Appendix T

Tunnel Report

Ketchikan Gravina Island Access

Peninsula Point Tunnel Report

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1 Executive Summary

The first significant tunnel for vehicular traffic (horse and carriage) was completed in 1897 under the Thames River in London. The first immersed tube highway tunnel was built in 1910 linking Detroit, Michigan with Windsor, Canada. Since the beginning of the last century, more than 100 immersed tunnels worldwide (25 in the US) have been constructed as individual steel or concrete float-in structural segments, and then sunk, covered, and connected for the road or rail crossings.

The possibility of installing a roadway tunnel under Tongass Narrows does have some real advantages for the community of Ketchikan. Firstly, it will not impact any of the aviation operations that are going on in the area, both now and in the future. Secondly, it removes what some may consider a visual detriment along the local skyline.

It does appear however, that although the costs to construct this facility may be competitive with a bridge structure, they may be in fact even more when long term operating costs are factored into the totals. Construction of an immersed tube highway tunnel between Peninsula Point on Revilla Island and Lewis Point on Gravina Island is estimated to be $400,000,000, with an annual operating expense of about $2,000,000. In all fairness, a narrower tunnel section can be provided in the neighborhood of $300,000,000, but the driver comfort will probably be significantly reduced, especially beyond the design year capacity.

A significant concern with this alternative is the amount of fill placed within the Tongass Narrows, reducing the channel opening by about half at low tide. While this is not a major hydraulic problem, the resource agencies will probably want to have more information before permits could be issued.

A more serious concern is that in order to maintain a maximum grade of 6 percent, the navigational trackline of the cruise ships will have to move to the Alaska Marine Highway trackline. This may not be an easy task since it is believed that their current alignment is predicated on shallower water on the west side of the channel beyond the proposed tunnel crossing.

In conclusion, it is believed that with further investigation, a site may be found that could meet the various constraints, but it may also result in a tunnel of extended length such that the costs will be significantly more than a bridge structure.

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2 Introduction

The current level of available project funding is insufficient to complete construction of the preferred Gravina Island bridge access Alternative F1. The likelihood of a sizeable supplement ($195 mil) anytime in the near or foreseeable future is doubtful. For these reasons, the Department is compelled to investigate all feasible transportation alternatives that could accomplish the basic purpose and need of the project, including past alternatives and explore possibly new or hybrid ones. They have been directed to take a more comprehensive look into the feasibility of a submerged tube concept at or near the area of Peninsula Point on Revilla Island and crossing Tongass Narrows to Gravina Island.

The potential tunnel crossing of Tongass Narrows is located about 2.5 miles roadway north of the Ketchikan International Airport terminal, between Lewis Point on Gravina Island and Peninsula Point on Revilla Island, a water distance of almost three-quarters of a mile, and appears to provide a location where grades and ship channel clearance could be met.

2.1 Project Location

Located near the bottom of the southeast Alaska panhandle, the City of Ketchikan is 235 miles south of Juneau and about 680 miles north of Seattle. In addition to the City, the Ketchikan Gateway Borough encompasses two major islands, Revillagigedo Island and Gravina Island. Tongass Narrows separates these islands, with Revilla Island northeast and Gravina Island southwest of the waterway. Extending from Nicholas Passage to Clarence Straight, Tongass Narrows appears to be an intercoastal waterway carved along a geologic fault line (similar to Gastineau Channel), which stretches 13 miles and varies in width from approximately ¼ to 1 mile. The map at right shows the two islands being connected by this project.

Most businesses and residences are on Revilla Island; Gravina Island is largely undeveloped, except for the Ketchikan International Airport and some industrial development, including a timber processing plant just to the north of the airport.

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2.2 Community Overview

The current population of Ketchikan is 14,800; projections for 2010 and 2025 are 16,200 and 18,300 residents, respectively, and at slightly greater than 1 percent annual growth, to 19,300 in 2030 -- a higher growth rate would not significantly change the design standards recommended for this improvement. These forecast figures reflect the conservative, medium level (base-case) economic scenario that best estimates a reasonable future level of growth in the borough and were used as the basis for the project traffic analysis.

2.3 Purpose and Need

For some time, there has been keen interest in building an access to Gravina Island, not only to access the airport, but also to develop the vast land holdings of the borough. The Ketchikan Gateway Borough, which is the planning authority for the project area, has conducted or supported several studies in past years that characterize the availability and accessibility of developable land. More than a dozen studies and plans supported by the borough have been conducted since the 1981 study, all detailing problems with land use and accessibility.

3 Project Description

This project is intended to provide an economical full-time roadway link from Ketchikan to Gravina Island across the Tongass Narrows, an active waterway used by boating that ranges in size from recreational craft to ocean-going vessels such as large cruise ships. These larger vessels will ultimately dictate the navigational opening of any Tongass Narrows crossing. Beginning at Lewis Point, just north of the Airport on Gravina Island, the immersed tube tunnel will cross the channel on a skew and connect to Peninsula Point on the North Tongass Highway, just south of Ward Cove.

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3.1 Access Control

This National Highway System (NHS) facility will be an intermodal connector to the airport. A roadway access that links intracity travel between the downtown and the airport is usually considered an arterial. The functional classification of an arterial roadway will set the design standards to be used for this facility. AASHTO recommends that a rural arterial should also have minimum interference to the through movement, ie: a controlled-access corridor. The Department has designated this controlled-access route between the airport and the City of Ketchikan as part of the NHS, the most important road network in the country.

3.2 Traffic

The new roadway is anticipated to attract an estimated 275 vehicles on opening day in 2010; and just under 9,000 trips daily between downtown Ketchikan and the airport and creation of an economic development area on Gravina Island by the design year at the forecasted medium level of economic activity. The FHWA *Road Tunnel Design Guidelines* recommend that tunnels should be constructed for 100-150 year life; so if growth is maintained as predicted, then within 100 years, the ADT should be about 20,000 vehicles.

The design hourly volume, the figure used to determine size of a roadway, is estimated to be 10 percent, or about 900 cars per hour. With a directional split of 45 percent/55 percent (afternoon peak to/from Gravina), a rural two-lane facility will adequately handle this amount of traffic at a Level of Service “B” through the design year.

Annual use by pedestrians and bicycles within the highway corridor is predictably less than for a similarly sized city in the Lower 48. Winter conditions and wet summers are conditions that limit uses of these alternative transportation modes. It is anticipated that fewer than 100 pedestrians and 200 bicyclists will use this facility in the design year.

3.3 Design Standards

The roadway design criteria for the Gravina Island access were developed from the Policy on Geometric Design of Highways and Streets, 2001 by the American Association of State Highway and Transportation Officials (AASHTO), as amended by the Department’s current edition of the Alaska Preconstruction Manual (2005).

The tunnel will be designed in accordance with the latest design standards, including the requirements of the current editions of FHWA’s Road Tunnel Design Guidelines, and American National Standards Institute’s ANSI/IESNA RP-22, *American National Standard Practice for Tunnel Lighting*. It will also be subject to the codes and standards of the National Fire Protection Association’s NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways*. A tunnel exceeding 800 feet must meet all provisions in the standard.

The land across Gravina Island expected to provide the future growth expansion area for Ketchikan is undeveloped rural rolling topography pocketed by boggy areas. The northern end of the Island is characterized as steep mountainous terrain. Revilla Island between the shore and the North Tongass Highway is fairly flat and level, but the roadway itself in the Project area is built on a high embankment. Tongass Narrows bottoms out at around -150 feet below MLLW in the crossing area. This topography will dictate the maximum grades for the new roadway and tunnel.

The draft *Design Study Report* was approved on August 1, 2005, and formalized the standards for the proposed roadway to Gravina Island. The highway will ultimately be a paved 40-foot wide, rural, two-lane roadway within a controlled-access corridor.

The desirable design speed for the project will be 50 miles per hour (mph), although lower speeds may be appropriate for the tunnel (30mph) and in locations around the airport and near the end of the tunnel on Revilla Island. Passing zones are to be optimized for this roadway.

There are no exceptions to the established design standards for this project.

3.4 Shipping Channel Clearances

Since the tunnel will span a very active shipping lane, the section must pass the minimum navigation template established in discussions with the AMHS Port Captain and the Cruise Ship Pilots Association during the environmental phase.

Shipping clearances are governed by the type of vessel. Tongass Narrows is primarily used by ferries of the AMHS, and requires a horizontal clear span will be 500 feet for two-way traffic centered on their ferry trackline. The vertical depth for vessel draft below mean lower low water (MLLW) will be 40 feet.

In the summer months, it is navigated by large vessels of the cruise ship industry. The navigational envelope is bounded by a horizontal clear span of 550 feet for one-way shipping centered on the existing cruise ship trackline. The minimum depth of the channel below MLLW will also be 40 feet.

3.5 Alignment

The landscape on the north end of Gravina Island is mountainous, transitioning into gently rolling wetlands approaching the airport with relief that varies only about 100 feet. It is through this area that the Department built the gravel pioneer Lewis Reef Road to meet the gravel logging Seley Road coming from the mill to the north of Lewis Point.

Coming out of the tunnel on Revilla Island, the roadway enters the busy suburban Ketchikan street network of the North Tongass Highway.

3.5.1 Immersed Tube Tunnel

The crossing of Tongass Narrows will be accomplished by an immersed tube highway tunnel linking Lewis Point on Gravina Island with Peninsula Point on Revilla. The tunnel, aligned approximately due north, is 3200 feet long with a 6 percent downgrade to mid-channel and then a 6.8 percent upgrade to Revilla, and finally intersecting with

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the North Tongass Highway. It will have a portal entrance structure that also houses the mechanical equipment for the tunnel

3.5.2 Roadways

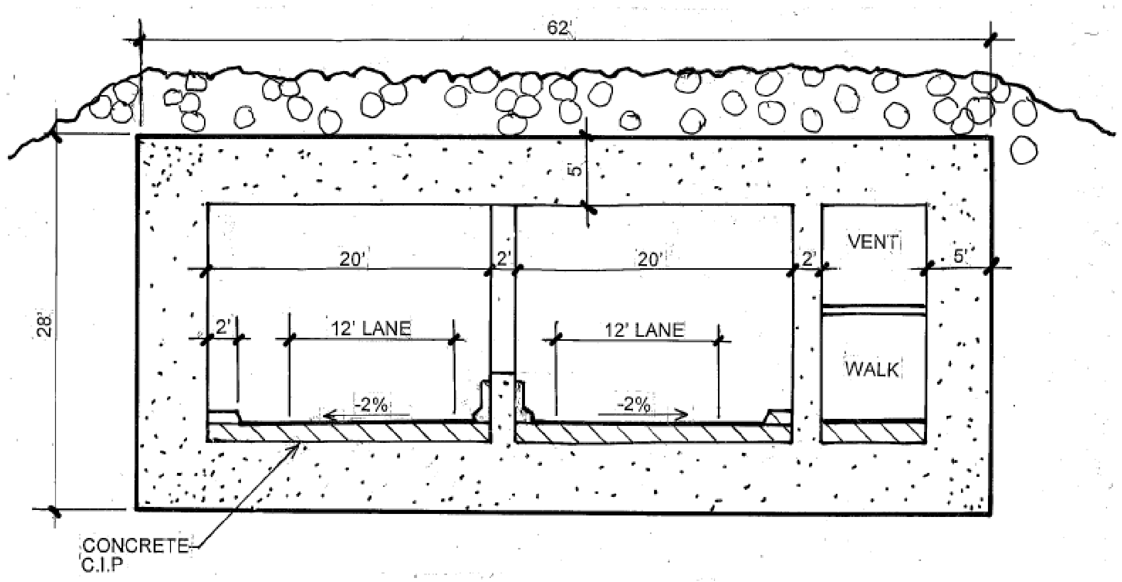
The maximum desirable grade is 7 percent, but the majority of the grades are below this limit. The minimum desirable radius of curvature is 835 feet, but long sweeping curves have been provided to maximize passing sight distance.
The final 500 foot (40mph) curve will slow drivers down before and continues to a stop condition stopping.

3.6 Typical Section

The approved roadway typical section for this project is a two-lane paved facility, 40 feet wide (8-12-12-8). The FHWA recommends that all tunnels should be designed to the same highway standards as for the open approach road. They also recommend that the design life of a tunnel be at least 100 years[1], so a 40 foot wide road would allow for a possible reversible lane configuration at a later date.

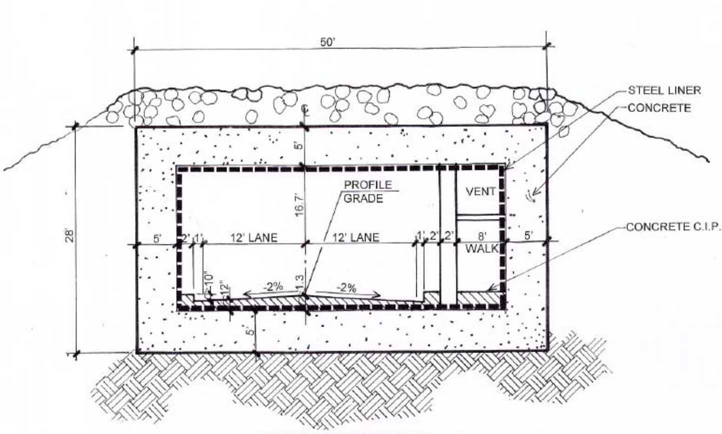
3.6.1 Immersed Tube Tunnel

The tunnel is proposed to be a rectangular steel box liner comprising three enclosures; the 40 foot by 16½ foot roadway segment, an 8 foot wide separated pedestrian segment, and a ventilation/utility shaft, all incased in 5 foot thick concrete, protected by 5 feet of rock rubble material. The total unit would be about 60 feet wide and 30 feet high.



TYPICAL TUBE SECTION

1 FHWA Road Tunnel Design Guidelines, January 2004, page 2

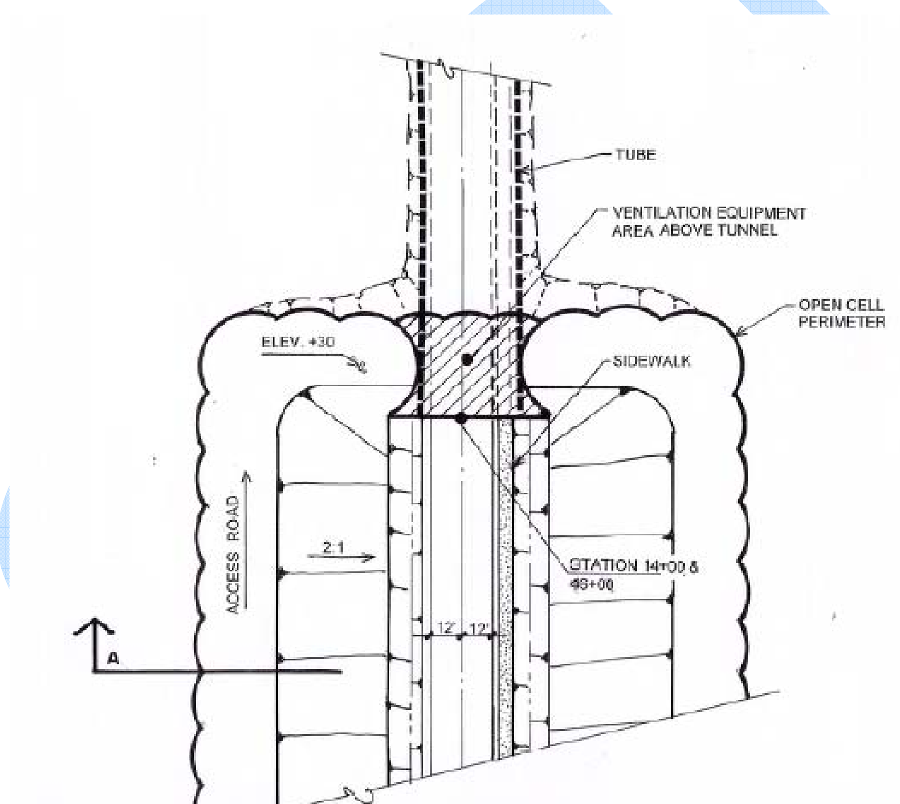


TYPICAL TUBE SECTION

One way to reduce costs is to reduce the tunnel section for the 40 foot wide roadway, and instead provide for a 26 foot wide roadway with 2 foot shy to the walls (see below). This section is consistent with AASHTO standards[2] and the current FHWA tunnel guidelines[3]. With the reduced width also comes the obligation to provide 24 hour emergency service to remove disabled vehicles.

3.6.2 TUNNEL PORTAL

The beginning of the tube is anchored by an open-celled sheetpile bulkhead (Sta 14~) going down to a concrete portal entrance. The end of the tunnel has a similar portal and open-celled bulkhead (Sta 47~), except it is on a curve to the right to align as the right-angle intersection. Each portal structure also houses the ventilation system.



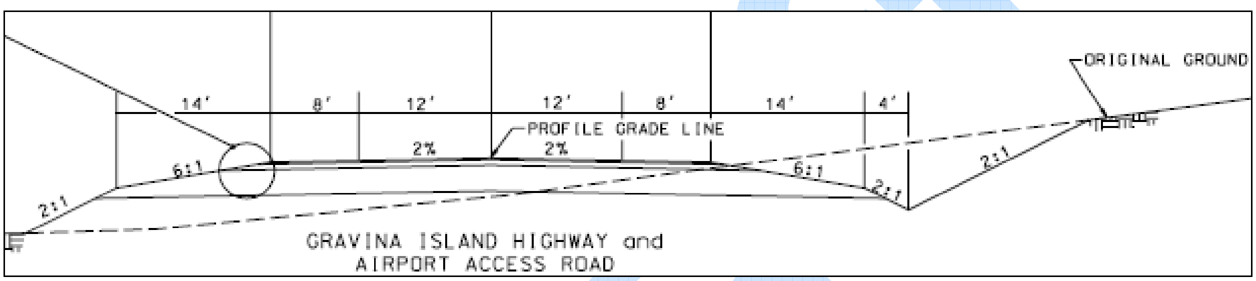
PORTAL PLAN

2 AASHTO Policy on Geometric Design of Highways and Streets, 2001, page 357
3 FHWA Road Tunnel Design Guidelines, January 2004, page 7

3.6.3 Roadways

The year 2030 has been designated as the design year for this project. The anticipated daily traffic in that year is about 8,900. The design hourly volume (DHV) for 2030, the figure used to determine the size of a roadway, is 10 percent, or 890 vehicles per hour. A two-lane facility will easily accommodate this volume through the end of the design year.

With a DHV of 890 cars per hour, the recommended rural typical section is two 12-foot driving lanes with 8-foot shoulders, for a total paved roadway width of 40 feet. The embankment will average 4 feet above original ground to maintain good drainage and a dry structural section. Traversable slopes will be constructed within the 28-foot clear zone. Ditches will be 4 feet deep to accommodate drainage.



The ultimate plan will be to upgrade the Lewis Reef Road that the Department constructed in 2006 to a paved 40 foot wide roadway up to the Seley Road intersection just past Quarry Creek. It this point, the new road would follow the EIS Road alignment that was developed to access borough property during the project development (environmental) phase. Before arrived at the Seley Mill, the road would connect to the tunnel alignment and cross Tongass Narrows.

The proposed interim typical section is for a 32 foot wide gravel road connecting to the existing gravel Seley Road until the construction of the EIS Road or upgrade of the Lewis Reef Road. Until then, the interim roadway will proceed down the hill towards the tunnel to a point at the beginning of the open-celled sheetpile bulkhead and portal entrance. At this location, the roadway will be built to the final 40 foot width typical section, continuing on through the tunnel and out the other side to connect to the North Tongass Highway.

Due to the low pedestrian and bicycles volumes, no separated pathway is planned for the project at this time. The right-of-way corridor proposed will not preclude construction of offset facilities at some later date. The tunnel will include a pedestrian walkway. All pedestrian features will be ADA compliant.

3.7 Utilities

Ketchikan Public Utilities (KPU) provides water, power, and telephones services to most residents in Ketchikan. One of three KPU divisions provides potable water to almost all developed areas within the city of Ketchikan on Revilla Island and to the airport on

Gravina Island through a submarine pressure main. The main water distribution system of KPU consists of three tanks and more than 21 miles of pipe that ranges from 2 to 16 inches in diameter.

KPU provides electricity to the Ketchikan area, including the City of Ketchikan, the City of Saxman, Gravina Island, and Pennock Island. Portions of Gravina and Pennock islands are served by underwater line.

KPU Telecommunications currently has more than 11,000 lines to subscribers on Revilla and Gravina islands. The telephone system includes service to the airport, also by submarine cable.

Both the City of Ketchikan and the City of Saxman operate wastewater systems, including collector lines and treatment plants. The airport operates its own sewer system. Owners of properties outside the service areas of Ketchikan and Saxman and on Gravina and Pennock islands are responsible for their own sewer systems. It is assumed that most have septic tanks and leach fields.

The identified aerial and buried utility impacts are at the intersection of the Gravina Island Highway and North Tongass Highway. Some coordination and minor relocation is expected with the power and telephone distribution services -- typical with an intersection improvement project. There are no known submarine cables in Tongass Narrows along the proposed tunnel routing.

The utilities have indicated an interest in provisions for future expansion across to Gravina Island and along the new roadway corridor.

3.8 Right-of-Way

As a means of providing fair treatment for those persons displaced by federal-aid projects, the Department follows the *Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970*, as amended. This legislation provides for uniform and equitable treatment of persons displaced from their homes or businesses by federally assisted programs, and establishes uniform and equitable land acquisition policies for these programs. Whenever acquiring real property for a project results in displacing anyone, the Department is required to reimburse the displaced persons and provide relocation planning, assistance coordination, and advisory services.

Businesses displaced by a federal program generally are relocated to similar business settings in the local community, although they may have to locate elsewhere. The cost of relocating is covered as part of the relocation process. In accordance with the law, all owners of acquired property, without discrimination, are compensated for their loss of property at fair market value and all displaced persons are moved at no expense to them. Vacant housing and business sites are generally available in Ketchikan, should relocation be required.

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The proposed alignment will affect mostly borough property on Gravina Island. On Revilla Island, the tunnel access will land on Peninsula Point just south of the *Temsco Helicopters* flight service before tying into the North Tongass Avenue, impacting them, *ProMac Air*, and the Department of Transportation offices.

Additionally, staging areas within the right-of-way for construction has been identified on each side of the Narrows. The primary staging area will be on Gravina Island where there is the most undeveloped land available between Seley's Mill and the portal entrance. The land on Revilla Island will be limited to only the acquired properties.

Consistent with the old PLOs (Public Land Orders) that established the Primary Highway System in Alaska (predecessor to the NHS), a 300-foot wide controlled-access right-of-way corridor is recommended.

4 Area Soils and Geology

The soils of Southeast Alaska are generally forested soils or muskegs high in organic matter. Forested soils occur in many areas, from lowlands to rocky side slopes to steep slopes; these soils range from poorly to well drained, with most areas being moderately well drained. Muskegs are commonly found on level or gently sloping landforms and have poor drainage. The depth to bedrock in both forested soils and muskegs ranges from less than 1 foot to more than 15 feet.

With little seasonal variation, Ketchikan is dominated by cool temperatures and heavy precipitation; consequently, soils are typically saturated. Because of the cool, wet climate, decomposition of organic matter is slow, and the soils are highly acidic and generally low in available nutrients. Glacial till or bedrock is normally found beneath the soil and is often responsible for the poor drainage on gentle slopes.

4.1 Uplands

Characteristics of the two main islands vary widely. Gravina Island is predominately marshy and wet, with as much as 6 feet of organics over bedrock. The land is incised by numerous drainages ranging in size from larger creeks to smaller unnamed channels that are dry much of the time. The vegetation is mostly scrub spruce trees, generally stunted by the wet conditions. Where there are rises or well-drained areas, the trees grow larger.

Revilla Island is generally covered in a lush green forest of coniferous trees mixed with alder. In contrast to the landscapes of Gravina Island, Revilla Island is very mountainous, rising steeply from Tongass Narrows. Little flat land is available to support development, limiting growth to the narrow shelf between the mountains and the sea. The restriction on land available for expansion, in conjunction with the desire for a road link to the airport, drives the need to provide physical access to Gravina Island.

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Gravina Island primarily consists of muskeg and poorly drained forested soils; the eastern portion of Gravina Island is primarily muskeg. The proposed alignment crosses overburden depths of 1 to 6 feet over bedrock. Beneath the muskeg is green shist and phyllite rock which is competent for building materials and processed aggregates. Usable excavated materials could be used for underwater fill over the tunnel.

4.2 Tongass Narrows

Tongass Narrows in this location between Lewis and Peninsula Points is about a half mile wide, with water depths over 150 feet deep. The geology of the crossing consists of gravelly/muddy beaches on both sides of the Narrows. The sea floor may be comprised of alternating zones of thick surface sediments and shallow or outcropped bedrock. The sediment thicknesses, especially near Lewis Point, may be thicker (approaching 30 feet) than in other areas of the Tongass Narrows due to its proximity to Ward Cove. Additionally, surface sediments could be soft, and compressible in the upper 5 to 10 feet below the mud line. Bedrock along this crossing will likely consist of phyllite material on the Gravina Island side of the crossing and Gneiss and/or slate-shale bedrock on the Revilla Island side. As with other portions of the Tongass Narrows, it is suspected that a fault and wide shear zone (100-200 foot thick) comprised of weak, highly fractured, highly altered bedrock runs parallel to the Narrows near the center of the channel.

It is planned to develop a quarry on the Gravina Island side to provide additional tunnel bedding and fill material.

5 Site and Environmental Constraints

The project area lies in the coastal maritime climate zone noted for its cool summers, mild winters, and heavy precipitation.

5.1 Tides and Currents

Any structure across the bottom of Tongass Narrows must take into account the velocities of the tidal currents in any reduced cross-section, and accommodate the draft of the larger shipping users. Tidal currents in Tongass Narrows are generally less than 1 knot. But speeds nearly double this have been measured at the surface; the fastest speeds are at mid-channel near the surface.

Tidal currents in Tongass Narrows are generally less than 1 knot. But speeds nearly double this have been measured at the surface; the fastest speeds are at mid-channel near the surface.

The mean tidal range is 12.95 feet, and flows northwest on the flood and southeast on the ebb.

5.2 Wave Climate

Tongass Narrows is heavily sheltered and does not see the major wave action typical of Dixon Entrance or the more open waters. Average wave heights never exceed a couple of feet. Cruise ships are limited to 7 knots to reduce wave erosion.

5.3 Crossing Length

The perpendicular width of Tongass Narrows between Peninsula and Lewis Points is approximately one-half mile. The total length of the tunnel is about 3,200 feet, but the actual water distance from high tides lines is closer to 0.7 miles (3,650 feet).

5.4 Water Depth

Depths along Tongass Narrows vary from 90 to 160 feet. The water depth in the crossing location exceeds -150 feet (MLLW) at the deepest part of the channel. From Gravina Island, the slope is fairly shallow for the first 1000 feet, but then drops sharply to a rounded bottom that rises up on a constant slope to Peninsula Point. This is typical of the bathymetry along this part of Tongass Narrows; shallow water with several seamounts on the west side.

5.5 Precipitation

Numerous days of cloud cover and extreme precipitation characterize the area. Ketchikan averages 162 inches (13.5 feet) of precipitation annually, including 32 inches of snowfall.

5.6 Wind

Prevailing winds in the Ketchikan area are from the southeast, and approximately one-third of the days annually are calm. The average high wind speed at the airport is about 60 mph, with gusts approaching 90 mph. The 100-year return gust is expected to be about 130 MPH.

5.7 Temperature

Summer temperatures range from 51ºF to 65ºF, and rarely exceed 70ºF; winter temperatures from 29ºF to 39ºF, with the coldest days in January. Because of the warming influence of the Pacific Ocean, it is uncommon for the temperature to stay below freezing all day.

5.8 Seismic

Southeast Alaska spans one of the world's most seismically active boundaries between the oceanic Pacific and continental North American plates. Three of the ten largest earthquakes in the world this past century originated along this subduction zone. Ketchikan is a significant distance from major seismic activity, but there is geologic evidence to indicate possible activity in the *Tongass Narrows Fault*. A significant ground shaking could occur from any of the local faults (Chatham or Fairweather faults), although a tsunami event would not be anticipated. According to the Corps of Engineers, Ketchikan is in seismic zone 3, meaning strong earthquakes of a magnitude 6.0 or greater could be expected. The recommended peak ground acceleration are PGA_{475} = 0.08 and PGA_{2500} = 0.18.

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5.9 Permits and Environmental Work Windows

The Gravina Island Access received a ROD from the FHWA in September 2004, and to date has received all necessary permits for a bridge crossing along the F1 Alignment. Tunnels were considered but dismissed early in the NEPA process due to expense (both initial and long term), inter and subtidal habitat impacts, shipping disruptions during construction, difficult alignments, and ability to handle all traffic (access by restricted vehicles) at all times. Now a new tunnel on the north end of Tongass Narrows will require a major rewrite of the current environmental document.

