road outside the village proper is assumed for this site.

3.9.5 Native Allotments

There are no Native allotments in the immediate vicinity of the Igrugaivik townsite (see Figure 14). However, there is a Native allotment to the south of a potential sewage treatment plant.

3.9.6 Relocation Costs – Igrugaivik

Design and construction administration are not included in the construction cost estimate. The cost estimate to build a new village site at Igrugaivik is **$246.1 million**. Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$164,800,000
Erosion Protection	$1,045,440
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$20,521,057
Transportation System	N/A
Total Cost	**$246,100,000**

3.9.7 Recommended Plan for Igrugaivik

The Igrugaivik Site is the southernmost of the three village sites on the south side of the Singauk Entrance. It is located south of the Kiniktuuraq site and is accessible to the Wulik River by a side slough.

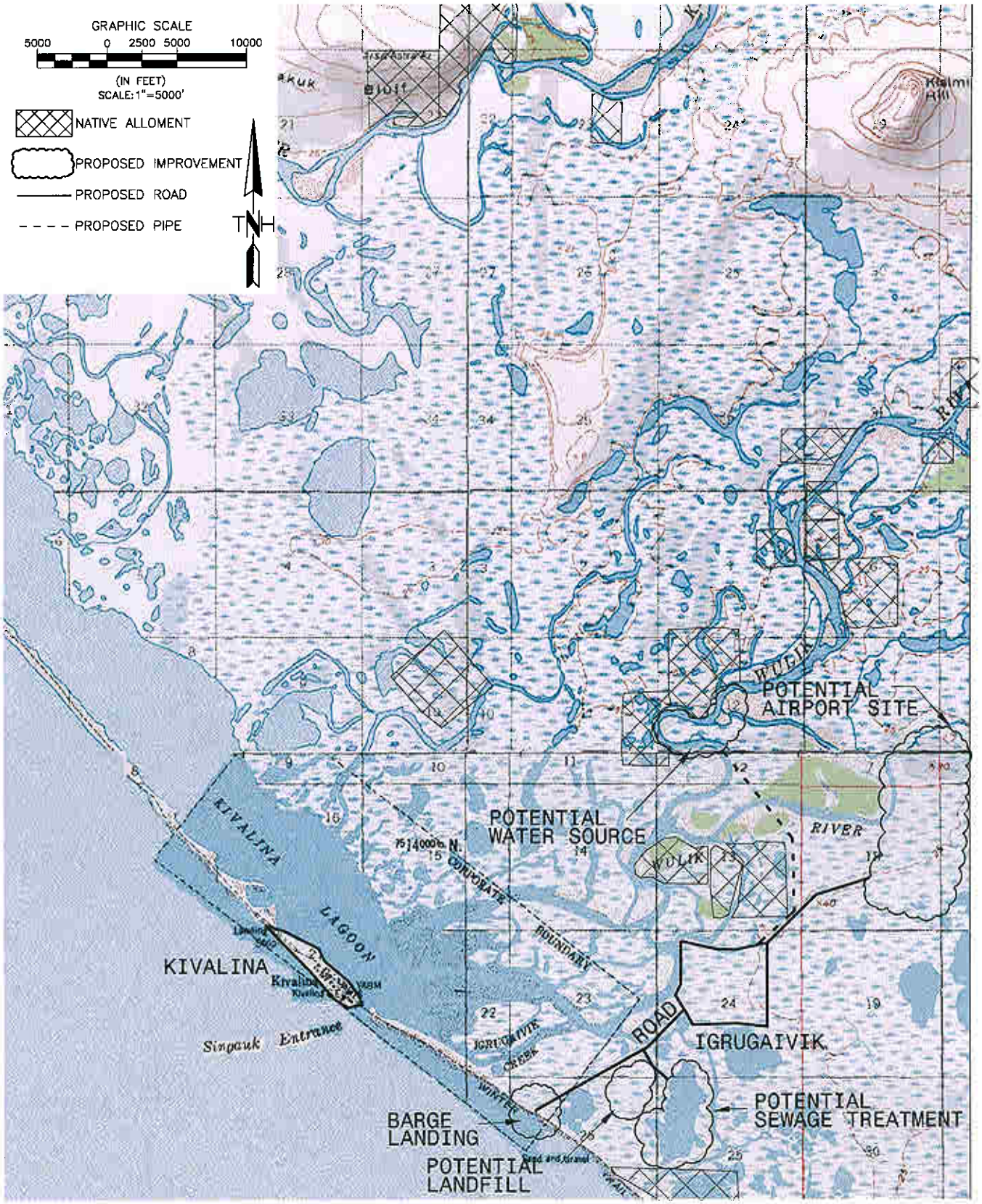
The new runway for the village site at Igrugaivik may be located about at the same location as described for the Kiniktuuraq Site. It is about 1 mile west of the proposed Igrugaivik Site. It is anticipated that this area may provide a poor subgrade on which to base the 150 ft X 4,000 ft runway, and a geofabric base may be required to provide support and separation for the muskeg

below. The short length of village to runway road and the close routing of the barge landing to village road mean that siting the landfill along either may be difficult.

Siting the landfill at the same location proposed for the Kiniktuuraq Site, on the base of the gravel spit, adjacent to the dredged channel should provide the required separation from the new runway, as well as a close location to the village for ease of use and to the barge landing for transport of recyclable materials, batteries and hazmat for shipping.

The most likely raw water source for the Igrugaivik Site is the Wulik River. Potential sources of raw water will be investigated in the water study that is currently pending publication. There are no other known sources of water in the Igrugaivik Site area. It is anticipated that a raw water intake structure should be constructed in a thaw bulb, to furnish a year round water supply.

The sewage lagoon should be located south of the town site to allow surface discharge to flow southward, away from the proposed village pad. A surface discharge should be established to dispose of the treated lagoon effluent onto the surrounding wetlands.



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LAYER MGR: *.lay CTB FILE: *.ctb

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TRYCK NYMAN HAYES, INC.
911 W. 8TH AVENUE, SUITE 300
ANCHORAGE, AK 99501-3497
TEL: (907)279-0543 • FAX: (907)276-7979

FIGURE 14

IGRUGAIVIK CONCEPTUAL LAYOUT

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: JT	PROJECT No: 03003.007
SCALE: 1" = 5000'	REV. –
CAD DWG FILE:	
FIELD BOOK: –	SHEET 1 OF 1
GRID: –	