The following permits have been received but will require an amendment or complete resubmission:

- US Army Corps of Engineers Section 404/10 Wetlands Permit
- USCG Bridge Permit
- Alaska Coastal Management Program Consistency Determination
- Alaska Department of Natural Resources Title 41 permits

Resource permits require an in-water work window to minimize impacts to fishes/mammals and the habitat in Tongass Narrows. The current window allows drilling, blasting, and pile driving only between November 1st to February 28th. Additionally, there will be the cruise ship schedule, May 1st through September 30th, which must also be considered when working in the channel with anchored barges and equipment.

Other incidental permits (such as a water extraction permit from DNR) or amendments to existing permits may need to be obtained by the constructor. Additional items of construction (temporary barge locations, staging areas, etc) may require permit modifications.

6 Local Resources

6.1 Construction Materials

6.2 Fabrication Sites

The drydock in service at Alaska Ship & Drydock is a 9,600 long ton (10,752 short ton) facility, and according to the Crandall Drydock drawings, the useable dock dimensions are 384 feet in length by 107 feet in width. Based upon the initial dimensions of the proposed tunnel elements, it does not appear that this facility will be a viable local fabrication facility.

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7 Construction Methods

7.1 Immersed Tube Tunnel

7.1.1 Tunnel Embankment and Trench Construction

7.1.2 Tunnel Element Fabrication and Placement

7.2 Tunnel Portal Construction

7.3 Roadways

All the roads between North Tongass Avenue on Revilla Island and the Airport terminal on Gravina Island will be paved. They will be built using normal construction techniques typical in southeast Alaska, with materials quarried from along the runway clearzone.

8 Tunnel Operational Systems and Safety Requirements

The all important ventilation component will be addressed by four 175,000 CFM reversible jet fans; two located in each of the tunnel portals buildings. Drainage will be accomplished by five pumps rated at up to 3000 GPM. Tunnel lighting will have three separate zones; threshold, transition and interior lighting.

9 Federal Funding Constraints

Typical of projects using federal funds, this work must conform to all pertinent federal programs such as Davis-Bacon prevailing wages, DBE requirements, Buy America, etc.

9.1 Labor Wage Rates

Labor wage rates in Alaska are more commonly controlled by the state's Little Davis-Bacon Act rather than the federal wage rates.

9.2 DBE Requirements

This project will have a disadvantaged business enterprise (DBR) goal that the contractor will be urged to meet. This goal will probably be on the order of 10 percent.

9.3 Buy America Requirements

All steel and iron products, including coatings, incorporated into this project must be manufactured within the US, except for small amounts may be of foreign manufacture provided they do not exceed 0.1 percent of the total contract value, or $2,500, whichever is greater.

9.4 Training Program

This project is anticipated to last at least three (3) years, so there will be time to fully train skilled workers. In all likelihood, this project will require that the contractor to hire trainees is several crafts.

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10 Costs

10.1 Initial Construction Cost Estimate

Costs for the 40 foot wide Peninsula Point Tunnel access can be summarized as follows:

Phase	Cost
Environmental / Permits (1.5%):	$ 5,300,000
Design (7%):	24,600,000
Utility Relocation:	500,000
Right-of-Way Acquisition:	7,500,000
Roadway Construction:	3,500,000
Tunnel Construction:	320,000,000
Construction Administration (6%):	19,500,000
ICAP (4.0%):	15,300,000
Total:	**$ 396,200,000**

These numbers do not include the cost for upgrading Lewis Reef Road or Seley Road, or for extending the EIS Road.

For a narrower tunnel with a 30 foot wide section, the construction costs are expected to be $300,290,000. Both estimates assume a 20 percent construction contingency. See the appendix for a detailed breakdown of construction costs.

10.2 Maintenance and Operations

Maintenance and operational costs (M&O) are an integral element of any capital improvement. Assumed normal and routine roadway maintenance costs are typically expressed as a lane-mile expense. Additionally, necessary and periodic costs must be anticipated and taken into account during yearly budget cycles. The various costs that were used for the M&O estimates are described below.

10.2.1 Roadway Maintenance

These maintenance costs reflect all the normal and routine activities that are familiar to the public, including restriping, pothole patching, ditch cleaning and drainage control, brush clearing, and snow and ice removal. Experience has shown that costs on the order of $6,000 per lane-mile can be expected for a typical rural roadway in an area near a local maintenance station. This figure applies for the total length of the segment, including the structures, which require minor patching and snow removal. The lane-mile represents a one-way pass with a piece of equipment. If the roadway has full-width shoulders, either two passes for snow removal or use of a leading and following blade would be required. Therefore, a shoulder is typically considered another lane-mile for M&O estimate purposes. The proposed ultimate project is a 40-foot paved top, equivalent to four lane-miles.

10.2.2 Tunnel Maintenance

Maintenance of tunnels is almost always more expensive than bridges and roadway maintenance because of the myriad of items that need care. An annual maintenance expenditure includes the obvious drainage pumping system cleaning and repairs, but also the cleaning or repair of joints/seals, wall tile repairs, painting of metal parts, and occasional portal/bulkhead repairs.

Previous Ketchikan tunnel studies presented a wide range of M&O costs primarily involving electrical consumption plus typical maintenance. On past studies these ranged from $350,000 to $3,500,000 per year, an order of magnitude difference. Investigation into the higher number showed values were based on tunnels not similar in operation. The electrical loads, comprising only part of the overall M&O costs, are now estimated at about $500,000 to $600,000 annually.

10.2.2.1 Annual Personnel Costs

Staffing needs are estimated to be at least two state employees on duty at all times monitoring security cameras, fire detection, breakdowns, etc, and then calling for backup and responding to incidents. Year-round coverage will be about four teams of two.

10.2.2.2 Annual Power Costs

10.2.2.2.1 Lighting

10.2.2.2.2 Ventilation

10.2.2.2.3 Cathodic Protection

10.2.2.2.4 Communications and Traffic Surveillance

10.2.2.2.5 Other

The estimate also includes annual replacements costs to a dedicated replacement fund of $100,000. These costs are incurred in addition to the roadway maintenance costs.

10.2.3 Inspections

To ensure the proper care of a major capital investment, inspections must be a part of any preventative maintenance program. Costs for the annual tunnel inspection have been estimated at $5,000, and underwater inspections about $15-20,000 every 2-5 years.

10.2.4 Periodic Costs

Usually the main non-annual cost to anticipate is the expense of pavement overlays of the facility about every 10 years with a new wearing surface. Other considerations are

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periodic expenditures for the tunnel consisting of joint seal renewal, cathodic protection of sheetpiles, pump replacement, etc.

Since the Department's total Ketchikan roadway maintenance system is increasing, staffing and cost increases should be expected. The estimated M&O costs are summarized as follows:

Tasks	Annualized Cost
Roadway M&O*:	$ 25,000
Tunnel Electrical:	550,000
Employees:	1,200,000
Tunnel Inspections:	15,000
Periodic Repairs:	100,000
Replacement Fund:	100,000
Total:	**$ 1,990,000**

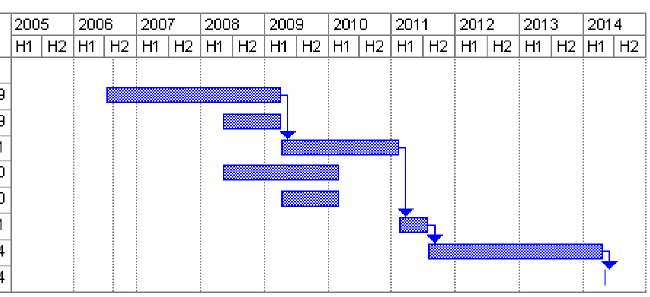
* does not count maintaining the Seley Road

It should be noted that periodic repairs are typically capital costs, not operational, and are addressed in subsequent federally-funded reconstruction or rehabilitation projects.

11 Construction Schedule

It is reasonable to assume that the environmental process and obtaining revised permits will take about three (3) years. Once design approval is in hand, the right-of-way acquisition and utility relocation process could begin for the next two (2) years, but part of this could be concurrent with the design. The design effort for a tunnel structure, because of the necessary expertise, will most likely be another two (2) years. The building of the crossing could easily take about three (3) construction seasons. So if work were to start in earnest after the first of 2007, an opening of the crossing could be expected by 2014. The construction schedule for the design-bid-build procurement model for this project is:

ID	Task Name	Duration	Start	Finish
1				
2	Supplemental Environmental Documer	36 mons	Mon 7/3/06	Fri 4/3/09
3	Amend Permits	12 mons	Mon 5/5/08	Fri 4/3/09
4	Design	24 mons	Mon 4/6/09	Fri 2/4/11
5	Right-of-Acquisition	24 mons	Mon 5/5/08	Fri 3/5/10
6	Utility Relocation	12 mons	Mon 4/6/09	Fri 3/5/10
7	Advertise and Award Construction C	6 mons	Mon 2/7/11	Fri 7/22/11
8	Construction	36 mons	Mon 7/25/11	Fri 4/25/14
9	Ribbon Cutting	1 day?	Mon 4/28/14	Mon 4/28/14



12 PROJECT RISKS

13 REFERENCES

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APPENDIX 14-A
TYPICAL SECTIONS

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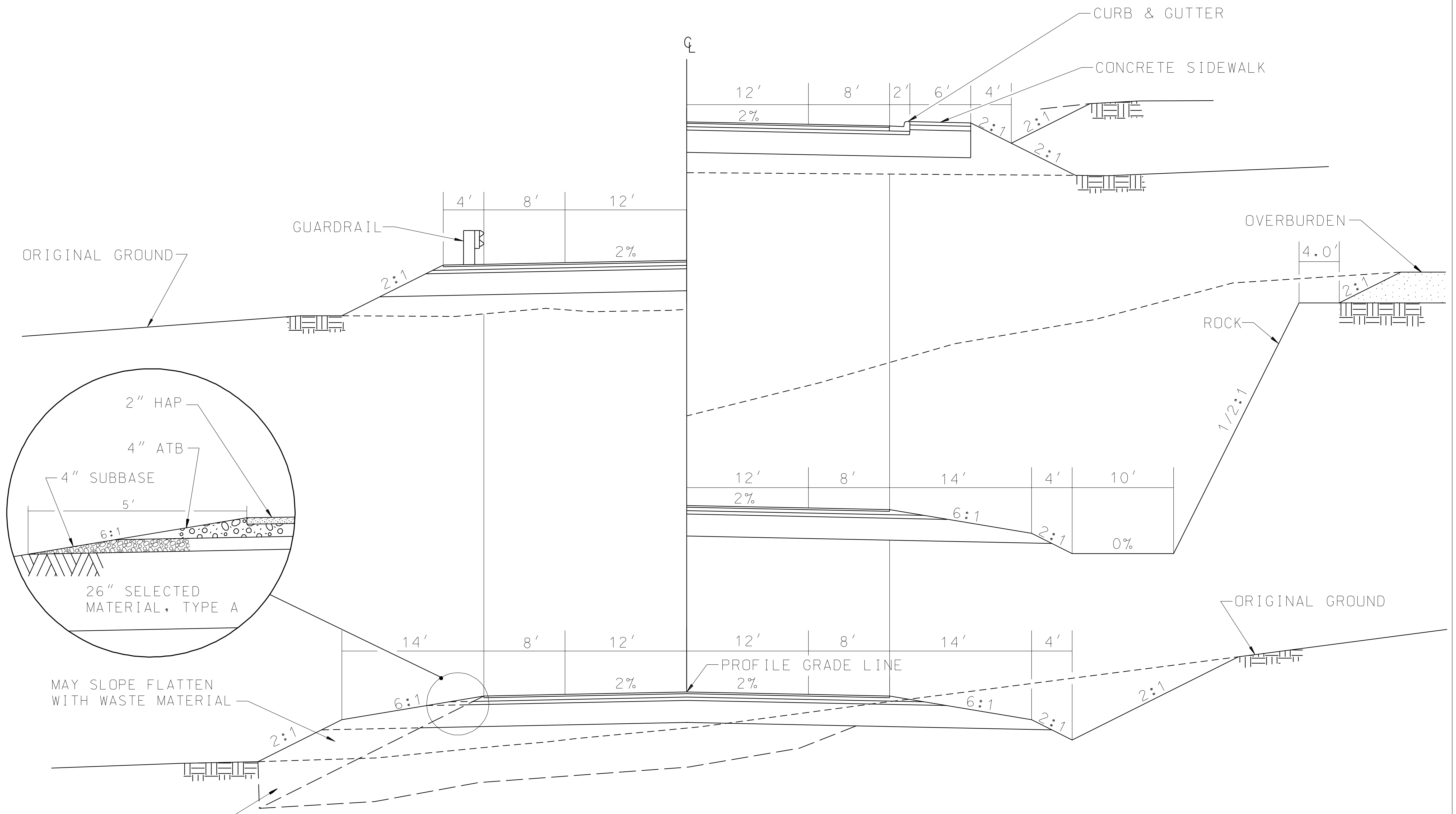


GRAVINA ISLAND HIGHWAY and
AIRPORT ACCESS ROAD

NOTES:

1. PAVEMENT SECTION DEPTHS ARE AS FOLLOWS:
   -- 2" HOT ASPHALT PAVEMENT (HAP), TYPE II, CLASS A
   -- 4" ASPHALT TREATED BASE (ATB)
   -- 4" SUBBASE, GRADING B
   -- 26" SELECTED MATERIAL, TYPE A
2. TOPSOIL AND SEED ALL DISTURBED AND EXPOSED NON-ROCK SLOPES TO BOTTOM OF SUBBASE LAYER.

FILENAME:	PLOT DATE:	DESIGNED BY:	DATE:
VPORT:	PLOT SCALE:	CHECKED BY:	DATE:
XREF:	SCALE:	DRAWN BY:	DATE:

REVISIONS

No.	DATE	DESCRIPTION

STATE	PROJECT DESIGNATION
ALASKA	HP-NCPD-0922(5)/67698

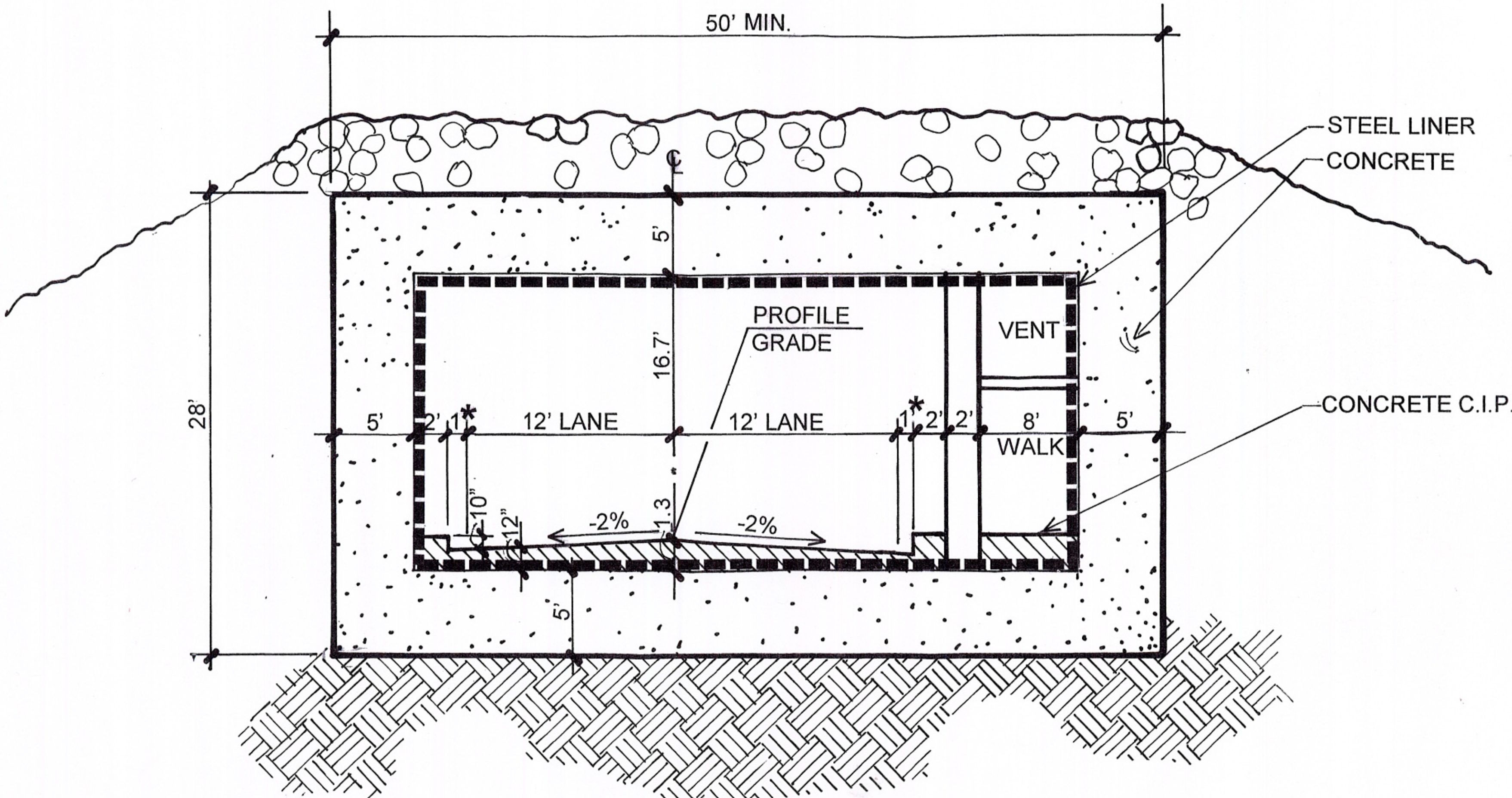
HDR ALASKA, INC.

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

KETCHIKAN GRAVINA ISLAND ACCESS

TYPICAL SECTIONS

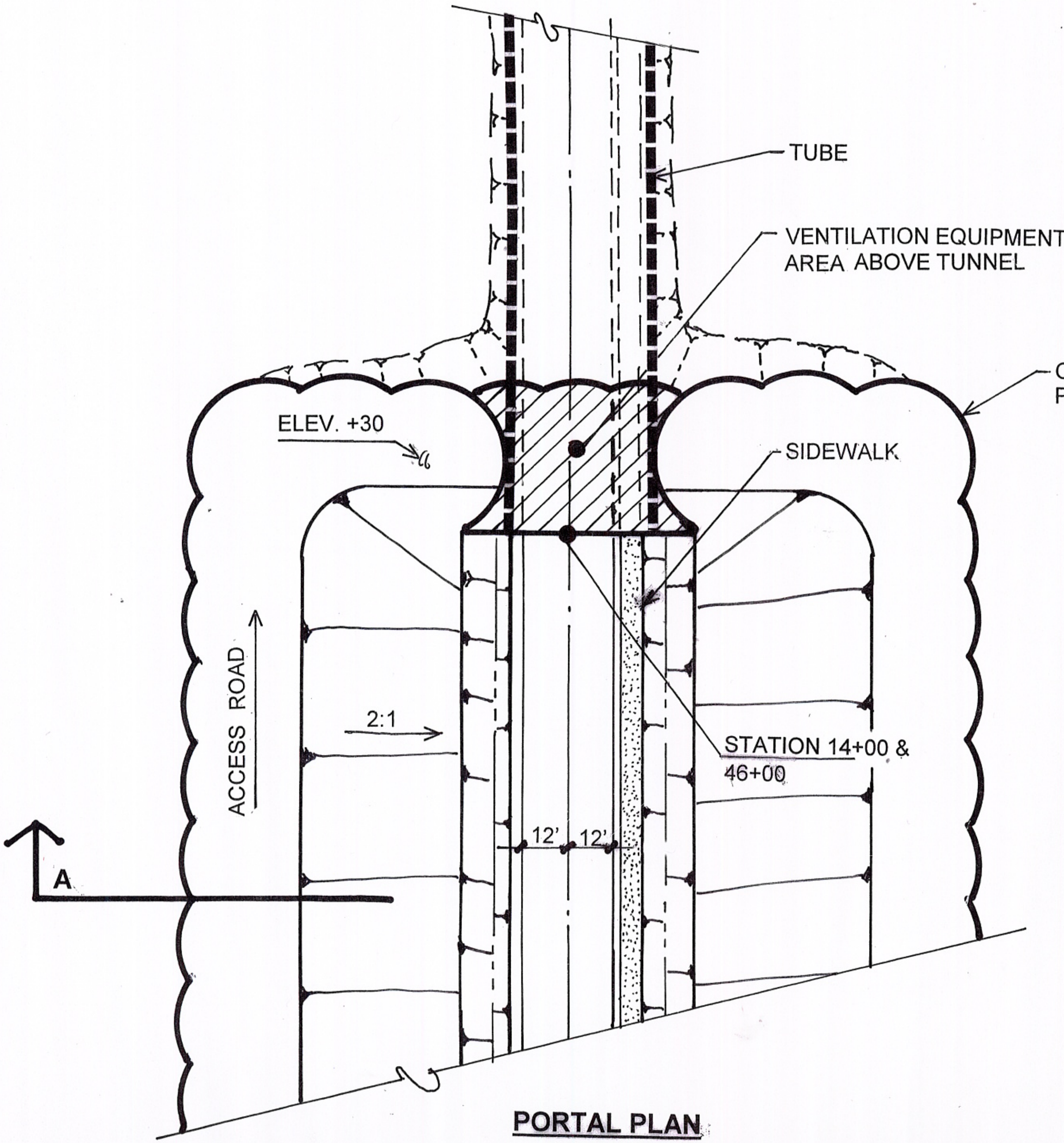
DATE 05.05 SHEET



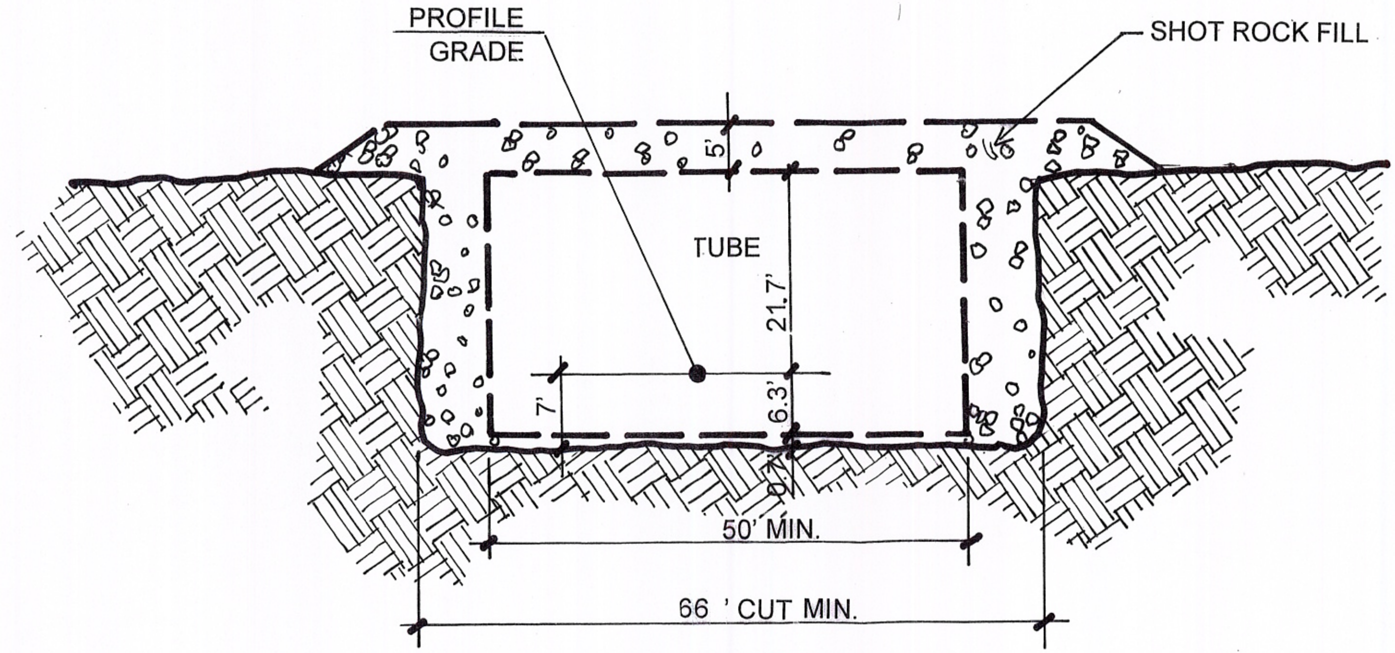
NOTE:

TYPICAL TUBE SECTION

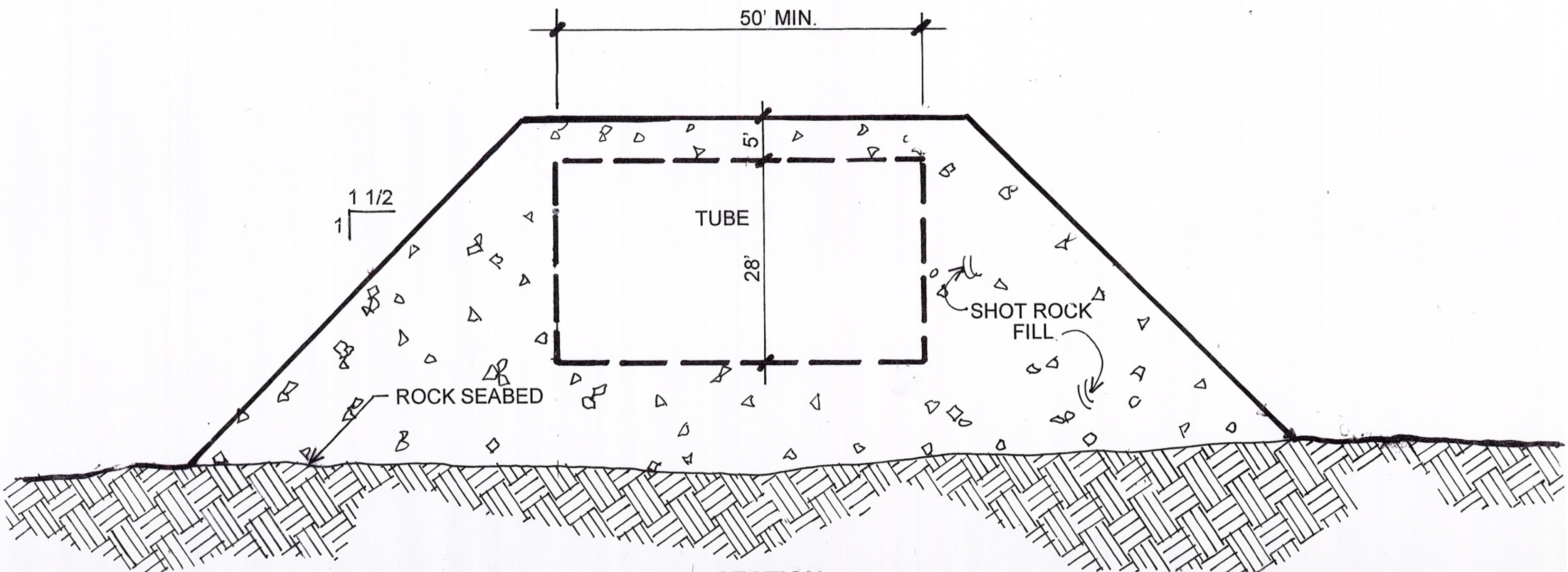
* MINIMUM SHOWN
8' SHOULDER ON APPROACHES


TUBE
VENTILATION EQUIPMENT
AREA ABOVE TUNNEL
OPEN CELL
PERIMETER
ELEV. +30
SIDEWALK
ACCESS ROAD
2:1
STATION 14+00 &
46+00
12'
12'
A

PORTAL PLAN

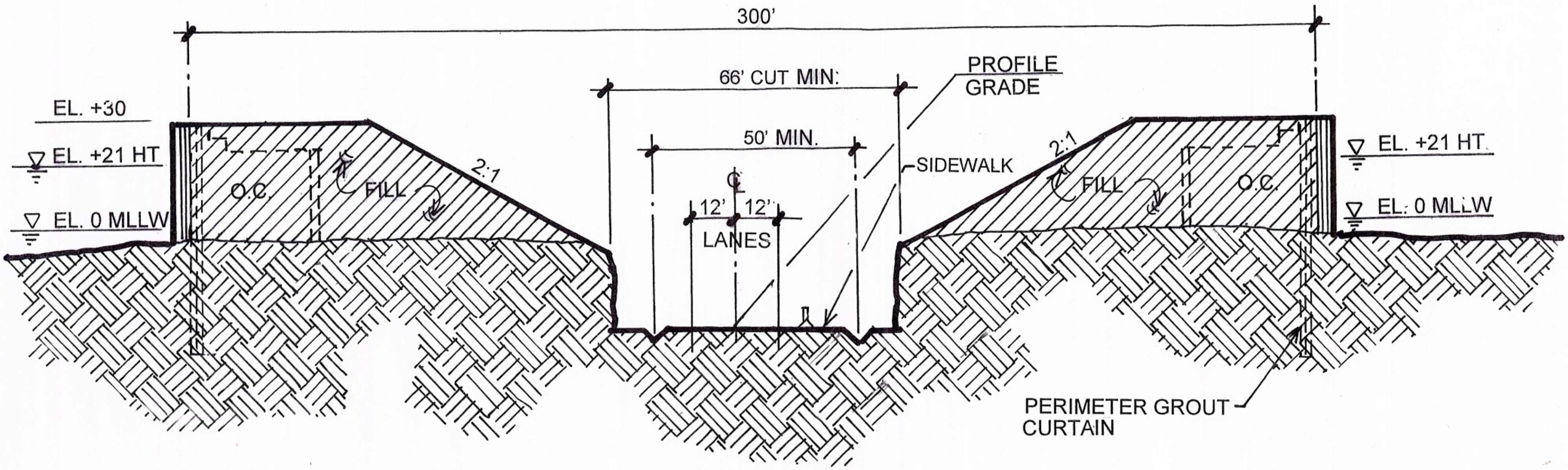


CUT SECTION



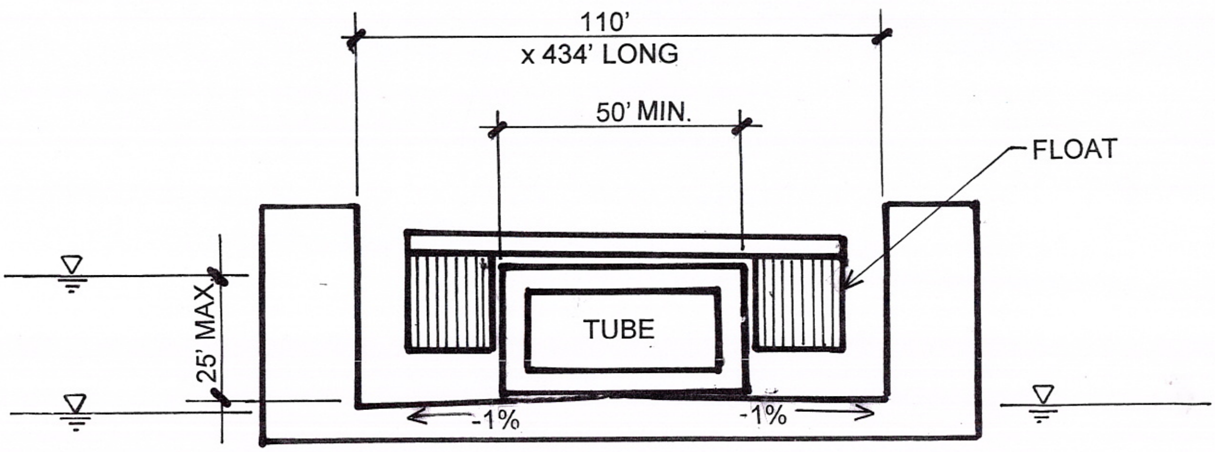
FILL SECTION

TYPICAL SECTIONS



300'
66' CUT MIN.
PROFILE GRADE
50' MIN.
EL. +30
EL. +21 HT
EL. 0 MLLW
O.C.
FILL
2:1
12'
12'
LANES
SIDEWALK
2:1
FILL
O.C.
EL. +21 HT.
EL. 0 MLLW
PERIMETER GROUT CURTAIN

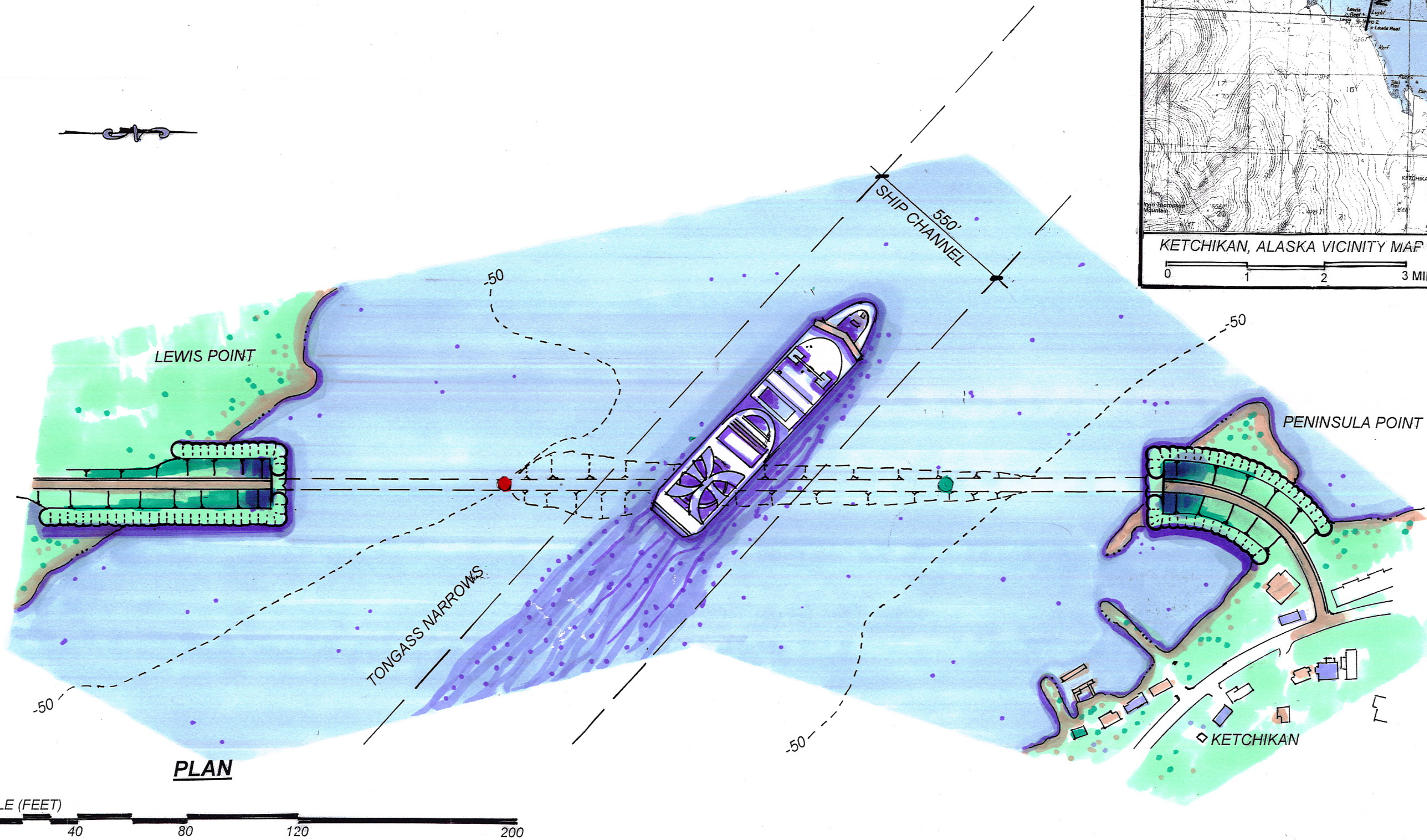
SECTION A

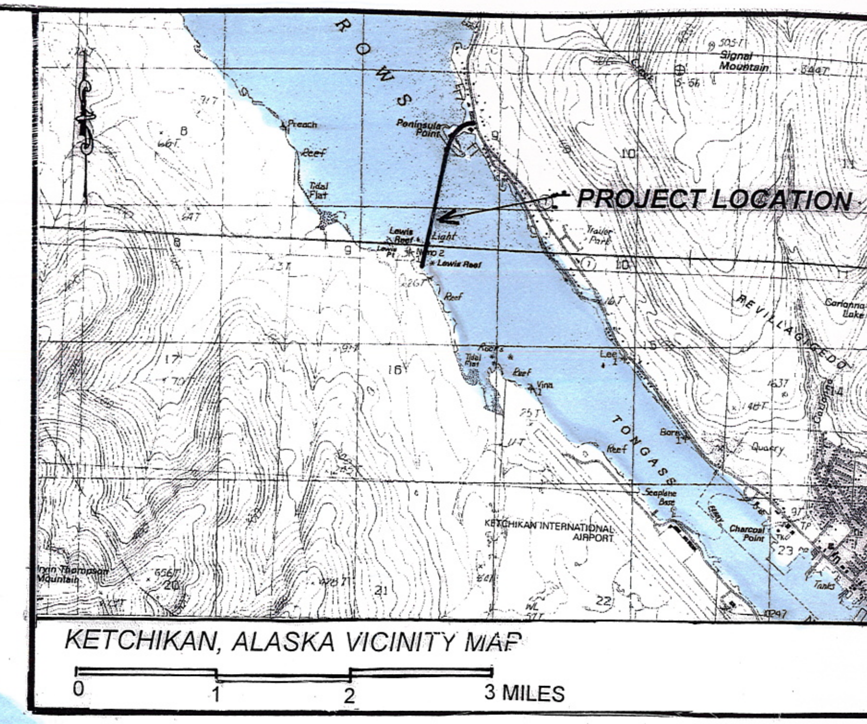


KETCHIKAN 10,000 TON DRYDOCK SECTION

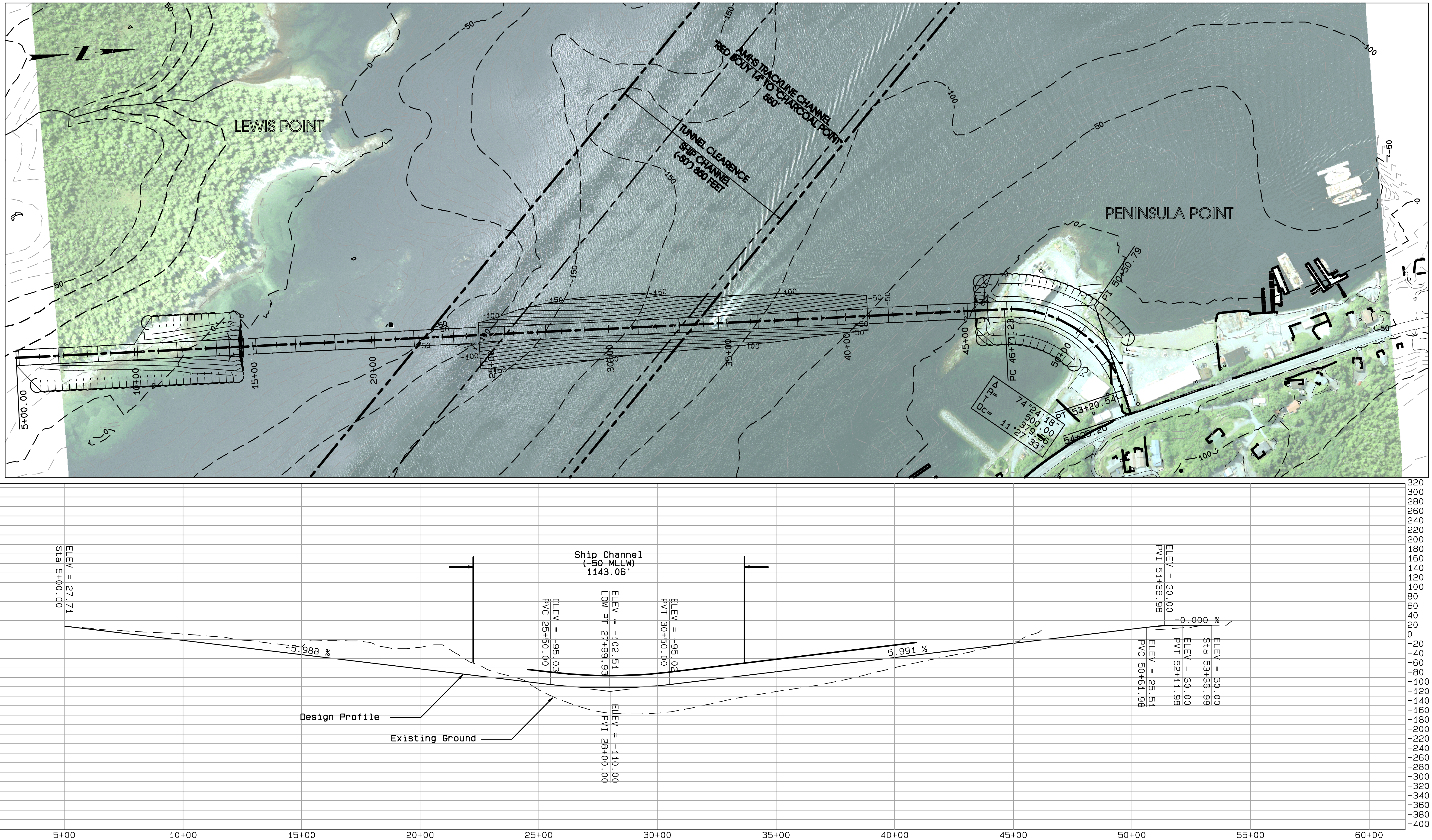
APPENDIX 14-B
PLAN AND PROFILE

draft





TONGASS NARROWS TUNNEL CROSSING CONCEPT PLAN



NOTES:

COORDINATE SYTEM = NAD83 ALASKA STAE PLANE, ZONE 1, FEET
VERTICAL DATUM = MLLW
VERTICAL UNITS = FEET

REV	DATE	DESCRIPTION

1506 West 36th Avenue
Anchorage, Alaska 99503
Phone: 907.561.1011
Fax: 907.563.4220
www.pnd-anc.com

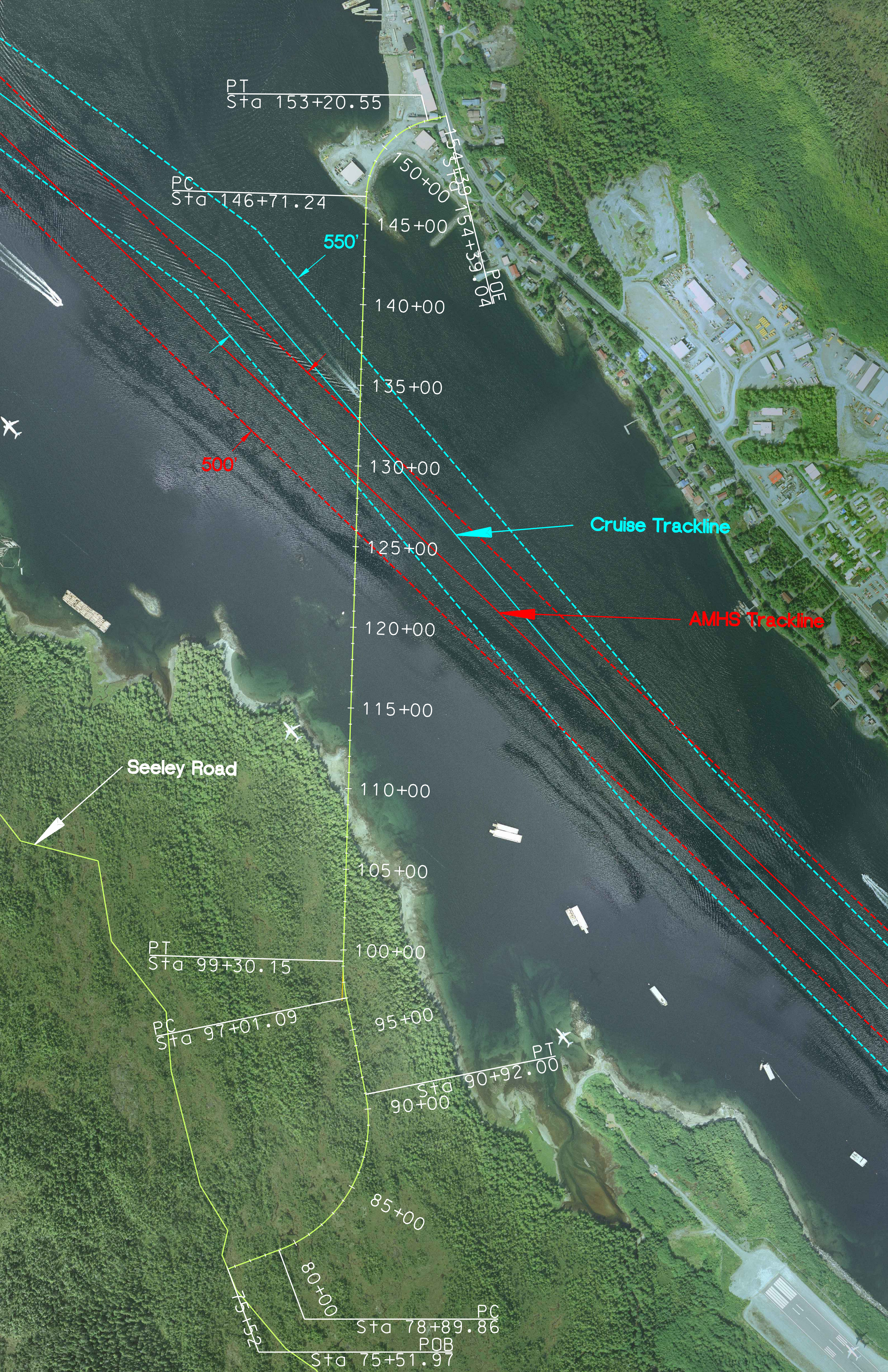
P N D
ENGINEERS
Incorporated

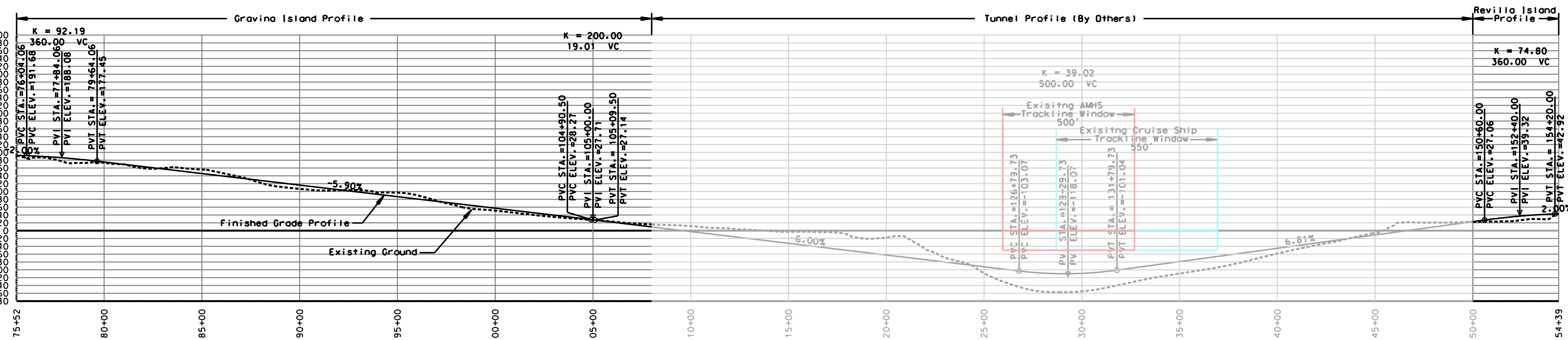
PROJECT: TONGASS NARROWS CROSSING

TITLE: PLAN & PROFILE CONCEPT

DRAWN BY:	TG		
DESIGNED BY:	DN\TG	DATE:	8/23/2006
CHECKED BY:	DN	PROJECT NO:	061084

SHEET NO: 1 OF 1


PT
Sta 153+20.55
PC
Sta 146+71.24
150+00
154+39
154+39.04 POE
145+00
550'
140+00
135+00
500'
130+00
Cruise Trackline
125+00
120+00
AMHS Trackline
115+00
Seeley Road
110+00
105+00
PT
Sta 99+30.15
100+00
PC
Sta 97+01.09
95+00
PT
Sta 90+92.00
90+00
85+00
80+00
PC
Sta 78+89.86
75+52
POB
Sta 75+51.97

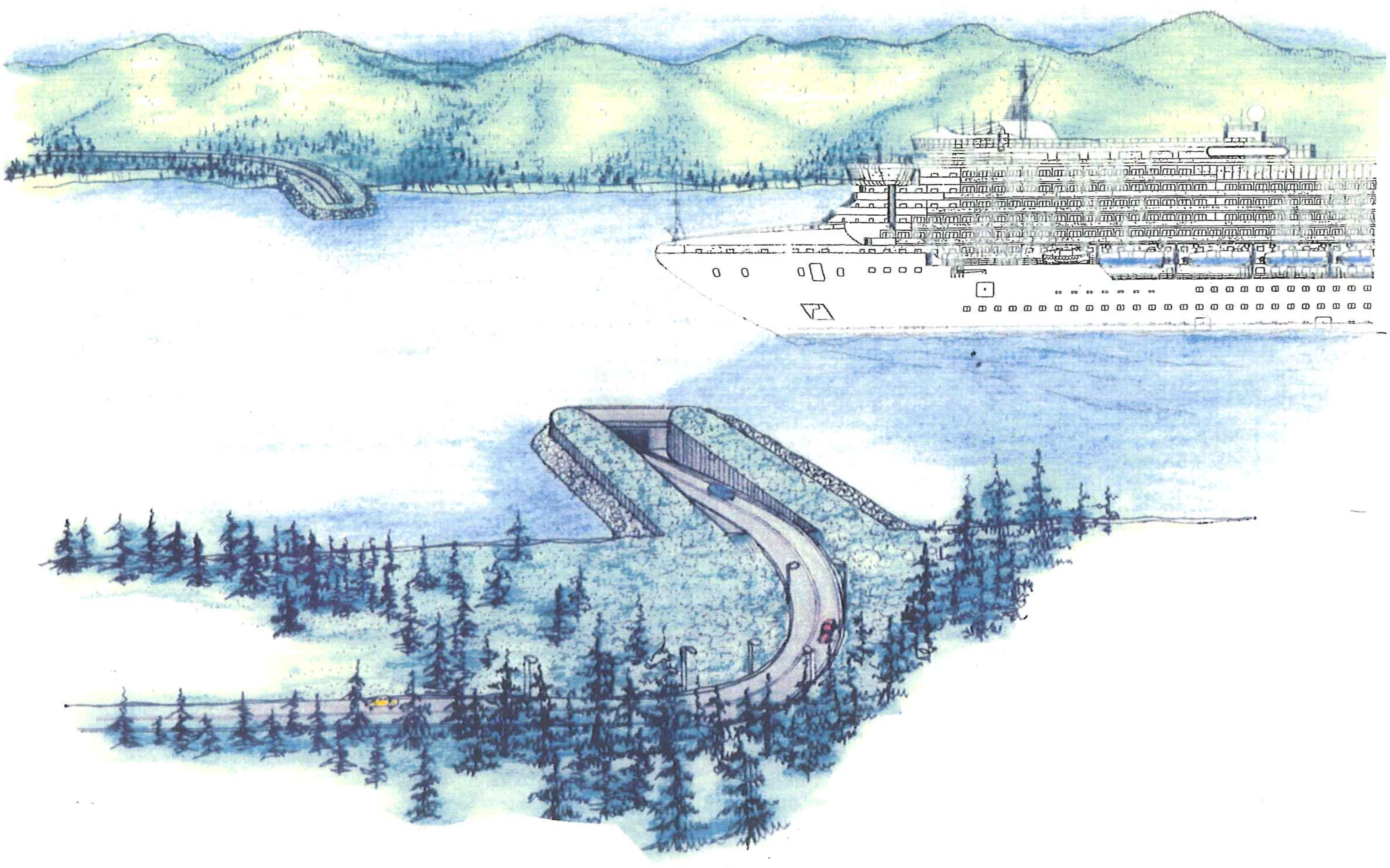

Gravina Island Profile
Tunnel Profile (By Others)
Revilla Island Profile
K = 92.19
360.00 VC
K = 200.00
19.01 VC
K = 39.02
500.00 VC
K = 74.80
360.00 VC
PVC ELEV.=191.68
PVI STA.=77+84.06
PVI ELEV.=188.08
PVT STA.= 79+64.06
PVT ELEV.=177.45
PVC STA.=104+90.50
PVC ELEV.=28.27
PVI STA.=105+00.00
PVI ELEV.=27.71
PVT STA.= 105+09.50
PVT ELEV.=27.14
PVC STA.=126+79.73
PVC ELEV.=-103.07
PVI STA.=129+29.73
PVI ELEV.=-118.07
PVT STA.= 131+79.73
PVT ELEV.=-101.04
PVC STA.=150+60.00
PVC ELEV.=27.06
PVI STA.=152+40.00
PVI ELEV.=39.32
PVT STA.= 154+20.00
PVT ELEV.=42.92
2.00%
-5.90%
-6.00%
6.81%
2.00%
Exisitng AMHS
Trackline Window
500'
Exisitng Cruise Ship
Trackline Window
550'
Finished Grade Profile
Existing Ground
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
75+52
80+00
85+00
90+00
95+00
100+00
105+00
110+00
115+00
120+00
125+00
130+00
135+00
140+00
145+00
150+00
154+39

APPENDIX 14-C
PND FINAL TUNNEL REPORT
FEBRUARY 2007

draft

TONGASS NARROWS CROSSING

LEWIS POINT TO PENINSULA POINT



February 2007

Prepared by: PND ENGINEERS, INC.
1506 West 36th Avenue,
Anchorage, Alaska 99503
Phone: 907.561.1011
Fax: 907.563.4220

FINAL REPORT

TONGASS NARROWS CROSSING
CONCEPT STUDY

Project Team

For the Tongass Narrows Crossing Tube Tunnel Concept Study, PND Engineers, Inc. served as subconsultant to HDR, Inc., the prime consultant to the Alaska Department of Transportation & Public Facilities. PND's subconsultants were Pool Engineering, Inc. of Ketchikan and PDC, Inc. of Anchorage with Danish tunnel government and consultant specialists.

Project Site

Governor Murkowski proposed examining a potential tube tunnel crossing of Tongass Narrows at a location about 2.5 miles north of the Gravina Island Airport Terminal. He suggested that Danish, other Europeans and engineers worldwide were successfully building these structures and such a solution might reduce crossing costs at Ketchikan while providing better operations for aircraft and shipping and shorter driving times.

A tube tunnel crossing from Peninsula Point to Lewis Point on Gravina Island, a distance of about one mile, appeared to provide a location where grades and ship channel clearance could be met.

This location's soils are thought to be primarily metamorphic rock overlain by thin layers of various soils upland and thin seabed sediments. Excavated material could mostly be used on the project as shot rock fill. At the Gravina end a quarry could be developed to supply any extra shot rock needed for fill. This could be done in conjunction with the road extension to the airport and would result in fill with close proximity to the project and thus lowest cost.

Project Approach

This project is an extension of work on a previous tunnel alignment closer to the Ketchikan Airport, thus the following similar criteria were used:

- Traffic – 890 DHV
- Roadway – two lanes, two-way (30' minimum clear width)
- Ship Channel Clearance – El -40 MLLW
- Ship Channel Width – 550 feet
- Maximum Road Grade – 6%
- Design Vehicle Speed – 30 mph (provides highest possible volume)
- Bathymetry – Latest NOAA
- Air Photos & Survey – Local city and borough mapping
- Extreme High Tide – El 21.2 (datum MLLW El 0.0)

Note that these criteria should be considered the least restrictive with the lowest cost possible for a safe operating low-volume tunnel. (See Danish photos in appendix for a similar tube tunnel.)

From this basic information a plan and profile drawing was developed along with typical details and sections at key elements. Detailed cross sections were then developed at 200-foot intervals along the alignment. Quantities of material were calculated sufficient to apply to costing methods. See appendix for various drawings. The plan and profile could be optimized, but for purposes of this concept study costs will be of sufficient accuracy. Also final geotechnical work may have a cost impact subject primarily to subsea soils encountered.

Mechanical and electrical preliminary design was done including air handling, lighting, security, emergency generation and drainage sufficient to develop capital and O&M costs. (See appendix.)

Costs and Constructibility

From developed quantities, costs were extended by Pool Engineering, Inc, PND Engineers, Inc. and PDC, Inc. with input on constructibility, capital costs and O&M costs from interviews with European parties and others having tube tunnel experience.

Constructibility was discussed among all consultants, particularly as related to conditions in Ketchikan. For example, Pool has excavated about 20,000 cubic yards of subsea shot rock in the area. PND estimated concrete work and approach (open cells) in a manner similar to recent large project experience. (See appendix for details.)

Discussions related to general approach taken by the project team at a concept level are found in the appendix.

Cost Summary

Grouping related construction items with a range of possible costs tends to show items of largest impact.

Item	Cost Range ($millions)
Mobilization & Miscellaneous	13 to 20
Approaches and Earthwork	28 to 41
Tube Tunnel	118 to 177
Mechanical & Electrical	15 to 22
Concept Level Range of Total Construction	**$174-$260 million**

M&O Annual Costs

Previous Ketchikan tunnel studies presented a wide range of M&O costs primarily involving electrical consumption plus typical maintenance. On past studies these ranged from $350,000 to $3,500,000 per year, an order of magnitude difference. Investigation into the higher number showed values were based on tunnels not similar in operation. PDC now estimates annual M&O costs at about $500,000 to $600,000/year.

Closure

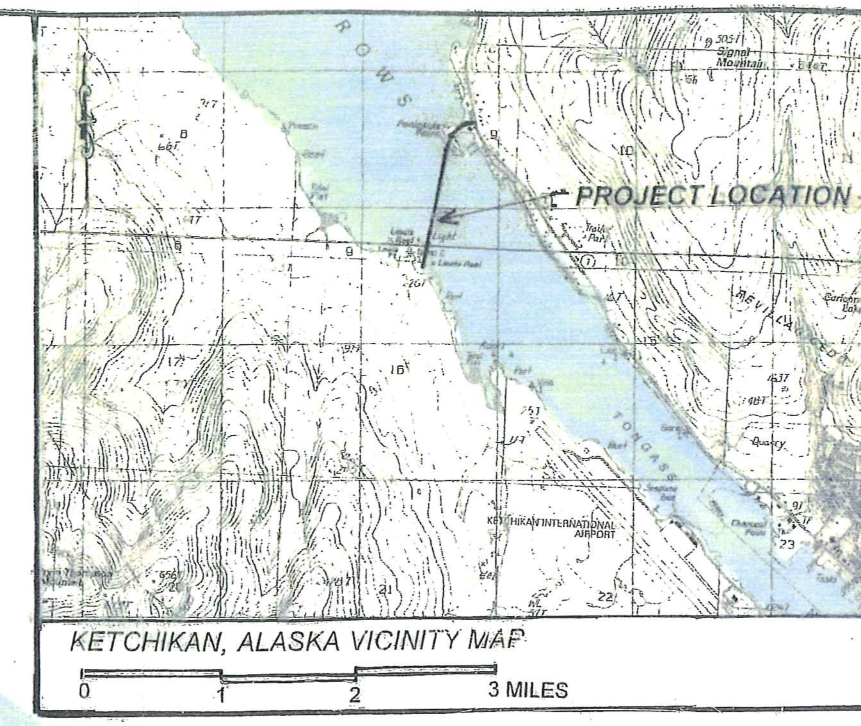
Tube tunnels are now in common use around the world, some in water depths greater than at Ketchikan. General costs found describing various configuration capital and O&M costs agree with costs estimated for the Tongass Crossing.

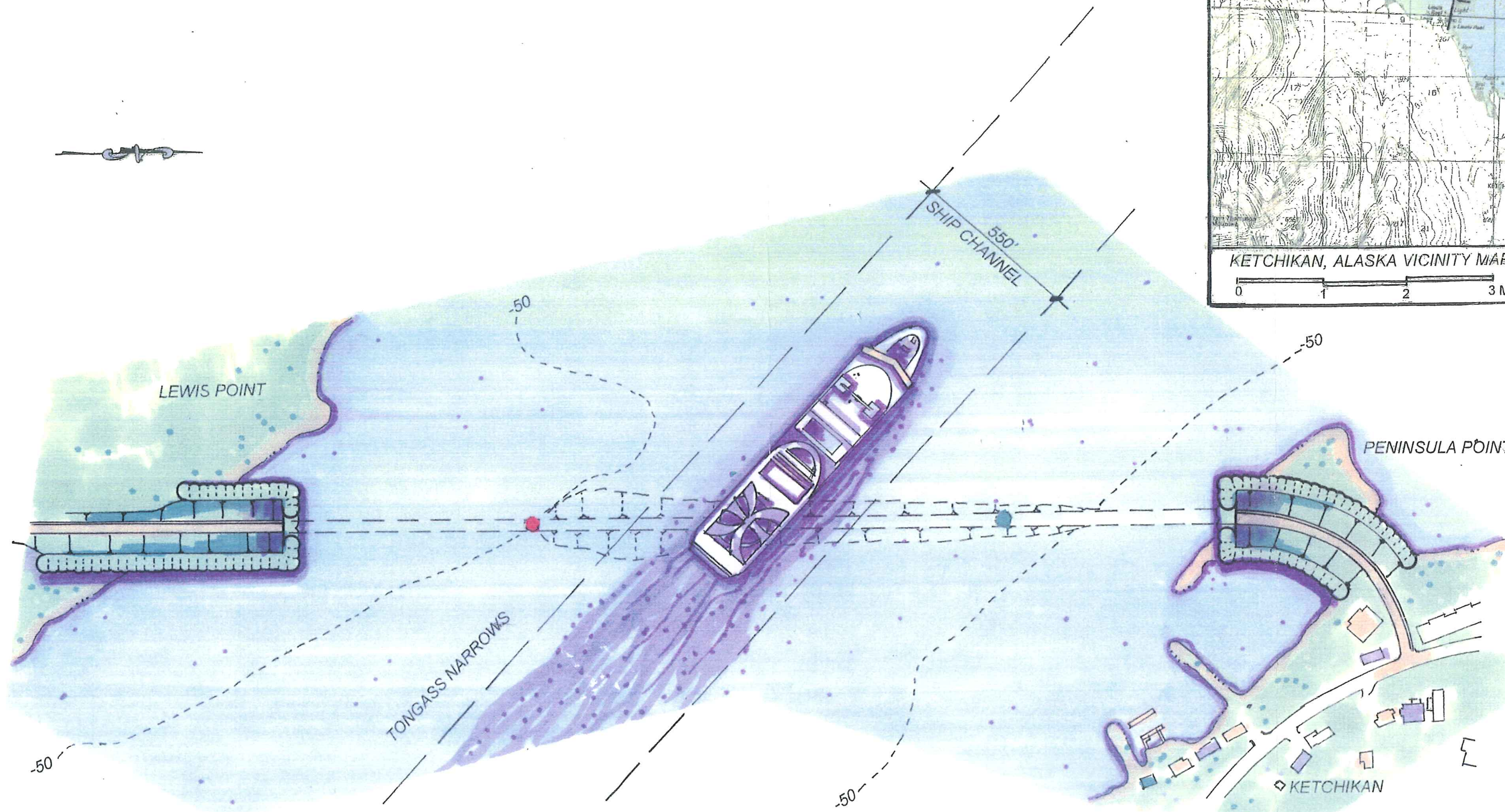
Mid-Range Cost Details

Mid-range capital construction costs can be summarized as follows using quantities and unit prices developed by various parties and checked for general accuracy:

	Item	Quantity	Unit Price	Cost ($million)
1)	Mobilization & Miscellaneous	All	L.S.	15.00
2)	Seabed Muck Excavation (approx.)	40,000 c.y.	10.00	0.40
3)	Rock Excavation	200,000 c.y.	20.00	4.00
4)	Shot Rock Fill Below Tube	310,000 c.y.	20.00	6.2
5)	Shot Rock Tube Cover Fill	200,000 c.y.	20.00	4.00
6)	Shot Rock Fill Vibracompaction	40,000 s.y.	25.00	1.00
7)	Open Cell Fill	160,000 c.y.	15.00	2.40
8)	Open Cell Fill Vibracompaction	12,000 s.y.	20.00	0.24
9)	Open Cells	3,500 tons	2400.00	8.4
10)	Cell perimeter Grouting	3,200 l.f.	500.00	1.60
11)	C.I.P. Closure Concrete	3,000 c.y.	1000.00	3.0
12)	C.I.P. Concrete Paving	3,500 c.y.	600.00	2.10
13)	Paving Leveling Layer	3,500 c.y.	25.00	0.88
14)	Barrier Rails, Signs, Etc.	All	L.S.	0.20
15)	Dry Dock or Graving Dock Costs	All	L.S.	3.60
16)	Tube Structural Steel w/Coatings	4,200 tons	5000.00	21.10
17)	Tube Reinforced Concrete	85,000 c.y.	1200.00	102.00
18)	Tube Placement	All	L.S.	3.00
19)	Tube Grouting	All	L.S.	1.00
20)	Tube C.I.P. Reinforced Concrete	5,600 c.y.	600.00	3.36
21)	Drainage Systems w/Pumps, Lighting System, Security System w/Connection to Police & Airport Security, Ventilation System w/Buildings, Doors, Sensors, Alarms, etc., Backup Generator System	All	L.S.	16.35
			Total	199.83
			10% Contingencies	19.98
	Estimated Total Mid-Range Construction Cost			**219.81**

Note: This estimate covers a project extending approximately one mile in length including about 3,200 feet of tube tunnel and is based upon criteria that present the lowest cost. Tunnel widening, for example, will increase cost. Location of tube construction may have a significant impact on cost. For purposes of this estimate the most cost-effective case was assumed.





PLAN

SCALE (FEET) 0 40 80 120 200

TONGASS NARROWS TUNNEL CROSSING CONCEPT PLAN

KETCHIKAN TUBE TUNNEL CONCEPT / PND PROJECT 061048

TRIP REPORT PREPARED BY MICHAEL N. HUGGINS

1.1 DENMARK TRIP– SCOPE OF EFFORT

The recent PND effort with regard to developing a tube tunnel concept and estimate included travel to the European country of Denmark to gather information about new and existing Immersed Tube Tunnels. The goals of the trip were as follows:

Item 1.2 Meet with Danish Road Directorate to gather technical background on the Operations and Maintenance costs for Limfjord and Guldborgsund Tunnels. These cost were compared with O&M costs for the George Massey Tunnel (formerly Deas Island) that crosses under the Fraser River in Burnaby, British Columbia.

Item 1.3 Meet with engineering firms versed in design of Immersed Tube Tunnels such as Christiani and Nielsen, COMAR, COWI Engineering. The intention was to determine if any of the concept details proposed for the Ketchikan Tunnel were outside the bounds of classic tube tunnel design both here in the United States and in Scandinavia.

Item 1.4 Meet with research engineers at the Danish Hydraulic Institute to review recent efforts to assess ship-handling and sea-keeping stability during tube tunnel installation.

Item 1.5 Visit Guldborgsund Tube Tunnel on the E-2 Danish Roadway. Gather detailed information regard tunnel geometrics, lane widths, traffic volumes, ventilation, lighting and approaches.

1.2 OPERATIONS AND MAINTENANCE HISTORY

1. George Massy Tunnel, Burnaby, British Columbia. Completed in 1959 with original design by Christiani and Nielsen. Configured with 4 lanes, with overall 2000-foot tunnel length.

1.1.	Operations and Maintenance	$704,000	per annum ($468,000 lane-mile)
1.1.1.	Mechanical / Drainage	$257,000	per annum ($170,000 lane-mile)
1.1.2.	Ventilation	$245,000	per annum ($161,000 lane mile)
1.1.3.	Lighting	$50,000	per annum ($33,000 lane mile
1.1.4.	Power Cost	$ 90,000	per annum ($60,000 lane mile)
1.1.5.	Corrosion and Paint Maintenance	$17,000	per annum
1.1.6.	Security Camera	$35,000	per annum
1.1.7.	Slopes and Landscape	$10,000	per annum
1.1.8.	Traffic Management System	$660,000	per annum (Excl from O &M)

2. Limfjord Tunnel, Aalborg, Denmark, 4 or 6 lanes (Variable) 1632 feet in length. The tunnel was completed in 1969 and is operating today with reversible lanes, and complex traffic management system.
   2.1. Operations and Maintenance — $1,190,000 per annum ($641,000 lane mile)
      2.1.1. Mechanical / Drainage — $222,000 per annum (110,000 lane-mile)
      2.1.2. Ventilation — $90,000 per annum (45,000 lane mile)
      2.1.3. Lighting — $24,000 per annum (13,000 lane mile
      2.1.4. Power Cost — $120,000 per annum (65,000 lane mile)
      2.1.5. Corrosion and Paint Maintenance — $45,000 per annum (24,000 lane mile)
      2.1.6. Security Systems — $86,000 per annum (46,000 lane mile)
      2.1.7. Reversible Lane Management — $603,000 per annum (325,000 lane-mile)

3. Gulborgsund Tunnel, Falster, Denmark - completed in 1994. Configured with 4 lanes, with a tunnel length of 1472 feet. Originally constructed with 4 lanes, though only 2 were placed into operation. Unlike Limfjord and George Massey Tunnel there no elaborate traffic management system is required. The tunnel is placed on the Danish equivalent of a two lane highway. The O&M is given for two lanes operating, versus 4 provided.
   3.1. Operations and Maintenance — $275,000 per annum ($500,000 lane mile)
      3.1.1. Mechanical / Drainage — $51,000 per annum (92,000 lane-mile)
      3.1.2. Ventilation — $10,000 per annum (18,000 lane mile)
      3.1.3. Lighting — $24,000 per annum (44,000 lane mile
      3.1.4. Snow Removal — $120,000 per annum (218,000 lane mile)
      3.1.5. Sweeping Debris from Ramps — $60,000 per annum (109,000 lane mile)
      3.1.6. Security Systems — $10,000 per annum (18,000 lane mile)
      3.1.7. Reversible Lane Management — $0 per annum (0 lane-mile)

The highest cost variable in operation and maintenance is based on the number of people and sophistication of systems utilized to regulate traffic flow in the tunnels. Reversible lanes, accident detection, emergency response during rush hour have very high costs. For both Limfjord and George Massey Tunnels, these costs are approximately 600,000 dollars per year. For the purposes of comparing these tunnels to the one contemplated in Ketchikan, the cost are compared for apples-to-apples system that are common to each structure.

Costs for the George Massy Tunnel were collected from the B.C Ministry of Transport under the direction of Alan Galambos. Cost for Limfjord and Guldborgsund were provided my Mr. Jens Thomsen, Senior Engineer for Danish Road Directorate.

1.3 TECHNICAL CHALLENGES / COMPARISON WITH RECENT TUNNELS

Whilst in Denmark, PND representatives met with the tunnel engineers employed by the Danish consulting firm COWI. The two individual were Stephen Slot Odgaard, and Egon Sorenson. Both are senior engineers within the COWI Tunnel Group. The particular discussion was directed to assessing the similarity or differences of the Ketchikan Tunnel with recent tunnels design by COWI. The following are the essential facts regarding a recent design for the Busan Geoje Tube Tunnel in South Korea (see attached project description):

1) The maximum water depth above the Busan-Geoje tube tunnel (2 miles in length) is 150-feet (50 Meters) The greatest water depth along the proposed tunnel alignment in Ketchikan is approximately 100 feet. The Busan-Geoje Tunnel features a structural depth of approximately 4'-6" which is comparable with the proposed concept.

2) To fill a deep spot on the alignment near the western portal structure the Busan-Geoje Tunnel features a raised embankment. The fill represents approximately 10% of the alignment distance and is made over soft ground.

3) The sea-bed sediments are soft for the majority of the tunnel alignment and the low ground pressure of the tube element is ideal for bridging this material.

4) Ship collision studies revealed that moderate draft vessels posed the greatest statistical risk. A vessel impact against the tunnel in the shall approach areas is prevented by widening the rock berms against the tunnel to provide "plowing" distance for the hull. The lateral forces on the tunnel, transmitted via the rock, are resisted by the element reinforcing and by stronger tunnel jointing.

5) The construction cost of the tunnel is 1,000,000,000 US Dollars. This equates to 90,000 dollars per foot, or 23,000 dollars per lane foot. Based on these figures the 3300-foot Ketchikan tunnel will have a crudely estimate price of $23,000 x 2 Lanes x 3300-feet, or 151,800,000 dollars. The estimate range for the Ketchikan Tunnel is currently held in the 180 to 280,000,000 dollar range.

6) The dimensions and stability of the rock embankments were questioned given the perceived seismicity of the State of Alaska. Given the .05g site acceleration per USGS maps, this issue was set aside.

7) The thickness of the rock berms to resist ship collision in shallow areas was suggested to be increased. This is a standard Danish practice for protection of bridge piers.

It was pointed out that the tunnel was 2 years from being a "real" project in the sense of beginning detailed design. It became apparent the tunnel will attract the interest of large design firms who sustain themselves on large public projects.

1.4 DANISH HYDRAULIC INSTITUTE / CURRENTS AND ELEMENT STABILITY

PND met with research engineers from the Danish Hydraulic Institute (Jesper Skourup, Ib Jensen) and discussed the merits and possibilities of modeling the new tunnel to determine affects on local currents if necessary, and to assess any complexities with setting the tube element in deeper water.

1) The water depth poses no real challenges since the currents are relatively low (less that 1-foot per second).

2) The only source of real trouble at the Busan Geoje tunnel has come from long period sea swells which rock the catamaran and tube element more forcibly if the characteristic wave/structure period begins to coincide.

3) The model basins at DHI are extensive and can accommodate large scale tests, and full bathymetry modeling of the tunnel for assessing upstream/downstream affects.

4) For the purposes of the Ketchikan cost estimate approximately 1.4 million dollars was allocated to complete hydraulic/hydrodynamic studies using models or CFD analysis at an independent firm.

1.5 Tunnel Geometry

The geometry of recent Danish tunnels is typified by application of the Eurocode, which is apparently a revision of the AASHTO LRFD code. The parameters for tunnel lane widths, shoulders, and clearance are summarized herewith:

1) Gulborgsund, Falster, Denmark near Nykobing (70 km/hr speed ± 50 mph)

   a. Lane Width: 12' (30' tube width, measured to face of walls)
   b. Clearance: 14'-8" roadway surface to tunnel roof
   c. Shoulder: 2'-0" from lane fog line
   d. No lane separation - two lanes currently in operation

2) Limfjord Tunnel, Aalborg, Denmark (70 km/hr speed ± 50 mph)

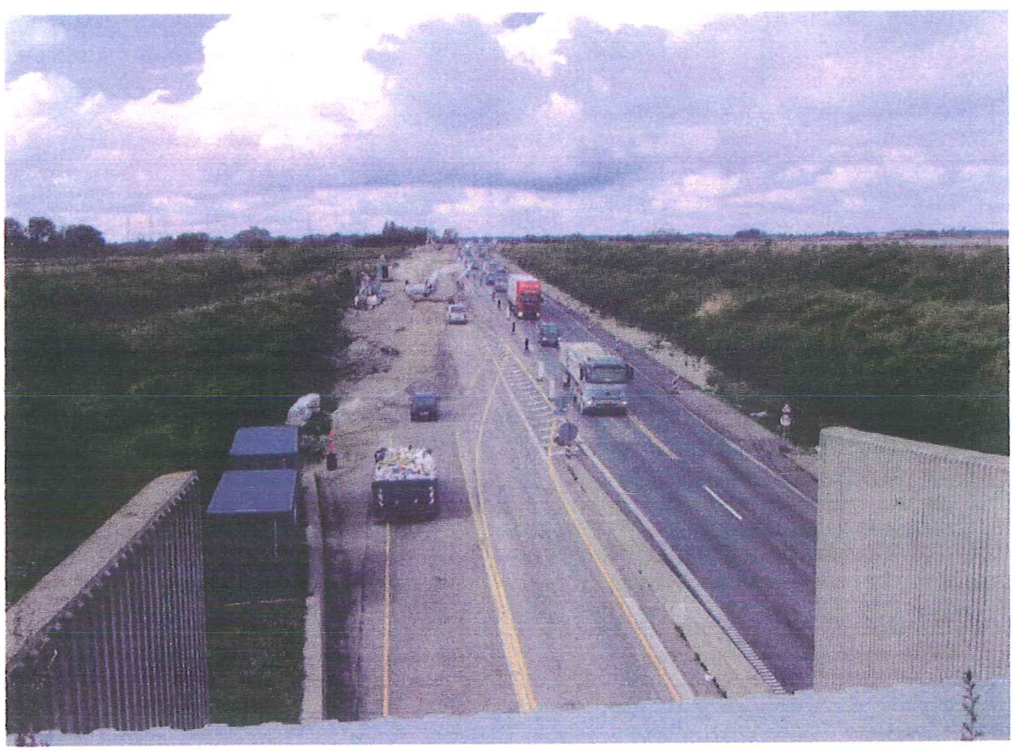
   a. Lane Width: 11-6"
   b. Clearance: 14'-6"
   c. Shoulder: 2'-0"
   d. Lanes grouped by direction (no opposing traffic)

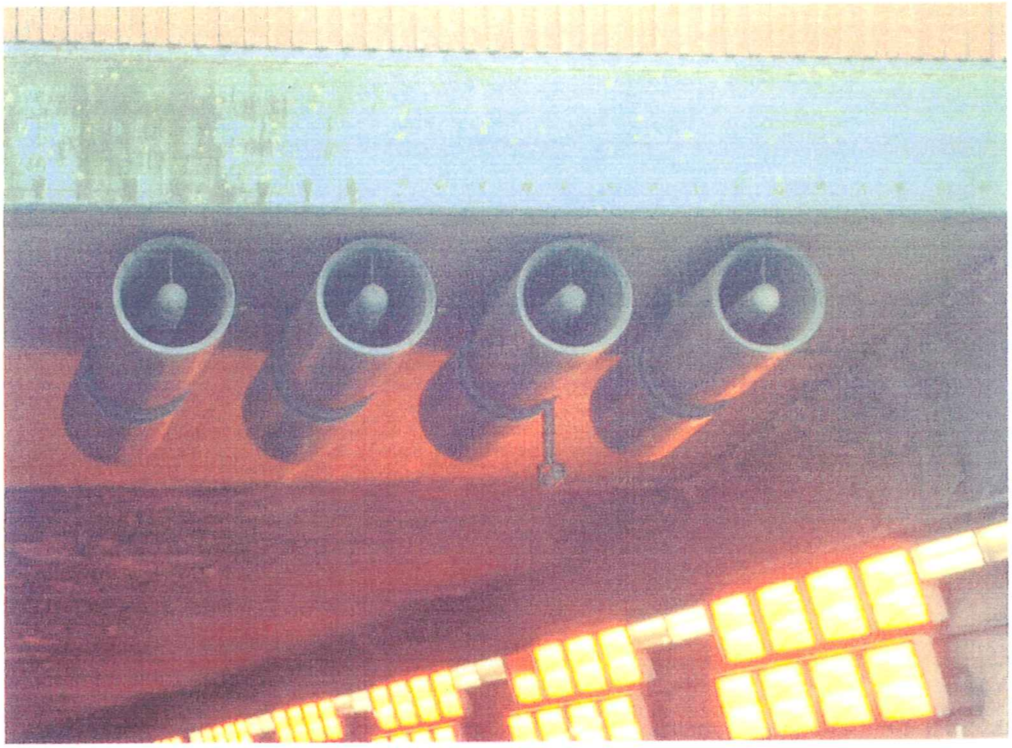
3) George Massey Tunnel, Burnaby B.C (no opposing traffic , 60 mph ± speed)

   a. Lane Width: 11'-6"
   b. Clearanc:e: 14'-8"
   c. Shoulder: 2'-0"
   d. Lanes grouped by direction (no opposing traffic)

Photographs from Guldborgsund (attached) depict the essential details of tube tunnels. Many of the items will be similar to those design for the Ketchikan crossing.

Appendix A
Tube Tunnel at Guldborgsund, Denmark

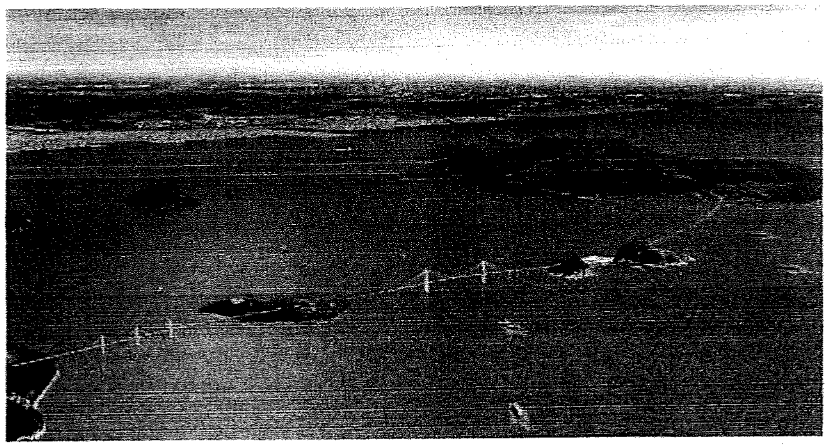


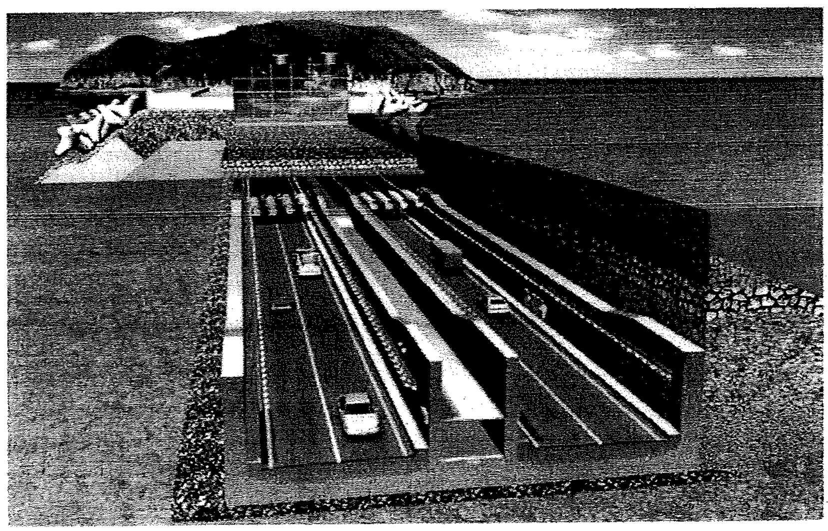


Busan - Geoje Immersed Tunnel, Korea

Services COWI - DEC JV

- **Basic design**
- **Detailed design for tunnels**
- **Detailed design for mechanical and electrical works**
- **Follow up during construction**





Project period: 2003 - 2009

Client: Daewoo Engineering & Construction Co. Ltd.

Construction costs: approx. USD 1 billion

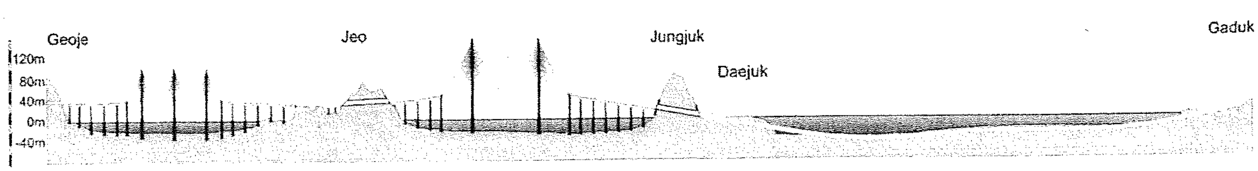
The Busan - Geoje Fixed Link involves the construction of an 8.2 km motorway connecting Busan, Korea's southernmost and second largest city, to the island of Geoje. The connection includes a 3,400 m immersed tunnel - one of the longest in the world - and two cable-stayed bridges each of 2 km in length

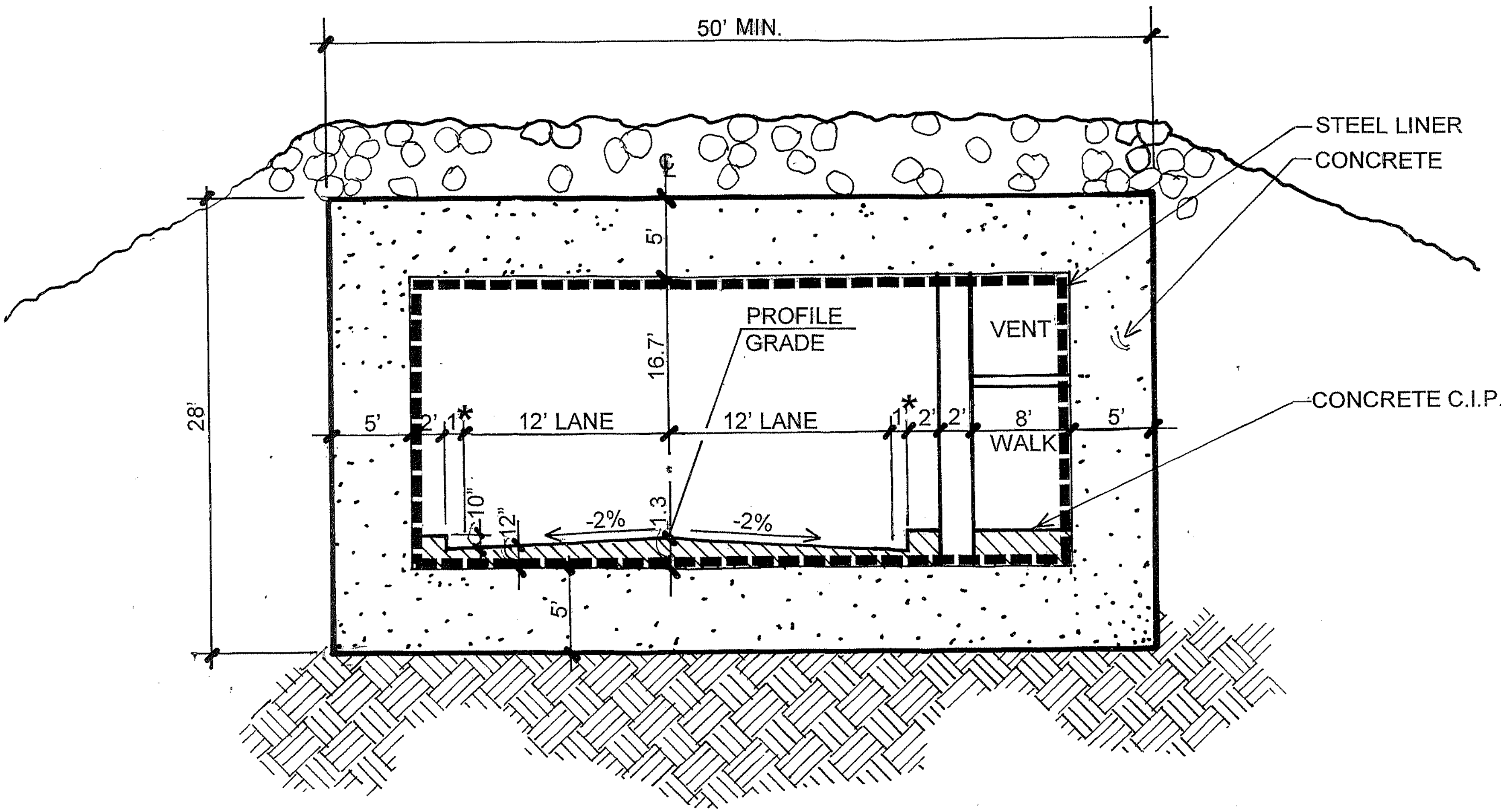
The total length of the tunnel will approximately be approximately 4 km with 270 m portals connecting the tunnel to the island of Geoje and the bridge section.

The design will include the immersed tunnel, west approach open cut structure, east approach open cut structure, ventilation buildings and all related mechanical, electrical and communication systems.

The immersed tunnel will be designed for two-lane traffic with emergency and crawler lane where appropriate. The centre section of the tunnel, between the motorway lanes, will contain utilities and the escape route.

The tunnel will consist of 18 precast tunnel elements placed within a dredged trench at a maximum water depth of 50 metres - the first time an immersed tunnel will be constructed at such depth.

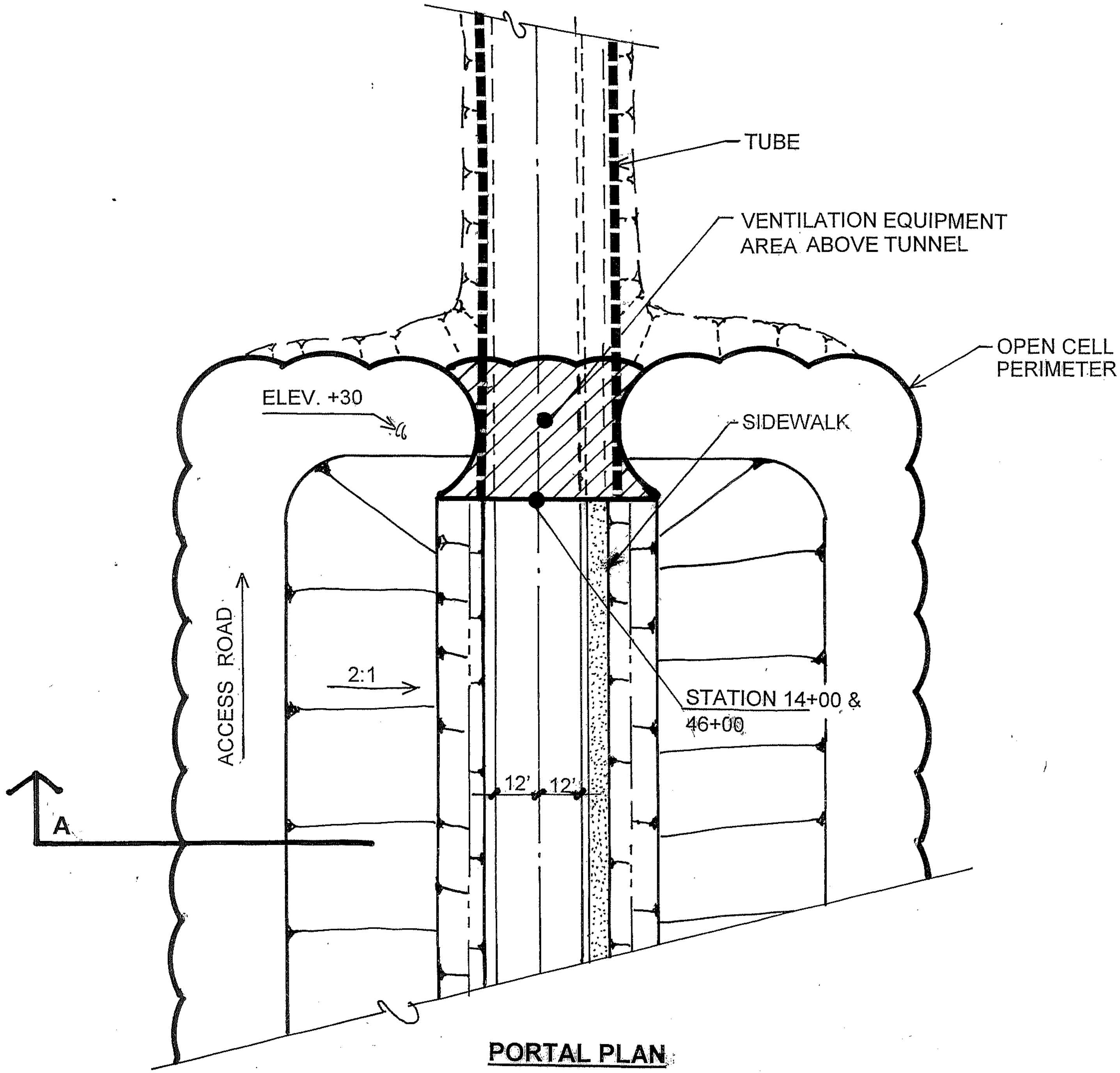




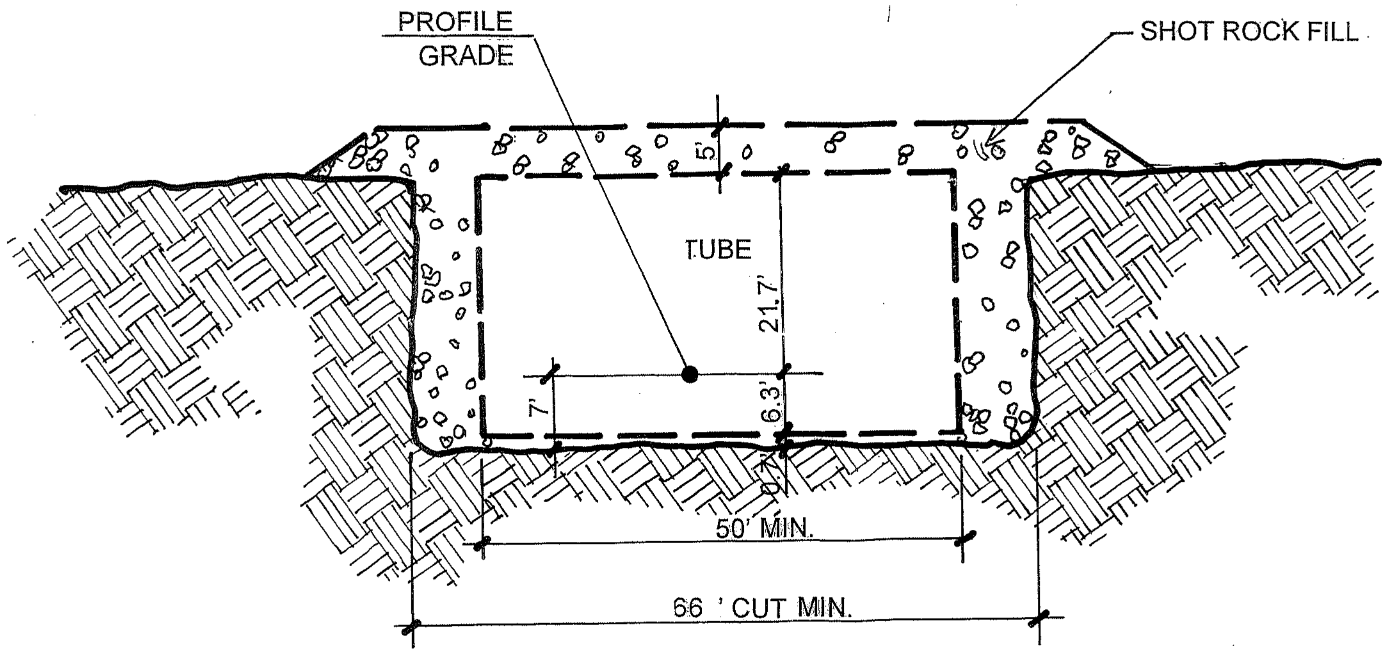
TYPICAL TUBE SECTION

NOTE:

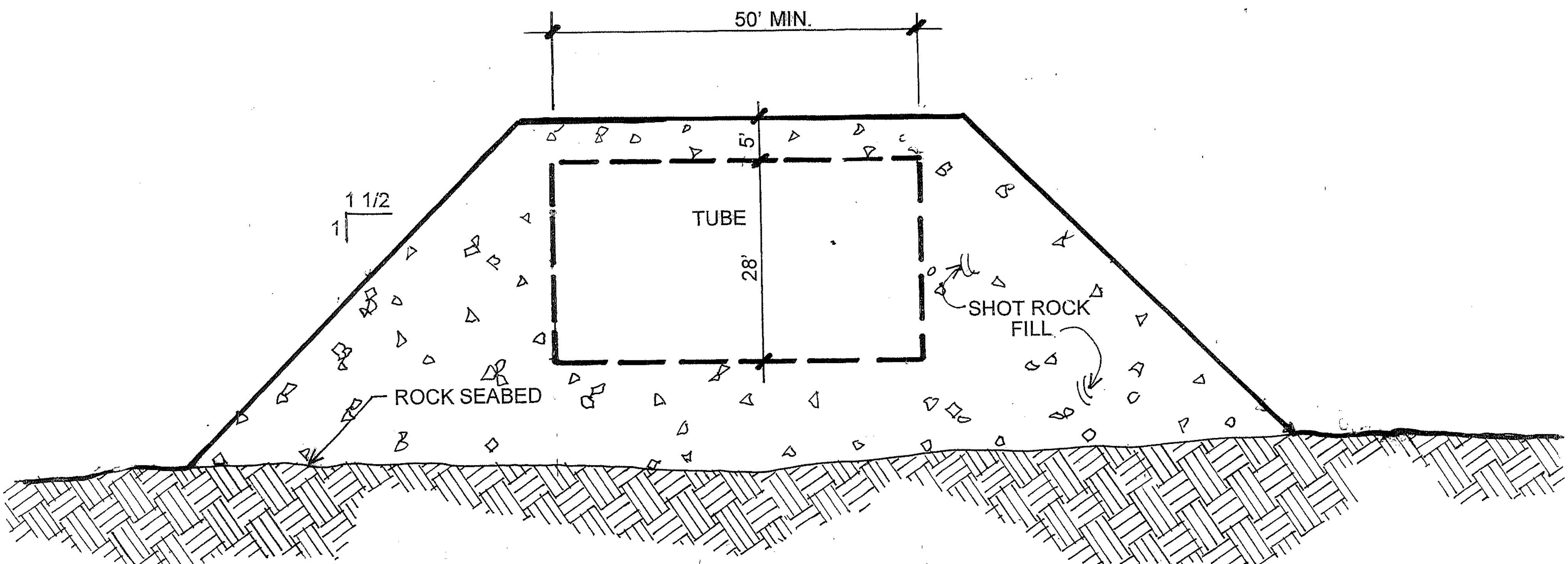
* MINIMUM SHOWN
8' SHOULDER ON APPROACHES


TUBE
VENTILATION EQUIPMENT AREA ABOVE TUNNEL
OPEN CELL PERIMETER
ELEV. +30
SIDEWALK
ACCESS ROAD
2:1
STATION 14+00 & 46+00
12'
12'
A

PORTAL PLAN

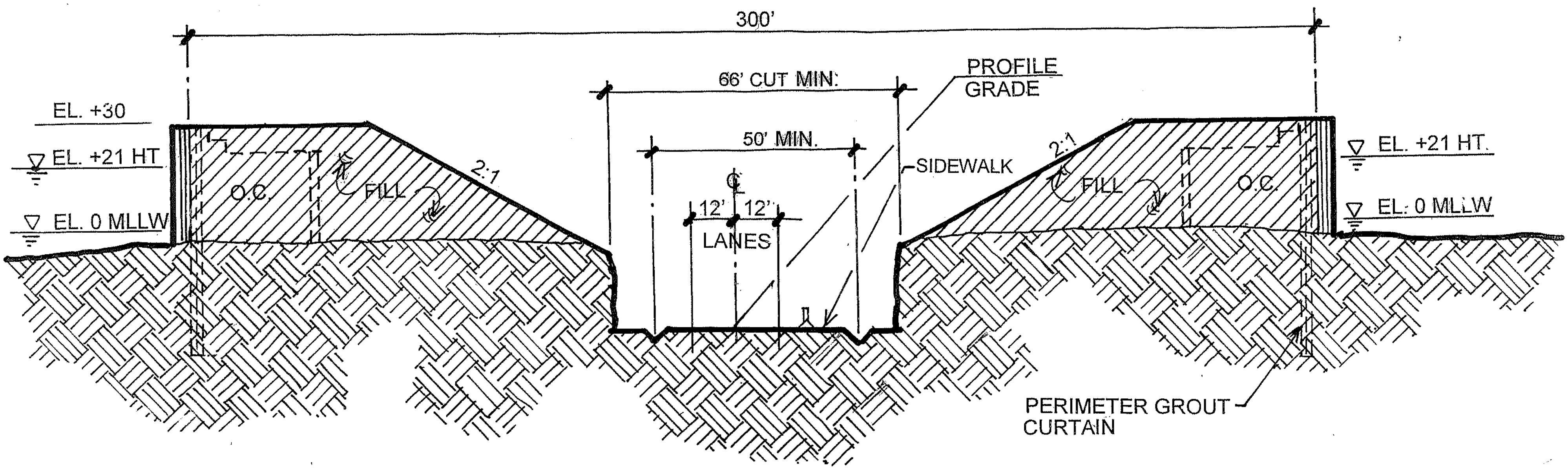


CUT SECTION

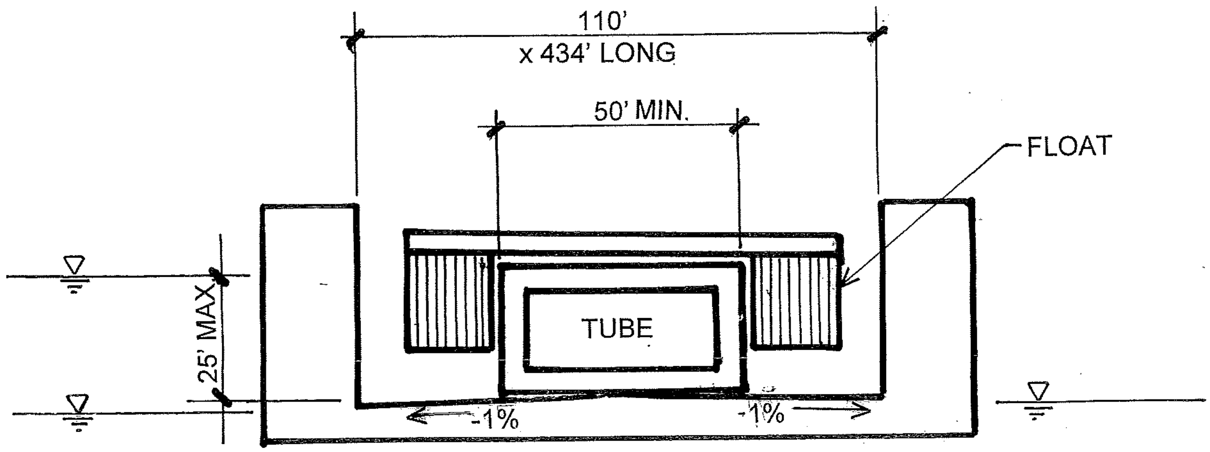


FILL SECTION

TYPICAL SECTIONS


300'
66' CUT MIN.
PROFILE GRADE
50' MIN.
EL. +30
EL. +21 HT
EL. 0 MLLW
O.C.
FILL
2:1
SIDEWALK
12'
12'
LANES
EL. +21 HT.
EL. 0 MLLW
PERIMETER GROUT CURTAIN

SECTION A



KETCHIKAN 10,000 TON DRYDOCK SECTION

TUBE TUNNEL ESTIMATE

1.1 TUBE TUNNEL ELEMENTS – SCOPE OF ESTIMATE

The cost estimate for the new immersed tube tunnel elements is based on application of both detailed and parametric estimate techniques. The estimate is derived from accurate cost history for construction of floating bridges in the State of Washington that follow a very similar construction sequence. The estimate attached herewith covers the following items:

- Construction of the elements in a graving dock or similar structure, served by tower cranes on a track system that will handle materials from delivery points, to actual point of installation into the tunnel elements. This work includes all rebar, post-tensioning, ready mix, steel cladding, forming costs, and the purchase and installation of fabricated steel assemblies that form the element to element joints

- Construction, installation/removal and handling of the temporary bulk heading, and ballast control systems to enable sinking the elements to the sea-bed.

- Construction, operation of the tunnel portal structures, sill area, temporary gates, and dewatering system that will permit using the approach as a casting site for the tunnel elements.

- Fabrication, assembly and operation of the systems necessary to grade the tunnel trench, and install the bedding material under the tunnel elements.

- Costs associated with mating the tunnel element to the transport catamaran, dropping the element to the sea-bed, adjustment of tunnel element fine grade, and installing the joint continuity bolts.

Not included in this estimate are any costs associated with construction of the approaches, rock work to drill/shoot/excavate the trench, construction of the elevated dike in the deep spot along the alignment, and covering the tunnel with armor rock once the elements are founded.

1.2 OVERALL SUMMARY

The following gross summary applies to the attached estimate for the tube element construction

1. Indirect costs prorated to tunnel element construction $ 39,000,000 dollars

2. Direct cost to construct, launch, tow, set, connect 11 elements: $101,500,000 dollars

3. Contractor Fee to construct tunnel elements $ 30,900,000 dollars

A "Summary of Estimate" spreadsheet is included herewith that provides a detailed breakdown of these items. The construction effort can be well understood by prorating the indirect cost and contractor fee to the direct cost(s) and then converting the values to "bid item" per cubic yard cost of tunnel concrete. The values are as follows:

1.	Cast Tube Elements in a graving dock	$1,500/c.y.
2.	Temporary Bulk-heading and Ballasting	$53/c.y.
3.	Sill Construction, Flooding, Towing, De-watering Dock	$151/c.y.
4.	Trench Fine Grading, Bedding Tunnel Elements	$220/c.y.
5.	Mate, Cradle, Transport, Set, Connect Elements	$70/c.y.

By way of comparison, the cost to produce 67,000 cubic yards of concrete for the Lacey V. Murrow Floating Bridge (in the State of Washington) was $86,000,000 dollars in 1994. This equates to $1,283/c.y. If escalated to 2006 dollars this figure would be approximately $1,650/c.y.

For the proposed tube tunnel the listed items 1 thru 3 and 5 are very similar to those necessary for pontoon bridge construction. Adding Items 1, 2, 3 and 5 to the base value of 1,500/cy reveals a per yard cost of $1,774 dollars. This value is reasonably close to the cost history for similar type construction. Effort to grade the tunnel trench is unique to tube tunnels and is an added per cubic yard cost.

If the tunnel elements are constructed in the Puget Sound area there is a potential to reduce indirect cost by 10,000,000 dollars, and the direct cost by 19,000,000 dollars. A detailed discussion of this reduction is provided in Item 1.6.

1.3 Indirect Cost Summary

An indirect cost estimate has been developed for the Ketchikan Tunnel as presented in the concept design. This is the price of the "infrastructure" necessary to perform the direct cost work associated with building the tunnel sections.

The total indirect cost estimated for the project is 47,000,000 dollars – a detailed break-down is included on the attached spreadsheet. To allow prorating this cost to actual tube element work a value of 80% has been applied, or 38,000,000 dollars. The remaining 20% is assumed to be allocated to approach and rock work not covered in this estimate. The indirect cost summary for tunnel element construction is as follows:

a.	Major Equipment	$16,300,000	Derricks, Barges, Cranes, Catamaran
b.	Misc. Equipment	$2,400,000	Compressors, pumps, welding, rigging
c.	Specialty Items	$4,400,000	Batch Plant, Concrete pumping
d.	Project Management	$8,200,000	Salaries, Housing, Proj. Engineering
e.	Survey / Geometry Control	$1,800,000	Equipment and Fixtures
f.	Safety Equipment	$500,000	Safety equipment, drug testing

g. Site Offices / Utilities $2,200,000 Office compound, dry-dock rent

h. Insurance, Bonds, Expense $2,300,000 Operations, and Bonding

1.4 DIRECT COST SUMMARY

The direct cost to construct the tube tunnel elements are the real dollars paid for permanent material, labor, equipment, consumable supplies, and subcontract services. The estimate is based on construction in Ketchikan using one approach ramp as a graving dock to build one 300-foot element at a time.

a.	Tube Elements Complete in the graving dock	$77,000,000
b.	Furnish, Install, Remove Temp Bulkheads	$2,700,000
c.	Furnish / Operate Sill, Gate, Dewatering	$7,600,000
d.	Grading Sea-bed, Build tunnel bedding rock	$11,000,000
e.	Mate, Transport, Lower, Connect	$3,500,000

1.5 "BID ITEM" COSTS (CONTRACTOR FEE + INDIRECT + DIRECT)

The contractor is expected to view the work to construct the tunnel elements as low risk with regard to complexity. However, the fee in the marketplace for doing this work is difficult to determine objectively. The price a contractor will charge to the owner for actually taking on the risk/reward for the project is dependant on backlog, market conditions, and potentially the availability of joint venture partners. The percentage estimated for this work is taken as 22%, and could be as low as 8% in the extreme.

- Contractor Fee for tube construction work is estimated to be: $31,000,000

Given this "fee" the net bid item cost to the owner (direct cost, plus indirect and fee added) is estimate to be as follows (for 85,000 cys).

a.	Tube Tunnel Elements Complete (in dock)	$129,000,000	($1,500 per c.y.)
b.	Furnish, Install, Remove Temp Bulkheads	$4,500,000	($54 per c.y.)
c.	Furnish / Operate Sill, Gate, Dewatering	$12,800,000	($151 per c.y.)
d.	Grading Sea-bed, Build tunnel bedding rock	$18,700,000	($220 per c.y.)
e.	Mate, Transport, Lower, Connect	$5,900,000	($70 per c.y.)
f.	Total Gross Cost for Tube Elements	$171,000,000	($2,000 per c.y)

1.6 POTENTIAL CHANGES TO THE BASELINE ESTIMATE

The estimate summarized herewith reflects the cost to construct the new tunnel within the limits of the greater Ketchikan area. From this baseline estimate it is possible to make adjustments based on different assumptions about where, when or how the tunnel might be constructed.

There is an economy to be gained by constructing the tunnel sections in the lower 48 states and towing them to Ketchikan for installation. At the time the elements leave the dock they are positive buoyant and can be towed to the project site assuming that ABS inspection/approval of the temporary "hull" is obtained. The ABS approval is necessary notwithstanding that auxiliary floatation or a catamaran will be attached to secure the element during transport.

Casting at a site such as Concrete Tech in Tacoma, or Todd Shipyard in Seattle, will reduce the indirect overhead cost from 38,000,000 to approximately 28,000,000. The reduction is achieved by eliminating the costs for onsite batch plant, steel plate assembly yards, tenting and heating for cool weather work, reduced equipment mobilization fees, and reducing costs for housing/feeding staff and craft labor in the Ketchikan area.

Labor efficiency will likely increase given the attractiveness of a large project constructed in an urban core area. It is estimated that a 15% improvement can be realized by constructing the elements in the Puget Sound area. For 85,000 cubic yards, at a base cost of 1,500/cy a reduction of $225/cy will enable a savings of 19,000,000 dollars. The cost per yard would decrease to $1,250 which would represent a realistic number for concrete work in the greater Seattle area.

The net aggregate savings would be $10,000,000 for indirect costs, and $19,000,000 for direct costs.

1.7 REFERENCE DOCUMENTS USED TO PREPARE THE BASELINE ESTIMATE

The estimate computation references the following documents:

1. Final Cost and Bid Costs for Lacey V. Murrow Floating Bridge (LVMB) . LVMB is a 6800' long x 60' wide x 20' deep floating bridge over Lake Washington, completed in 1994. The water depth is 300 feet. Twenty 300-foot long bridge pontoons were constructed in graving docks located in Seattle and Tacoma.

2. Production history from bridge, tunnel, and heavy foundation work compiled by Michael N. Huggins during the period 1988 to 2003. The cost history includes such projects Alsea Bay Bridge (3200-foot post-tensioned segmental bridge completed in 1991), Lacey V Murrow floating bridge, First Avenue South Bridge (Bascule with pre-cast approach girders completed in 1996), and Tacoma Narrows 2nd Crossing (Foundation caisson work - completed in 2004)

3. Final Bid costs for Hood Canal Floating Bridge (2003) – currently under construction.

DEEP COMPACTION USING VIBRATORY PILE HAMMERS

Dennis Nottingham, P.E., President, PND Incorporated, Anchorage, AK, USA

The need for deep compaction of submerged granular soils has led to improvements in this area. In 1971 L.B. Foster Company personnel patented a method of deep compaction using a vibratory pile hammer and pile probe. The technique had some success, but did not produce consistent results and thus found its way to obscurity. Other patents attempted to modify the technique by various probe modifications, but again without measurable improvement from a practical point of view. Solutions to economical deep compaction up to 100-foot depths particularly in saturated granular soils would have a great impact on the construction industry and new bulkhead structures being developed, thus PND was prompted into related research and development. The advent of higher horsepower vibratory hammers, coupled with PND engineers' experiments, observations and measurements, led to an "H" pile probe design which has produced measured soil density improvements up to 250% using SPT "N_{60}" values as a measure.

INTRODUCTION

The condition requiring deep compaction in fill placed below water level is a problem particularly for various bulkheads. During construction, sheet piles are placed before final filling operations, thus fill below water table will either be uncompacted or must be compacted after the structure is in place. Compaction causes fill settlement which can load tiebacks and cause distress in some cases.

The open cell type bulkhead was developed to avoid this problem, but nevertheless still needs compaction to ensure strength and help prevent long-term settlement. This is particularly true in high seismic areas where loose granular soils (i.e., less than "N_{60}" of 25 or so) might liquify and cause temporary loss of strength.

Other construction such as tubular tunnel backfill or large marine filled areas could also benefit from improved compaction techniques. Since vibratory type compaction effectively locally "liquifies" soil temporarily, affected soil must be of a granular nature with probably less than 15% by weight passing the No. 200 sieve.

Fine granular soils can be also use a variation of this method, but soils will not immediately densify. Instead, granular filled columns can be created for longer term stabilization.

VIBRACOMPACTION DEVELOPMENT

PND has researched deep compaction for several years, trying various methods including large surface vibratory compactors and various probes using vibratory pile hammers common to Alaskan marine construction. None of these methods were entirely successful until a new type probe surfaced through PND research and development.

It soon became apparent that previous deep compaction procedures using vibratory hammers and probes were simply not transmitting hammer energy into the surrounding soil.[i] New probe designs began to evolve in concert with larger horsepower vibratory hammers with obvious increased ability to densify soil.

One project on the Mississippi River with fine uniform sand backfill produced average SPT N_{60} increases of over 250%. This was based on a limited number of pre- and post-compaction comparative soil tests.

Further probe improvements were finally tested on a large scale project in the summer of 2003 at the Alaska Port MacKenzie project involving stabilization of a large fill extending 800 feet seaward fronted by a 500-foot Open Cell bulkhead used as a barge dock.

COMPACTION EQUIPMENT

Equipment specified for vibracompaction was a minimum 500 hp vibratory pile hammer with a HP14 probe. The probe was specified to include a series of angles welded to the web (see Figure 2). Previous PND experience had shown that the angles help to increase densification. This is accomplished as angles help push material laterally as the probe is raised and lowered.

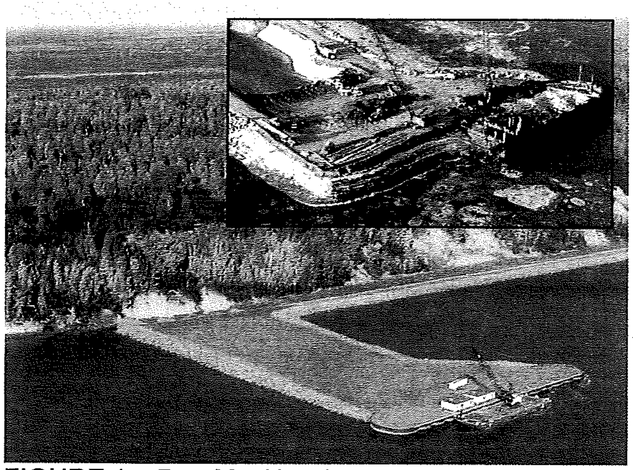


FIGURE 1 – Port MacKenzie

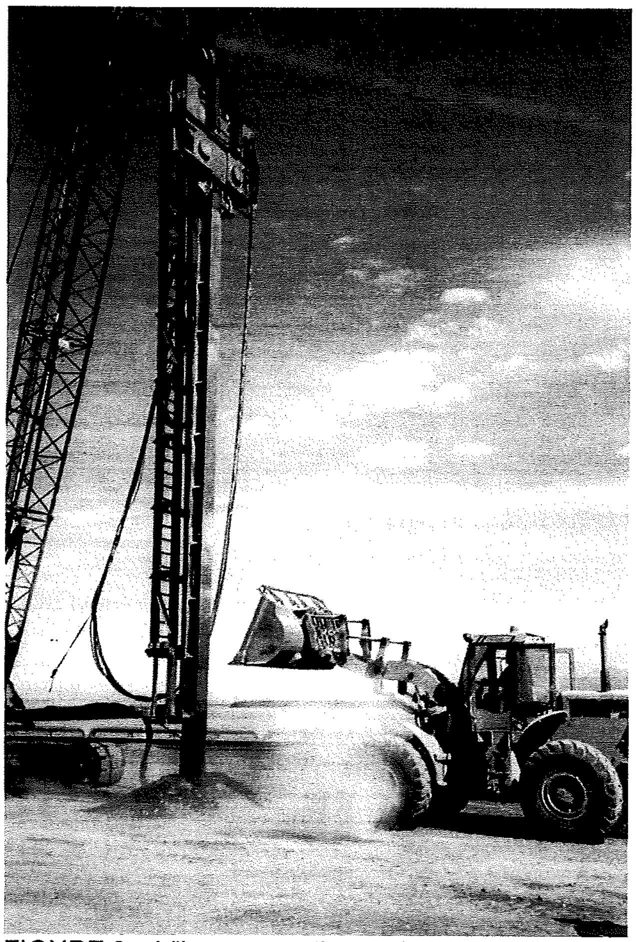


FIGURE 2 – Vibracompaction probe

For this project, the contractor provided an APE model 300 vibratory hammer. The contractor removed the counterweight from their crane and welded a framework to support the power pack of the hammer, while the probe and hammer were hung from a set of leads (Figure 3). This setup allowed the crane and compaction equipment to be portable and only required the contractor to have two workers on-site throughout the vibracompaction effort.

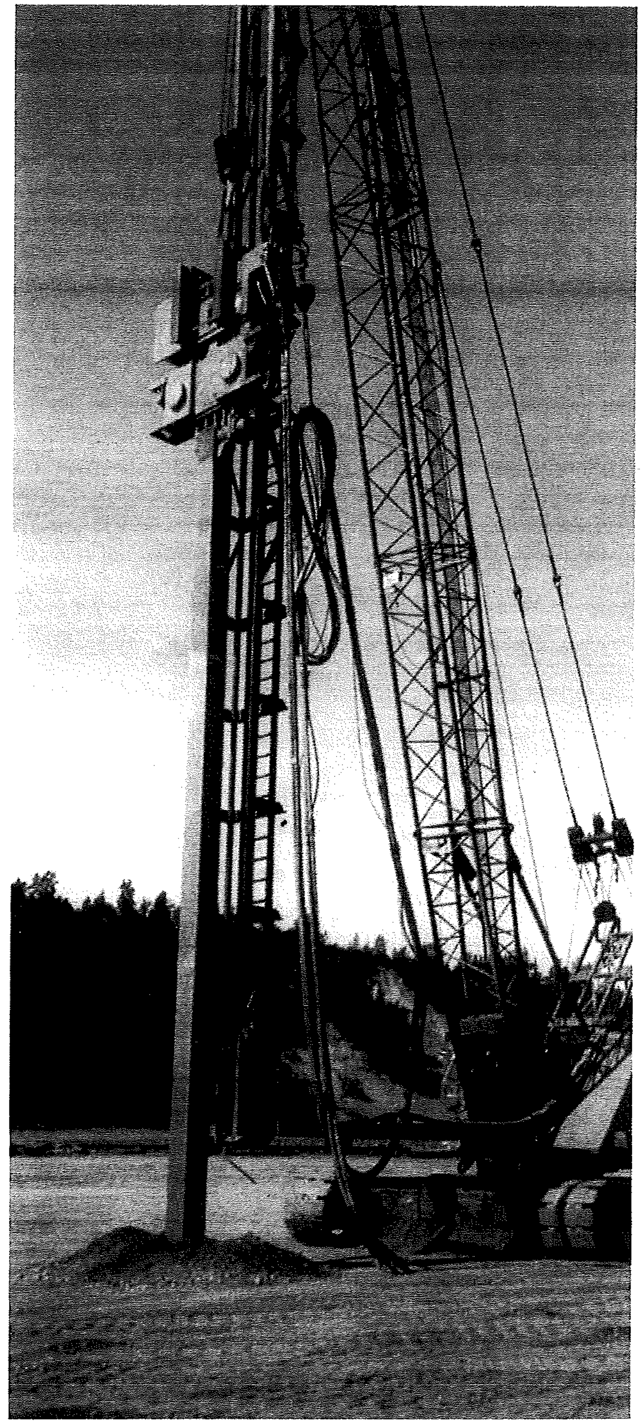


FIGURE 3 – Vibracompaction equipment.

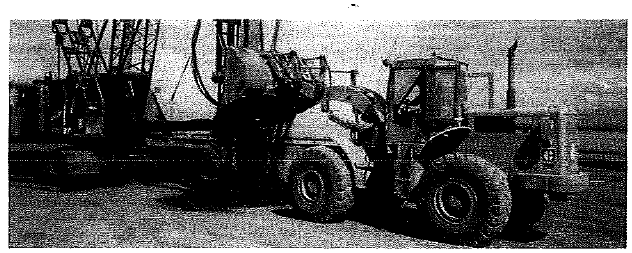


FIGURE 4 – Fill added to vibracompaction probe depression.

PROCEDURE

The two types of fill materials present on-site were gravelly sands and fine-grained soils overlying hard silty clays. The properties for each soil type required different probing requirements. Loose, gravelly sand is more permeable and susceptible to consolidation under vibratory loads when saturated. Because of these material properties, most of the compaction of this type of material takes place during and shortly after the probing process is completed. Essentially, the probe vibrates the soil particles vertically and laterally as the probe is lowered and raised. The soil particles achieve a state of localized instability and the soil particles densify as the soils settle as the excess pore water pressure is relieved. Raising and lowering the probe in a series of cycles allows for additional material to enter the hole and fill the voids created.

Consolidation of fine-grained soils requires substantially more time than the gravelly sand material and can take years depending upon the length of the drainage path, permeability, gradation, and cohesive qualities of the material. Because of these factors, consolidation of the soil matrix is usually very slow. The probing procedure used for the sandy soils was also used for the fine-grained soils, except that a coarser fill material was used (Figure 4). This procedure creates a series of granular fill columns within the fine-grained soil matrix which increases the overall bearing capacity. The granular fill columns will also function as vertical drains. In general, water will be able to dissipate laterally towards the drains at an increased rate. Therefore, the bearing capacity of the fill material will continue to increase with time.

PRODUCTION PROGRAM

Pattern and Procedure

After SPT calibration and probe spacing testing programs were completed, the contractor continued probing holes and placed fill material at each probe location.

Production Rate

The vibracompaction effort consisted of 1792 probe locations which consisted of:

- 1043 probes in the gravelly sand area requiring 7,020 cy of gravelly sand fill material.
- 749 probes in the fine-grained soils requiring 5,022 cy of three inch minus granular fill material

On average, the vibracompaction required 6.7 cy of fill per probe location at an average depth of over 40 feet. Some probe locations were reported to take up to 12 cy of fill material. Overall volumes were computed by truck load count.

The contractor averaged 27 probes per day (typical range between 22 to 35 probes per day). During one ten hour shift, he completed 41 probes.

Post Trip Hammer "N"

Analysis of the Post SPT data shows the average N_{60} of the perimeter gravelly sand fill material within the GWT increased significantly. There was no significant change in strength of the hard fine-grained seabed soil. The auto trip hammer results were corrected to N_{60} and are shown following.

Perimeter Fill Area
Gravelly Sand underlain by the seabed
Gravelly Sand (above water table) $N_{60} = 36$
Gravelly Sand (below water table) $N_{60} = 66$

Interior fill
Fine-grained soil underlain by the seabed
Fine-Grained Soils (above water table) $N_{60} = 2$
Fine-Grained Soils (below water table) $N_{60} = 12$

SUMMARY

The vibracompaction program has shown immediate improvements in the density of the perimeter gravelly sand fill material. Additionally, the post vibracompaction average blow count, ($N_{60} = 66$), of the soil below the GWT is clearly higher than required for liquefaction stability.

Gravelly Sand Fill
Blow Count Summary

Location	Pre N_{60}	Post N_{60}	Ratio (Post/Pre)
Above GWT	14	36	2.5+
Below GWT	26	66	2.5+

OTHER PROJECTS

Many other projects have had vibracompaction activity during research and development and with the final production system. Granular soils of many types have been compacted including soils ranging from fine sands to shot rock fill.

Open Cell bridge abutments founded on loose granular soils can readily be area stabilized using the vibracompaction process. An example is the Alaska Iliamna River Bridge. This was permitted, designed and constructed in 14 weeks in late 2003, complete with vibracompacted stabilized Open Cell abutment.

FIGURE 5 – Vibracompaction of shot rock fill at Dutch Harbor, Alaska.

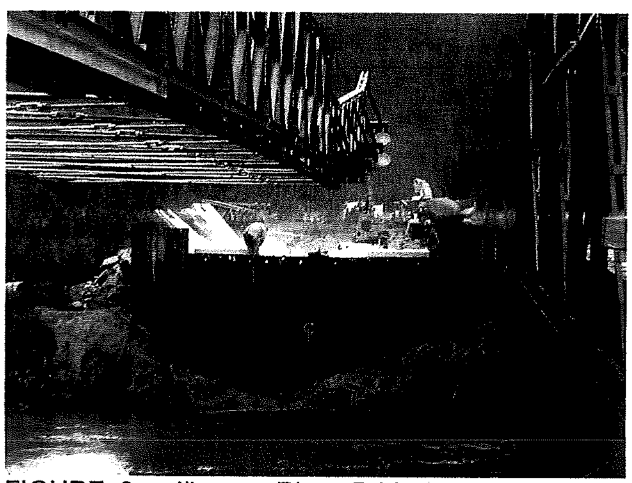


FIGURE 6 – Iliamna River Bridge with Open Cell abutment and Bailey Bridge launch in progress.

A dock at King Cove, Alaska, is typical of many docks built on loose, but stabilized granular soils.

Figure 8 shows a typical situation requiring deep compaction for a bulkhead. Figure 9 shows another potential use involving backfill compaction of a buried subsea tunnel or conduit.

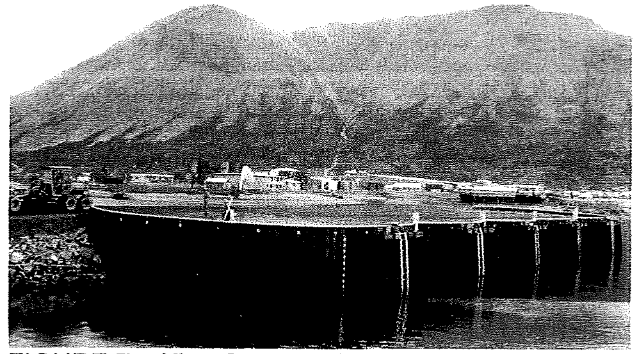


FIGURE 7 – King Cove Dock

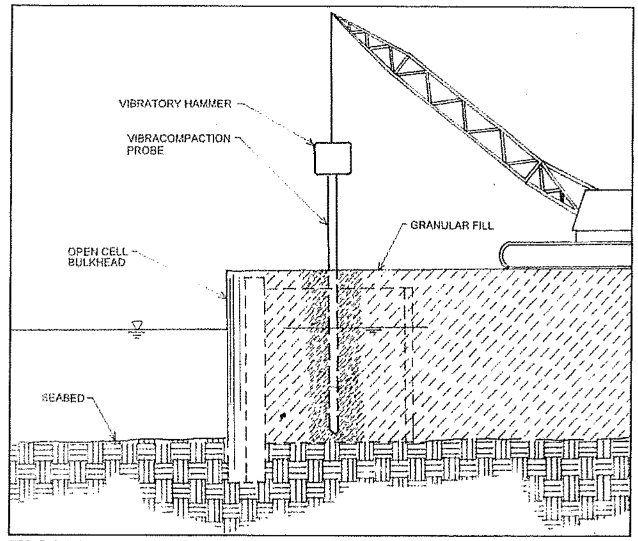


FIGURE 8 – Compaction below water table in fill.

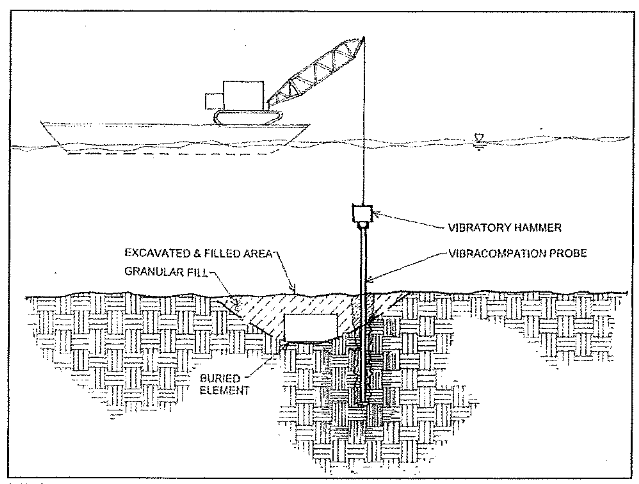


FIGURE 9 – Use of vibracompaction for deep water compaction.

CLOSURE

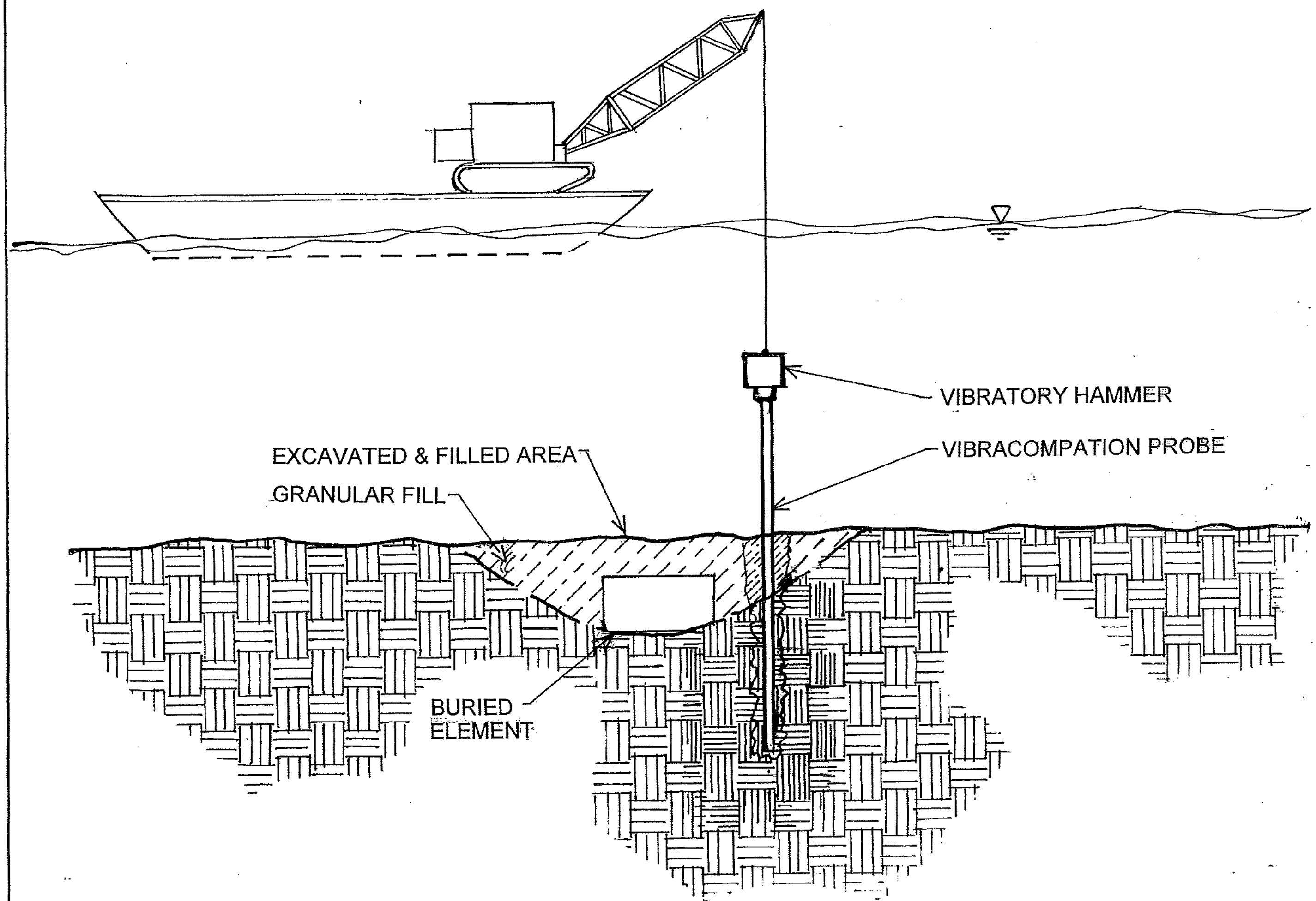
Deep vibracompaction such as described in the preceding has important application in high seismic areas with loose soils. The ability to compact to great depths now gives the engineer more tools with which to provide greater safety with lower cost to the public.

Other deep compaction methods are really not comparable to this method, which uses large-horsepower vibratory hammers coupled with the new probes capable of reaching far below groundline.

Anderson, Robert D., Alvin E. Herz, Clabeorn Jones, Harold Strickland and William K. Wilson, Nov. 23, 1971, U.S. Patent No. 3,621,659, Methods of Soil Compaction.

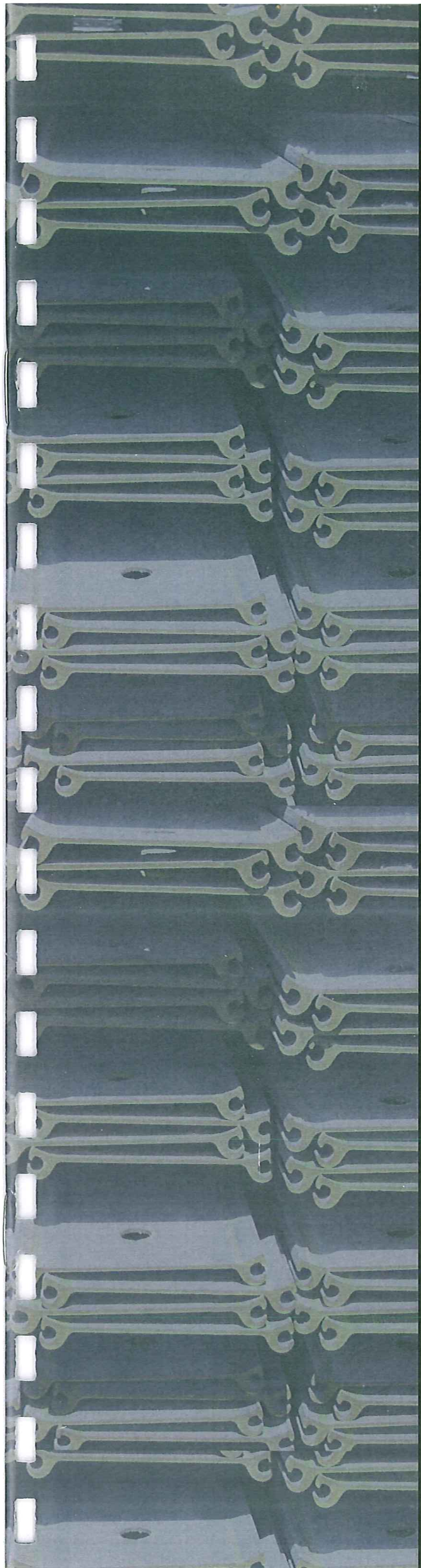
ASTM D-1586, 1999, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils, pg 145.

Laidlaw, Amy, Executive Director, Construction Innovation Forum, March 12, 1998, "Open-Cell Bulkheads Wins Prestigious NOVA Award" (press release).



USE OF VIBRACOMPACTION FOR DEEP WATER COMPACTION

FIGURE 9



OPEN CELL
TECHNOLOGY

PND
Incorporated

CONSULTING
ENGINEERS

August 17, 2006

Cost Estimate Assumption made by Charles Pool for Tongass Narrows Tunnel Crossing Concept Plan

1. Mobilization costs on earth work (rock excavation, shot rock fill, open cell fill, Vibro-Compaction, Cast-In-Place Concrete and other site specific items) would be ten percent (10%) of the estimated total costs of those items.

2. Seabed muck excavation would be preformed with a conventional crane barge with multiple anchor systems and heavy clam bucket. Muck would be loaded onto a bottom dump barge for ocean disposal or onto a deck barge for disposal at an approved uplands land fill.

3. Rock excavation above the Mean Lower Low Water (MLLW) elevation of 0.00 would be accomplished using conventional drill and blast techniques and removal by large excavators and trucks operating from shore side during low tide periods.

3A. Rock excavation below MLLW elevation 0.00 would be accomplished using barge mounted rock drilling equipment and underwater drilling and blasting techniques to break the stone into small pieces for removal by barge mounted excavators or cranes with heavy clam buckets.

4. Excavated rock would be loaded onto a bottom dump barge and the material placed in the areas below the tube requiring fill.

5. Shot rock tube cover fill will be drilled and blasted from an uplands rock quarry area and hauled by truck and loaded on dump barges for placement under water on top and around the sides of the finished tube after placement of the tube. A crane barge with clam bucket may be required for finish grading.

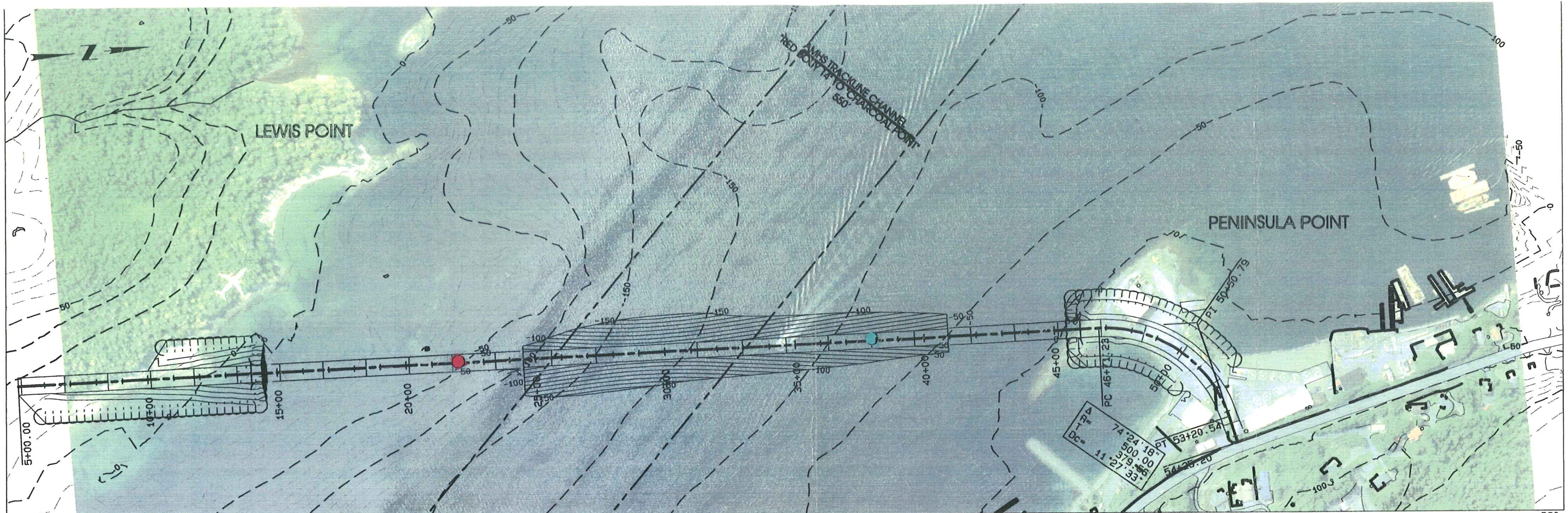
7. Open cell fill would consist of graded shot rock which would be quarried from an uplands source and trucked to the site and placed with conventional equipment.

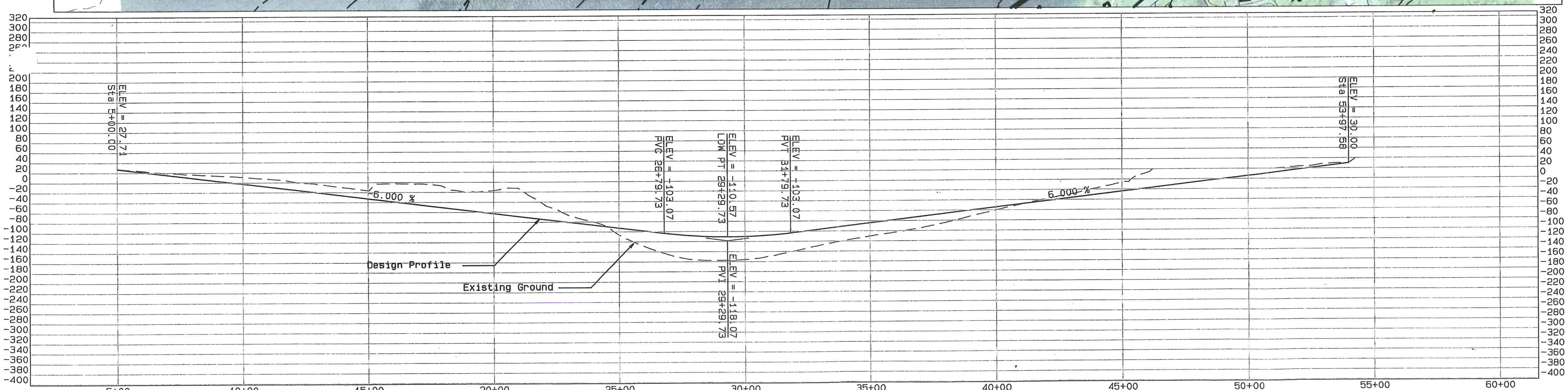
12. Cast-In-Place Concrete paving will be performed using conventional paving techniques inside the tube after tube placement.

The unique Open Cell™ bulkhead structure can be used economically for docks, bridge abutments, retaining structures and many other structure types. Open Cell sheet pile bulkheads were developed by PND for the express purpose of meeting the demand for an economical, easily constructed, extremely strong retaining structure.

Earth-filled structures historically have had a long history of problems with stability, scour and settlement. Open Cells are flexible steel sheet pile membranes supported by soil contact with embedded anchor walls. This concept creates an integral reinforced soil system. The result is a structure that can withstand large settlements and support a variety of heavy loads. In effect, viewed from above, the structure becomes a series of U-shaped vertical membranes that require no toe embedment for stability.

The Open Cell bulkhead is constructed of only three components: flat sheet piles, fabricated connector wyes and anchor piles. Compared to alternative structures, several cost savings are realized from this land based construction such as, reduced sheet pile area, greater construction tolerances, minimal pile penetration, and reduced effort for backfilling procedures. In seismic regions or weak soils, the tail walls can be extended as required to ensure fill mass stability.





NOTES:

COORDINATE SYTEM = NAD83 ALASKA STAE PLANE, ZONE 1, FEET
VERTICAL DATUM = MLLW
VERTICAL UNITS = FEET

REV	DATE	DESCRIPTION

1506 West 36th Avenue
Anchorage, Alaska 99503
Phone: 907.561.1011
Fax: 907.563.4220
www.pnd-anc.com

PND ENGINEERS Incorporated

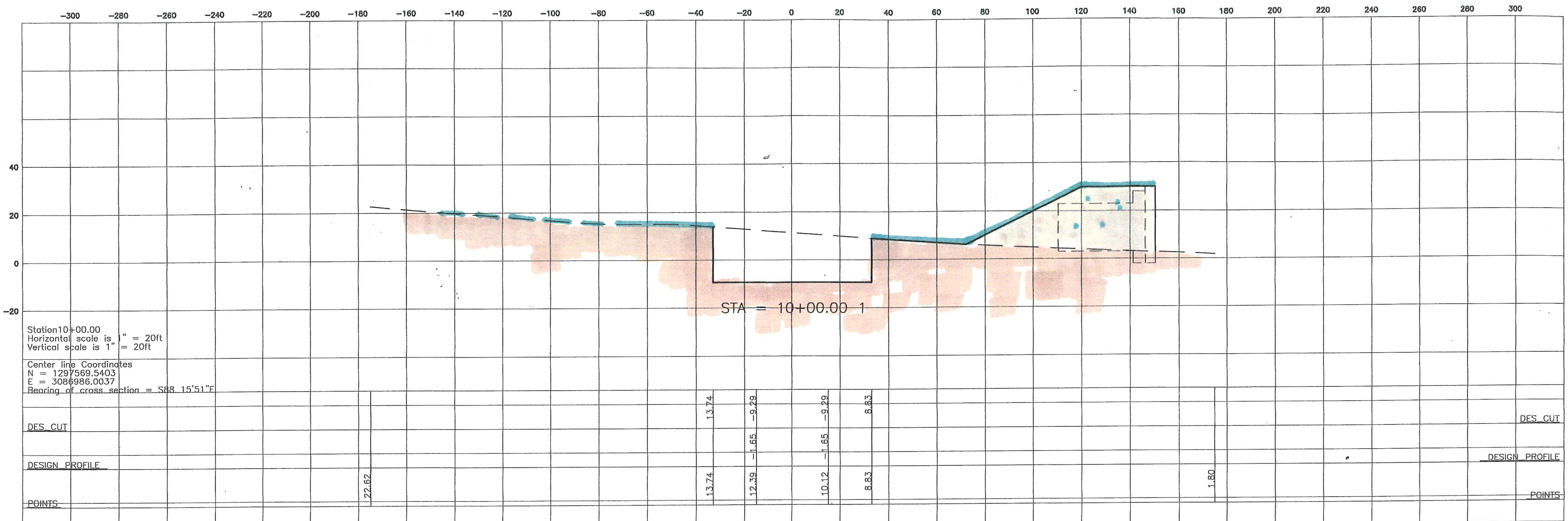
PROJECT: TONGASS NARROWS CROSSING

TITLE: PLAN & PROFILE CONCEPT

DRAWN BY:	TG		SHEET NO:
DESIGNED BY:	DN\TG	DATE: 8/17/2006	1 OF 1
CHECKED BY:	DN	PROJECT NO: 051084	

TONGASS NARROWS
TUNNEL CROSSING
CONCEPT PLAN

INDEX OF CROSS SECTIONS: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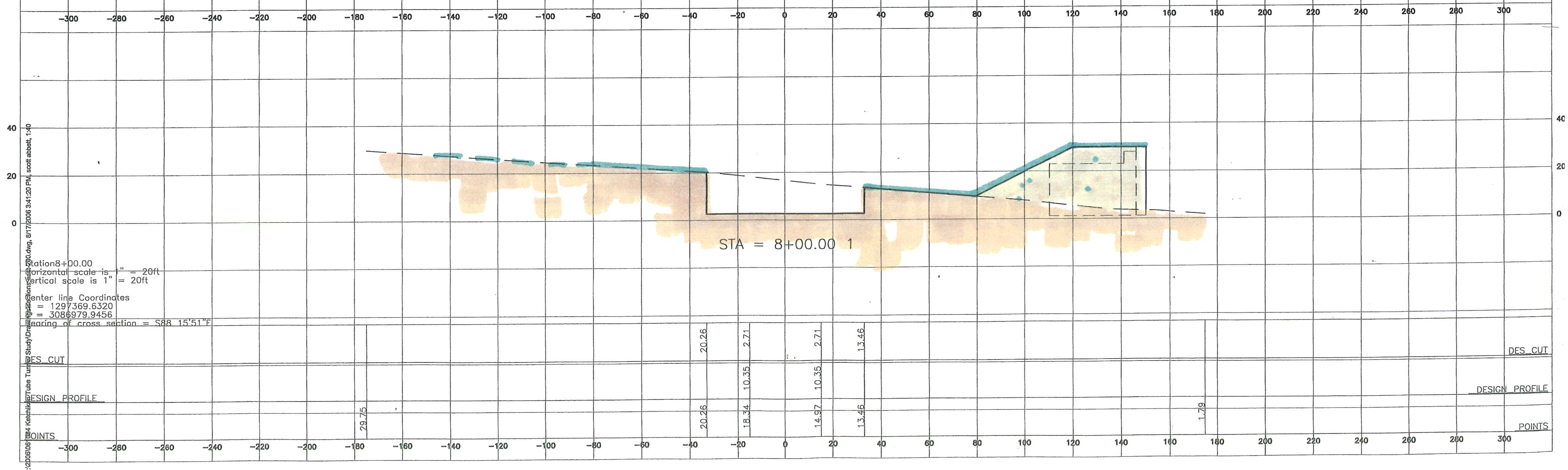
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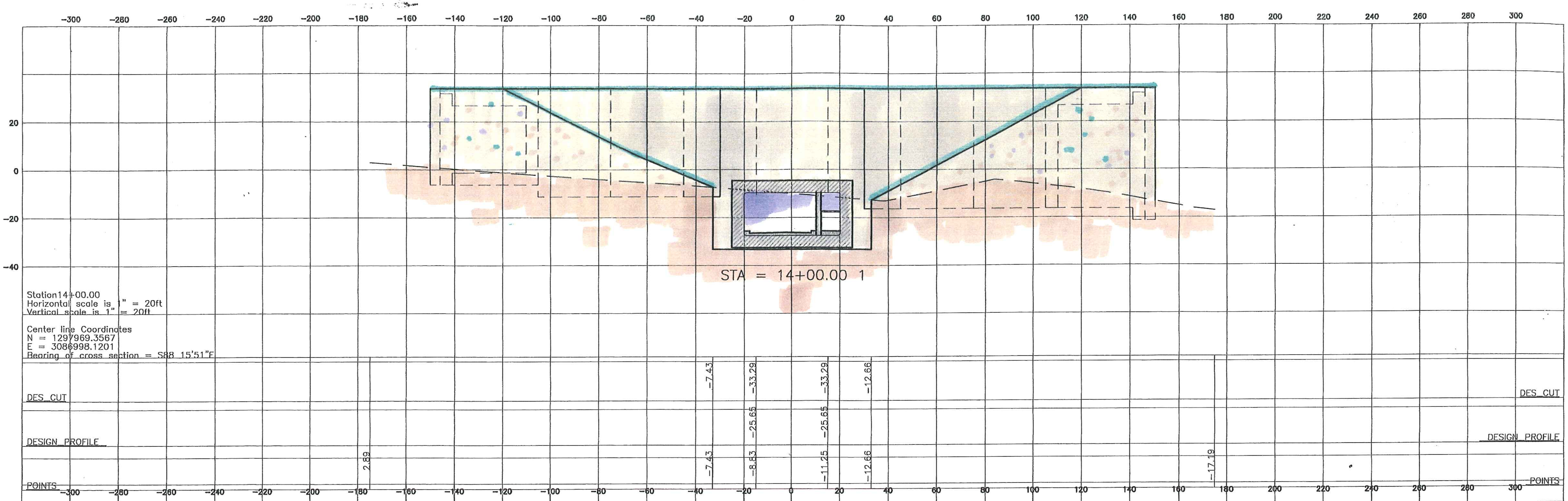
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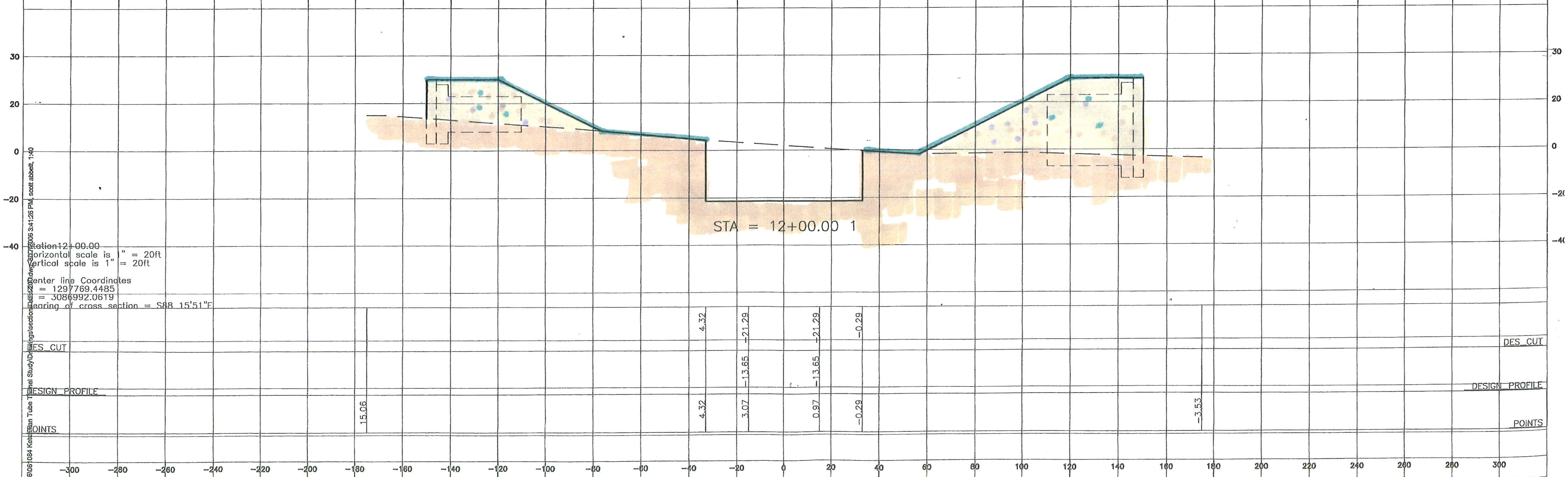
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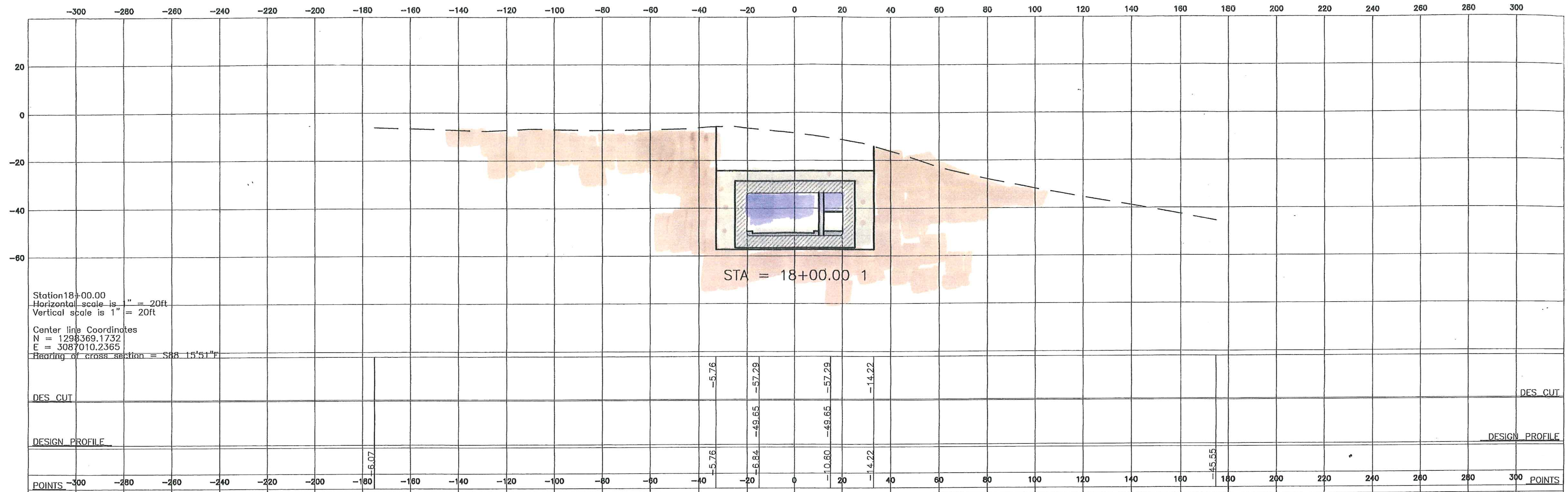
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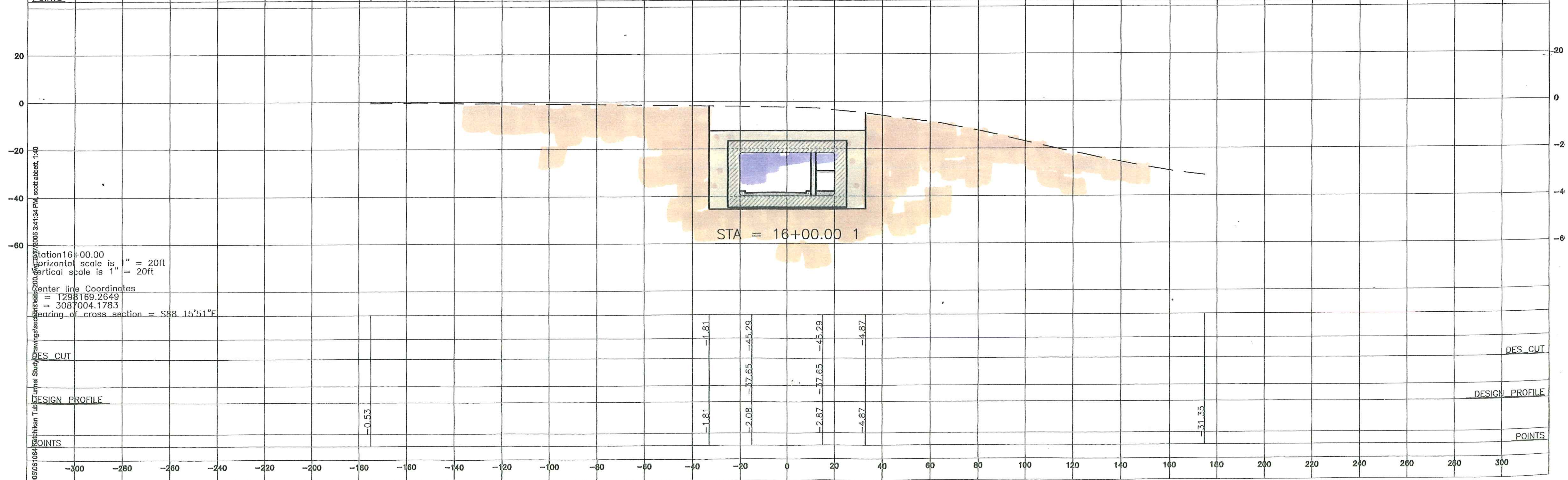
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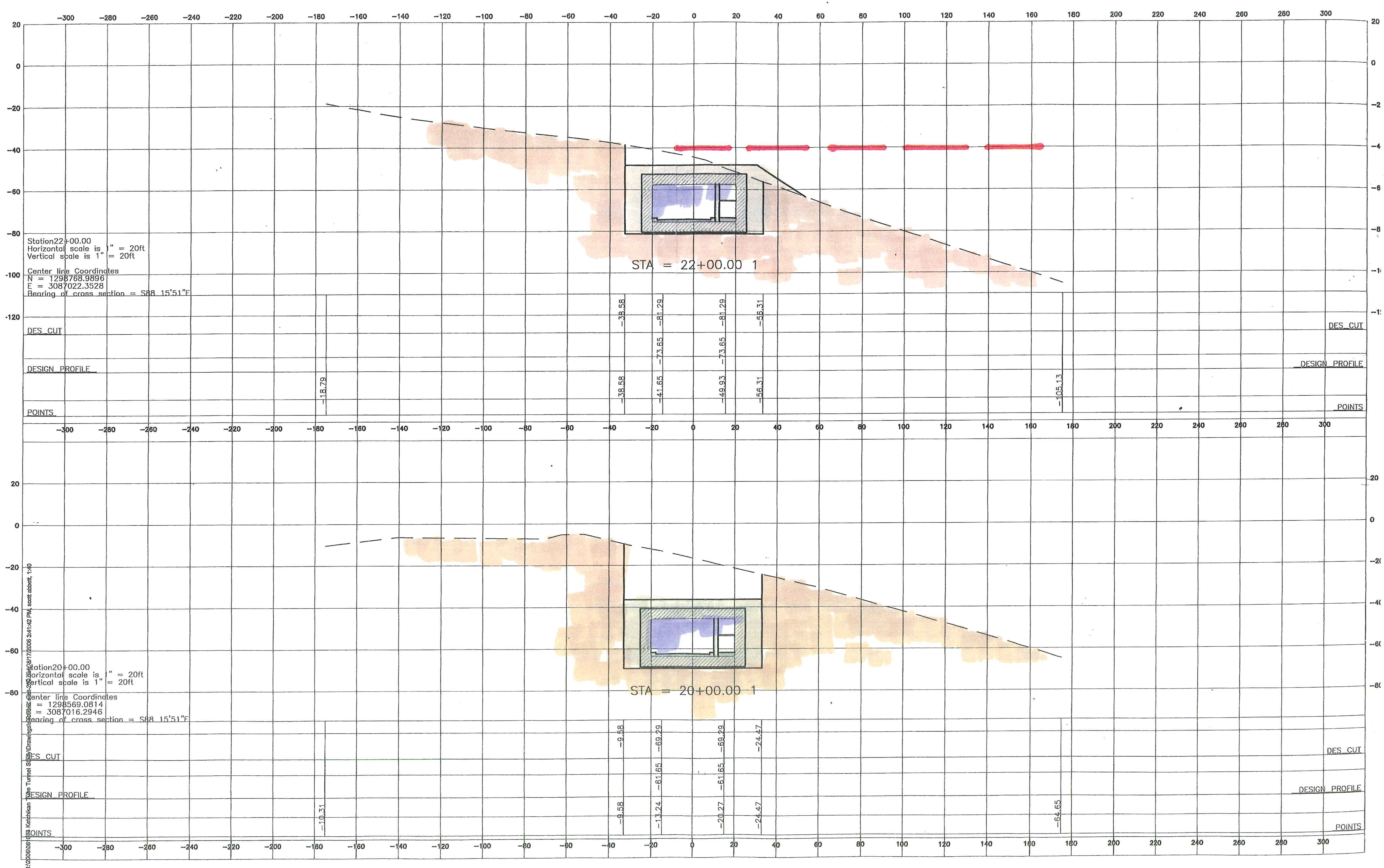
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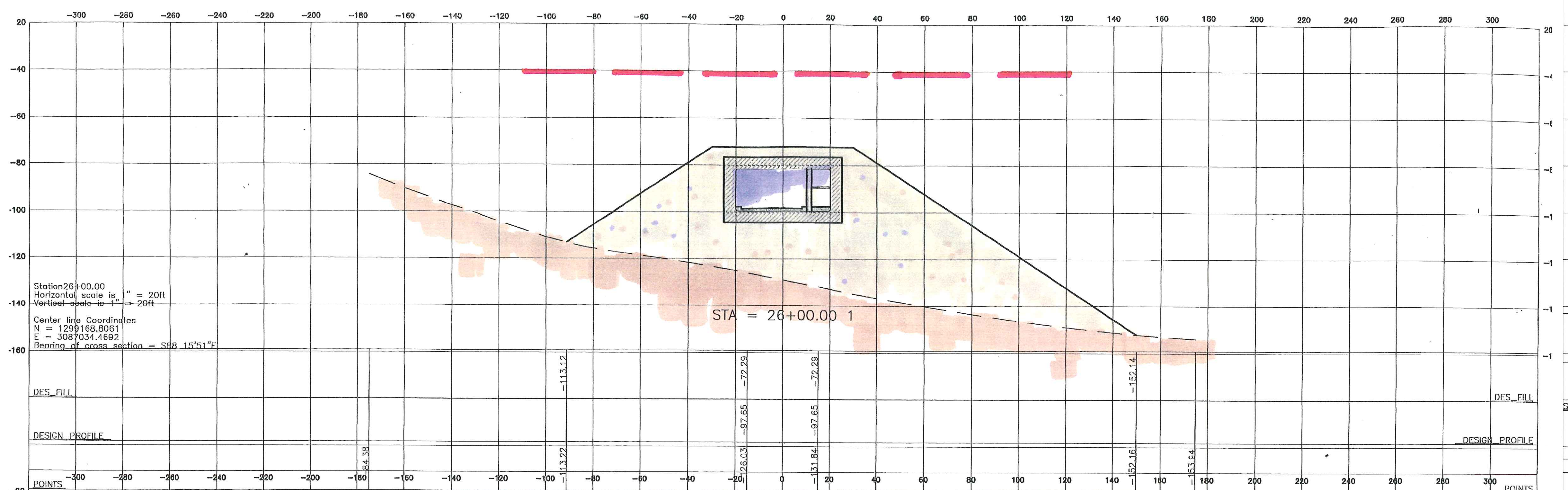
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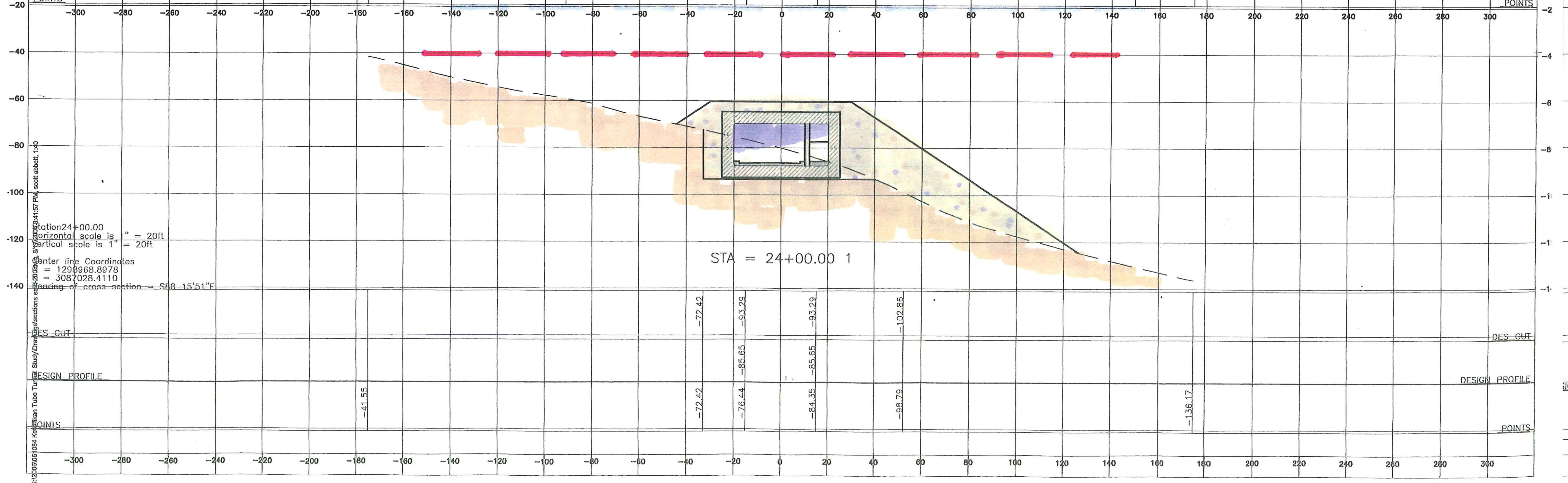
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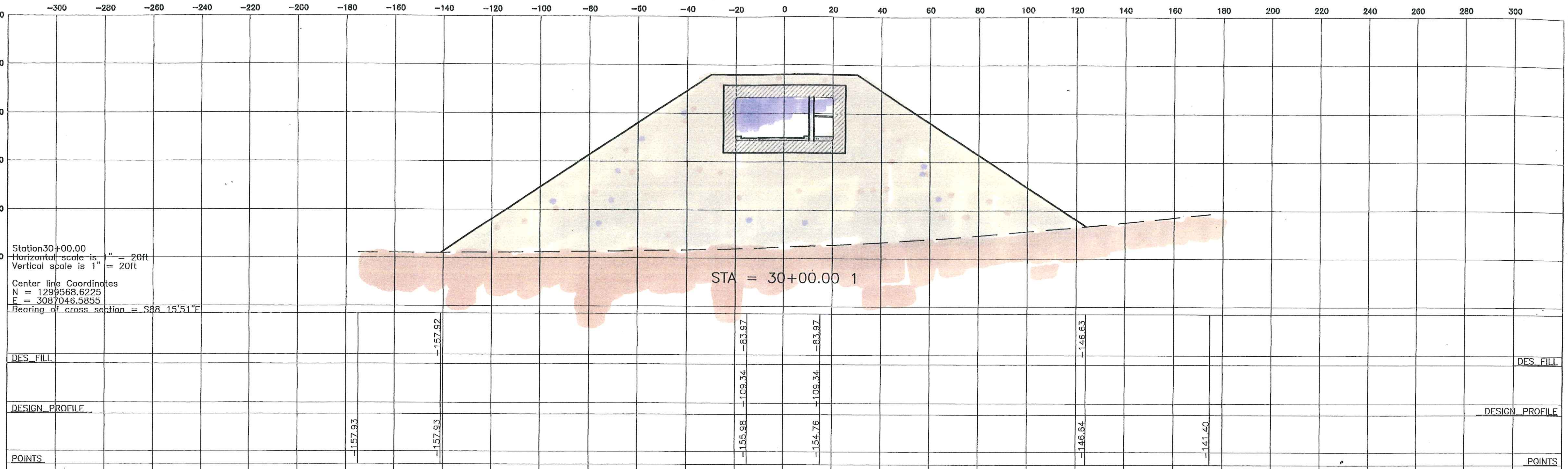

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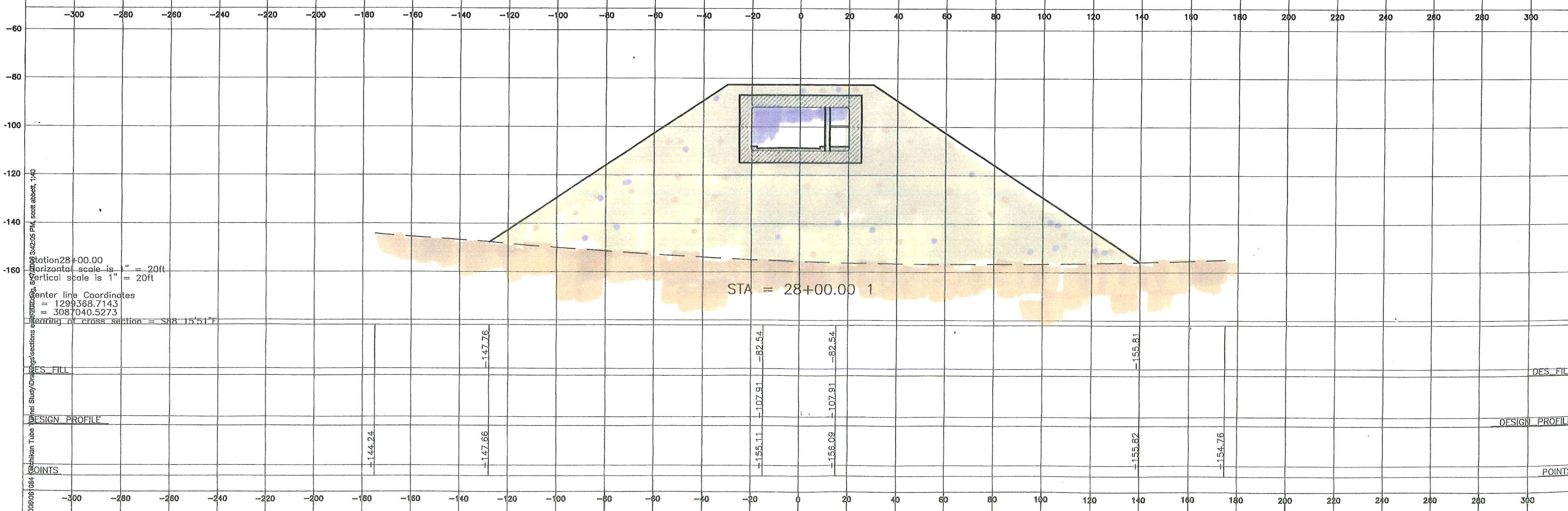

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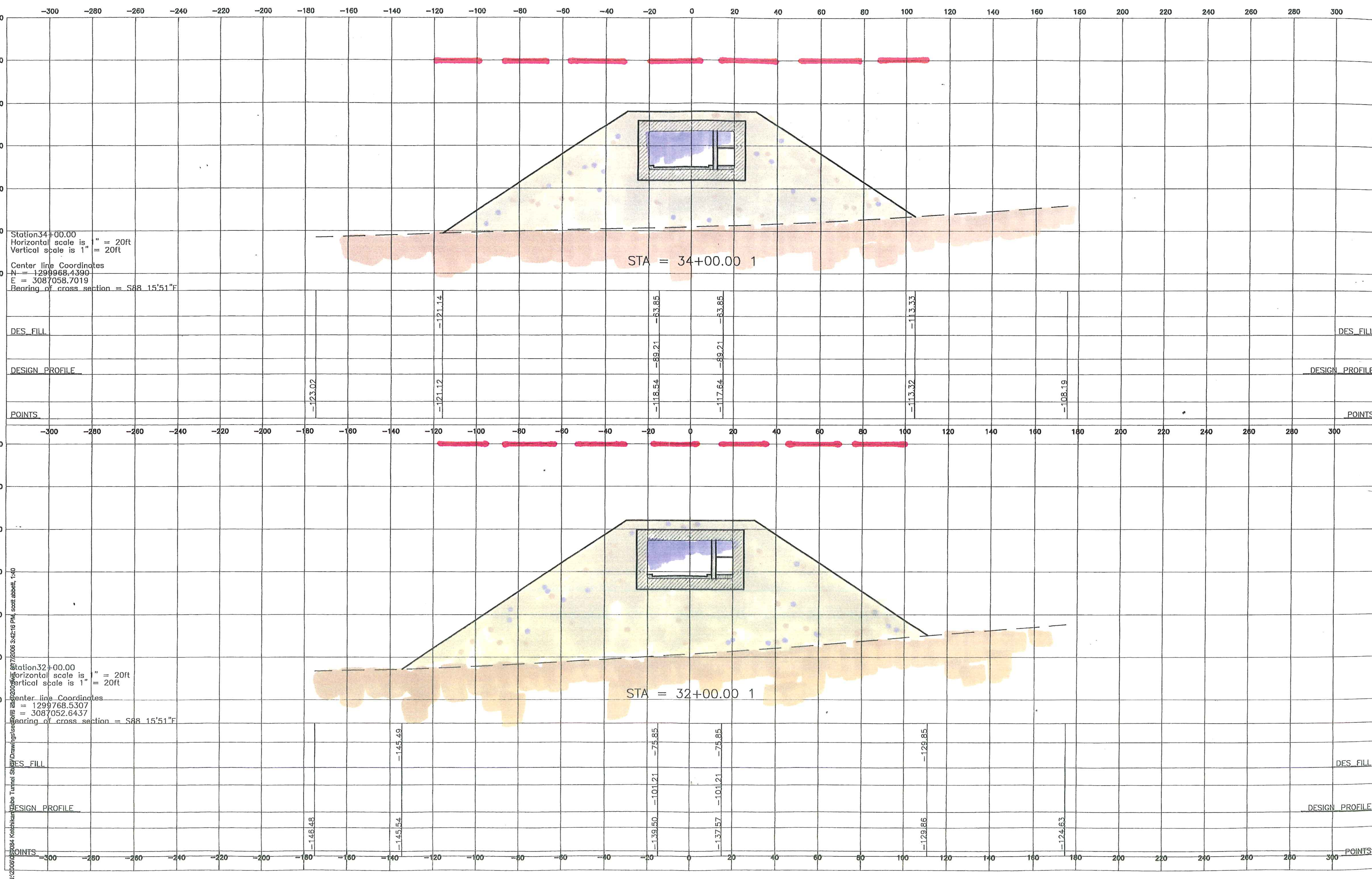
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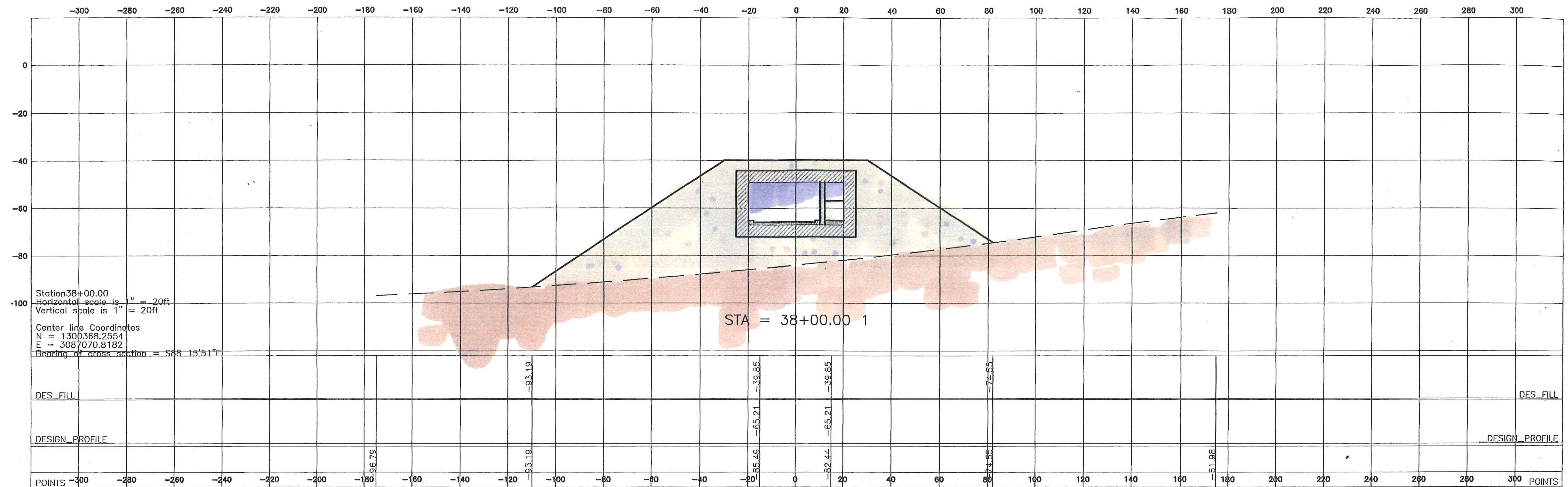

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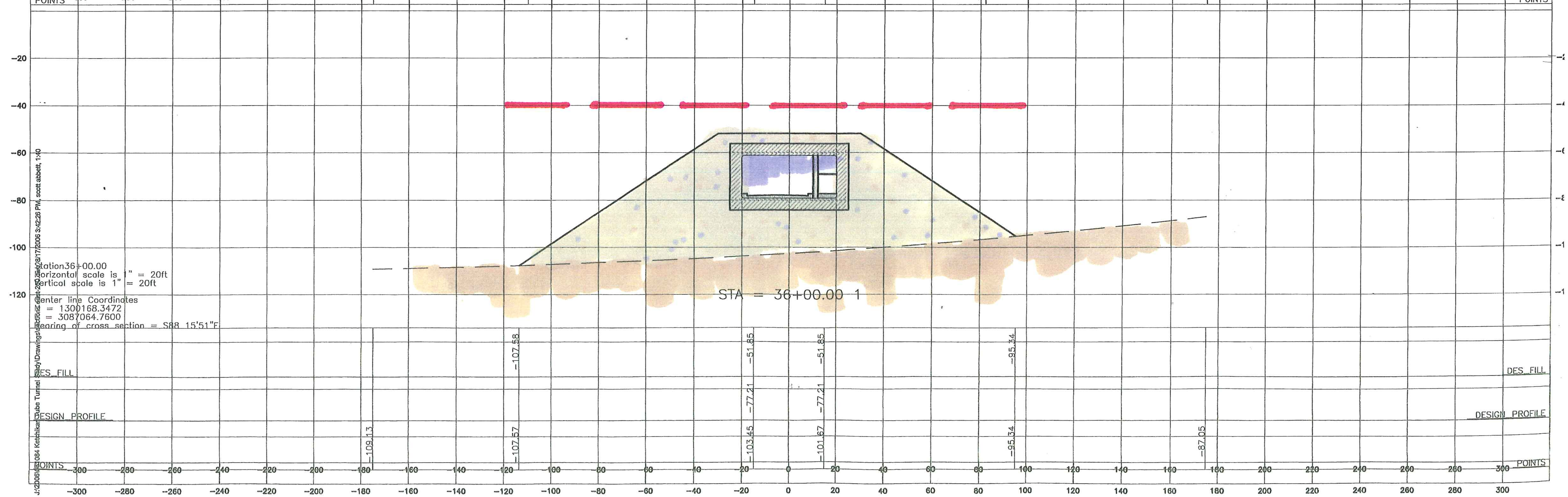

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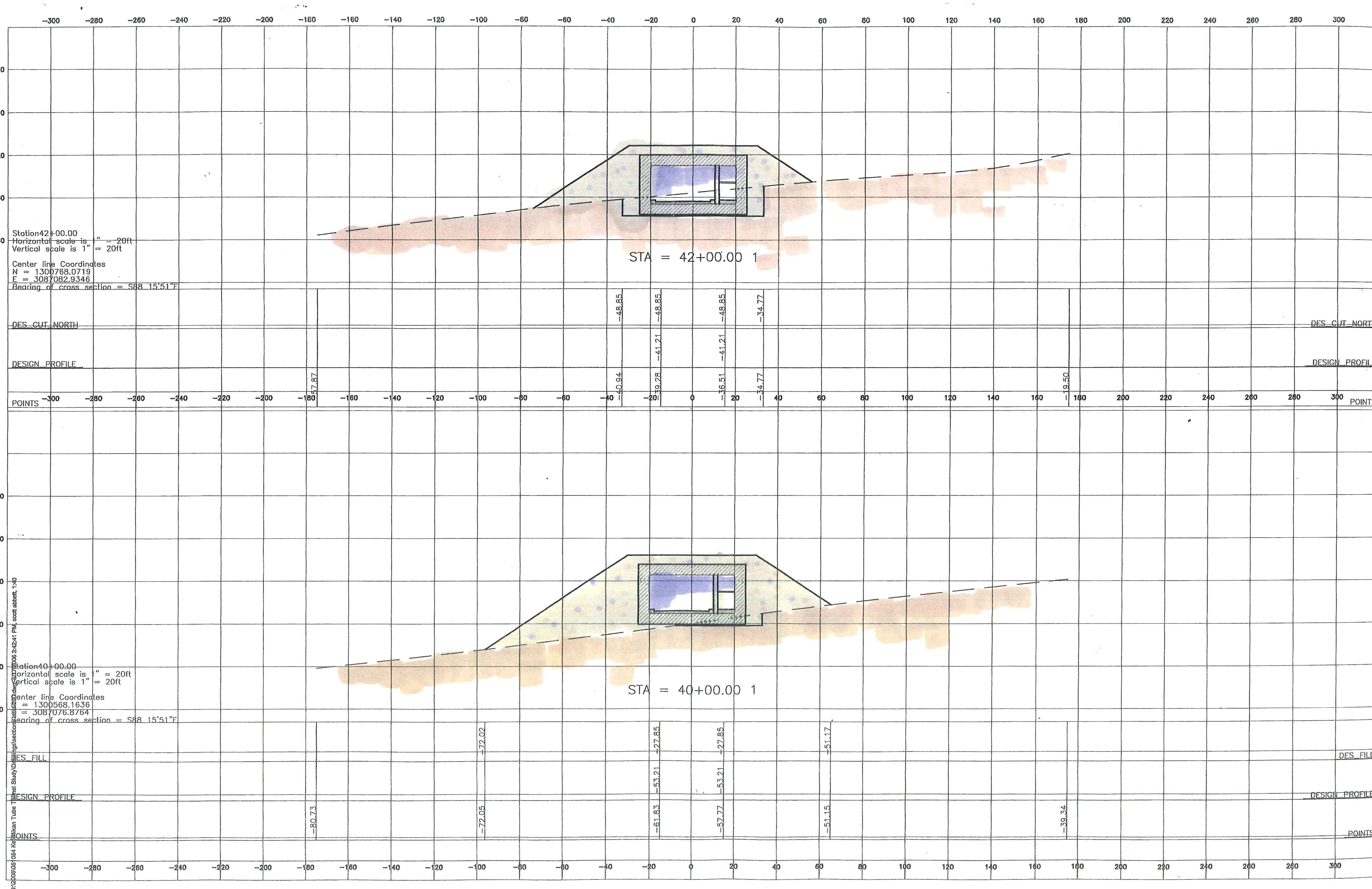

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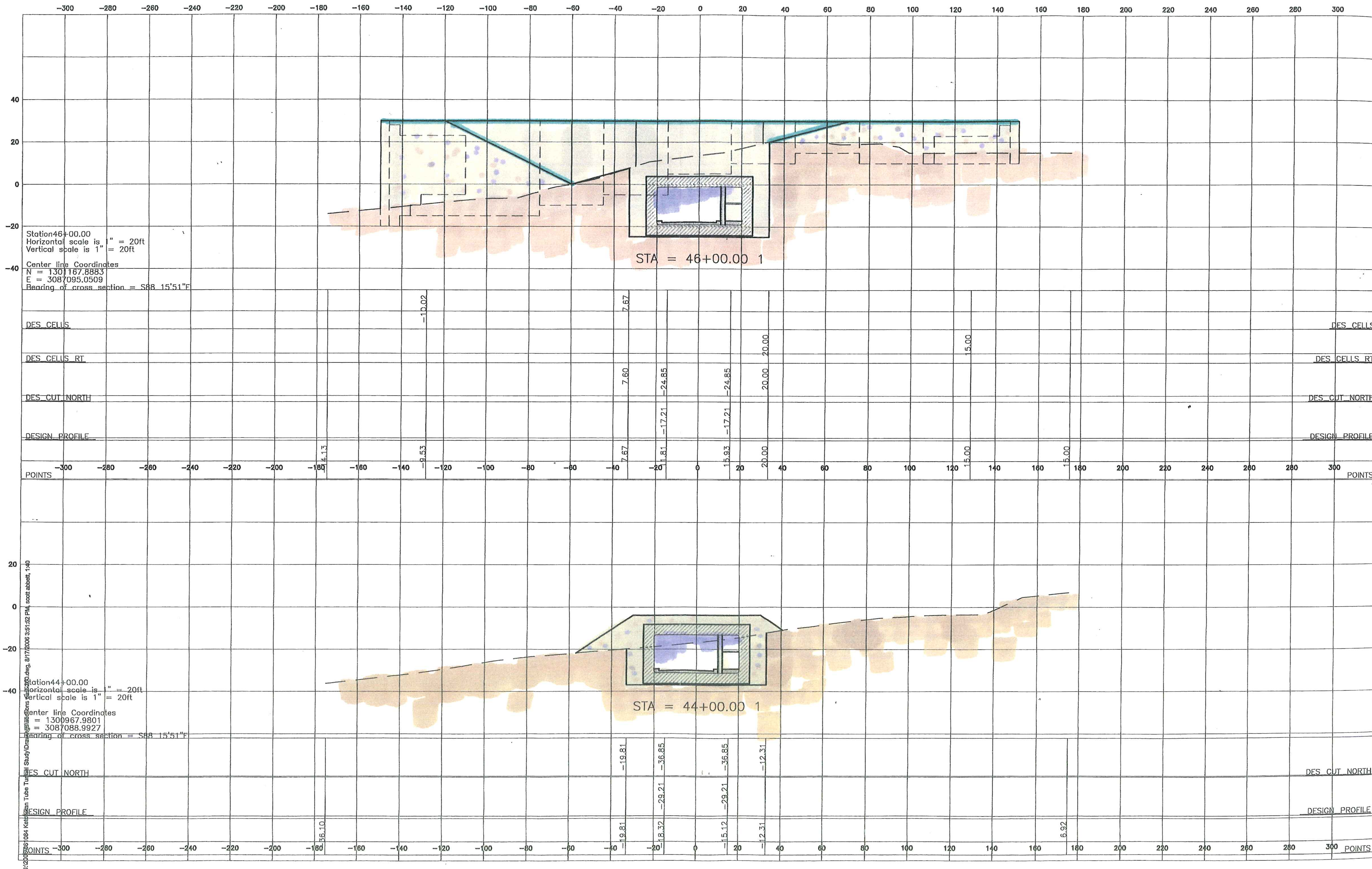
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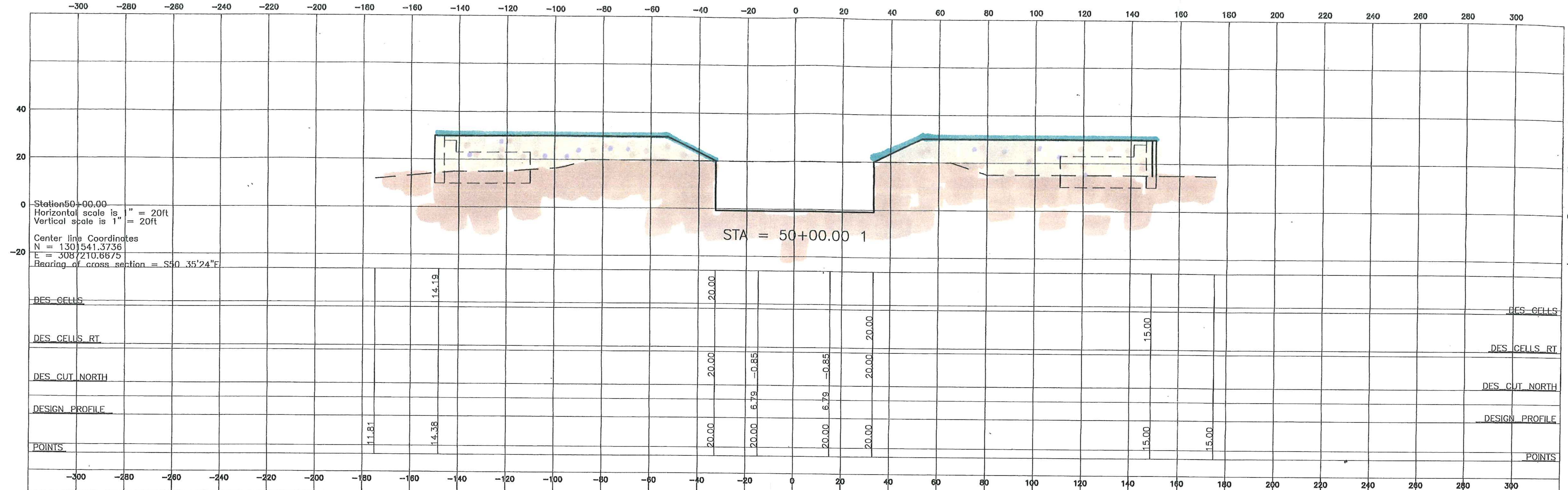
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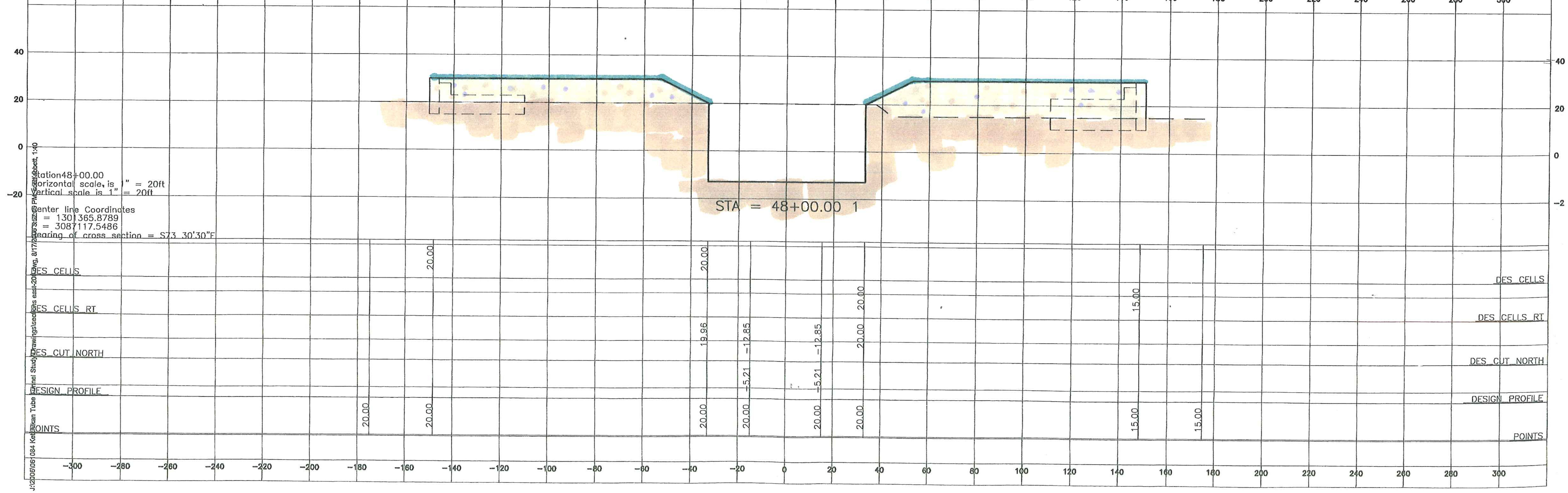
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Tongass Narrows Crossing Tunnel – Mechanical / Electrical Concepts

Ventilation Systems

The tunnel will be equipped with 4 identical variable pitch vain-axial fans. Two fans will be installed in fan rooms located within the portal houses at each end of the tunnel.

During normal tunnel operation, one fan at each end of the tunnel will provide the varying quantity of fresh outside air needed to maintain a healthy environment within the enclosed spaces of the tunnel.

The air quality of the tunnel will be monitored by redundant Carbon Monoxide (CO) sensors. This is done so that if the CO level is kept within acceptable limits, other air born materials will typically have concentrations less than CO, therefore these other substances such as unburned hydrocarbons and nitrogen oxides will also be kept in check.

If the tunnel is not in use (late at night for example), and the air quality inside the tunnel is acceptable, the ventilation fans will completely shut down.

Fresh air will be ducted to various locations along the tunnel from a ventilation duct located above the pedestrian walkway (located adjacent to the road way). Ventilation air will exit via the tunnel.

Should a fire develop within the tunnel, all four fans will draw air from the tunnel, through the ventilation duct system (reversing the flow of air seen during normal operation).

- Fan specification: Joy Axivane Mine (5'-0" diameter), 175,000 cfm @ 12.0 inches w.g., 450 hp motor (estimated maximum power requirement = 410 hp). The fan will be fully reversible within 90 seconds. Fans are manufactured by Howden Buffalo, Inc.
  - Under normal operation, carbon monoxide detectors within the tunnel will control these fans. Variable frequency motor control will be used to control fan speed.
  - In the event of fire within the tunnel, these same fans will become smoke evacuation fans.

Pumped Drainage System

The tunnel's lowest point is approximately 110 feet below sea level under the waterway separating Gravina Island from Ketchikan. If water is not removed from the tunnel, it will be quickly rendered unusable, therefore the utmost effort has to be made to keep the tunnel dry at all times. Compounding the problem of keeping the tunnel dry is the both constant and heavy rainfall that the Ketchikan area receives. The tunnel approaches will be open and will be sloped downward to the tunnel entrance. The approaches are 800 and 600 feet long (west / east) and 300 feet wide. Water from either approach will drain to a sump located at each of the entrance portals, and if the portal sumps become overloaded, the water will then flow to intermediate sumps, and then finally a low point sump in the center of the tunnel.

From the entrances, the tunnel will slope to a central low point. Midway along the tunnel will be intermediate sumps and pump sets. At the lowest point in the tunnel will be a final sump and pumpset. Pipes from each pump will discharge from their sump location back to oil water separators at either tunnel entrance. The reason for the intermediate and center sumps is that if either of the entrance portal sumps become clogged, overloaded, or is other wise rendered inoperable, the water will continue to drain to the midpoint sump and again if that becomes incapacitated, to the center of the tunnel.

In addition to accommodating rainwater drainage, due to the nature of underwater tunnels there will also be slight leakage through the tunnel that will need to be handled as well. The tunnel leakage will go to the rainwater system, and then be taken from the tunnel by the pumps and discharged.

At each tunnel portal there will be a pair of duplex pumps that will operate in a lead/lag fashion, where one will be turned on by the water level in the sump, then after a set time period of operation, that pump will rest and the other pump at the portal will operate as required. Each pair of pumps will be of the same size and able to handle the complete drainage requirements for the entrance portal it serves. In case one pump fails, the other pump will take over. Additionally the pumps will be setup so that one will operate and the other will be off, however if the operating pump is on continuously for a set period of time (15 minutes for example) then the other pump at that location will activate and help deal with the increased load.

The midpoint sump pumps will operate in the same fashion as the portal pumps, but each will be sized to accommodate 1/2 the calculated portal drainage capacity.

The low point sump pumps will operate in the same fashion as the portal pumps, however each will be sized to accommodate 1/2 the calculated total tunnel drainage capacity (portal capacity, as well as tunnel leakage).

Pump specifications

- West Portal: 3,000 gpm @ 20 feet of head (8.6 psi), 20 hp motor (estimated maximum power requirement = 15 hp).
- West Midpoint: 1,500 gpm @ 128 feet of head (56 psi), 50 hp motor (estimated maximum power requirement = 48 hp).
- Tunnel Midpoint: 2,740 gpm @ 235 feet of head (102 psi), 200 hp motor (estimated maximum power requirement = 163 hp).
- East Midpoint: 1,122 gpm @ 132 feet of head (58 psi), 40 hp motor (estimated maximum power requirement = 37 hp).
- East Portal: 2,244 gpm @ 20 feet of head (8.6 psi), 15 hp motor (estimated maximum power requirement = 11 hp).

At either entrance portal will be oil water separators (OWS), each with the capacity to handle the discharge from the sumps located along the roadway. The capacity of either OWS will be based upon the expected flow rates from each portal, therefore they will each be sized to accommodate 3,000 gpm.

Fuel System

At either end of the tunnel will be a 2 MW diesel driven generator intended to power the facility when there is a loss of grid system power. Each or these generators are listed as drawing 140 gallons/hour of fuel. It is intended that these generators be able to operate for 12 hours, therefore each generator needs at least a minimum of 1,700 gallons fuel storage.

- Tank specification: (2) Ace Tank 3,000 gallon, double wall, fireguard, skid mounted tanks, including all required appurtenances: level indication, leak detection, primary and secondary venting, and piping to the generator.

Sprinkler System

A fire suppression system might not be required by regulation or code; however investigation and analysis of recent tunnel fires suggests that a fire suppression system would be a prudent feature to add to the tunnel design. Such systems may become a requirement in the future.

A dry-pipe sprinkler system will be installed down the length of the tunnel.

Fire Alarm, Control, Security and other Signal System

Per the requirements of NFPA 502 if a tunnel is over 1,000 feet in length, all requirements of NFPA chapter 7 will need to be present for this project. Because of the NFPA requirements, there will be a number of information system installed within the tunnel:

- A fire detection and alarm system will be installed
- A direct digital control (DDC) system will be installed to control mechanical, lighting, and fire suppression systems. The DDC system will include carbon monoxide detection for fan control.
- A closed circuit television (CCTV) system will be provided to cover 100% of tunnel area.
- A remote system display and control will be provided. This display and control system may be installed in the police station, fire station, and/or airport security offices.

ELECTRICAL SYSTEMS

Lighting, power, communications and other electrical systems will be provided in accordance with

- FHWA Tunnel Design Guidelines
- NFPA 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways
- NEC
- NESC

Lighting

To achieve good color rendition and maximize visual acuity by drivers in and around the tunnel, metal halide has been selected for exterior and interior lighting. Certain lighting tasks (portal building spaces, some areas within the tunnel, etc.) may be illuminated using fluorescent luminaires, but those are considered incidental for this narrative.

Portal approaches will be illuminated at different levels depending on time of day and ambient brightness. High levels of solar illumination will produce a "picture frame" effect, causing undue concentration on the tunnel opening as motorists approach the portal. During high levels of solar illumination, pole or approach structure mounted floodlights will be at their brightest to illuminate areas adjacent to the tunnel opening to decrease contrast.. conversely, at night portal lighting will be minimum and when skies are overcast and direct sunlight is low, portal lighting will be reduced proportionately.

Tunnel lighting consists of three separate zones.

- Threshold
- Transition
- Interior

Threshold lighting consists of portal and transition lighting systems. Portal lighting is discussed above.

Transition lighting is intended to permit the driver entering the tunnel to adapt to lower lighting in the interior zone than the driver experienced prior to entering the tunnel. The worst case would be a driver in bright sunlight entering the tunnel. The transition zone must be long enough to permit the eye to adjust to the interior tunnel lighting. The time for the eye to adapt is established at 10 seconds. Therefore, the length of the transition zone is contingent on the established speed limit in the tunnel. Assuming 40 mph is the speed limit, the transition zone would be about 600 feet. Within the transition zone, the lighting must be about the same level as outside the tunnel just inside the tunnel entrance (330 cd/sq. meter) gradually reducing in level throughout the 600 feet long transition section until the interior zone lighting level of about 5 cd/sq. meter is encountered. The typical way this gradual reduction is accomplished is to increase spacing between adjacent lighting units more and more the further one travels into the tunnel from the portal.

Other lighting systems will include signage, instructional and informational boards, emergency and exit signs. These lighting systems will be developed along with the other design features as the project progresses.

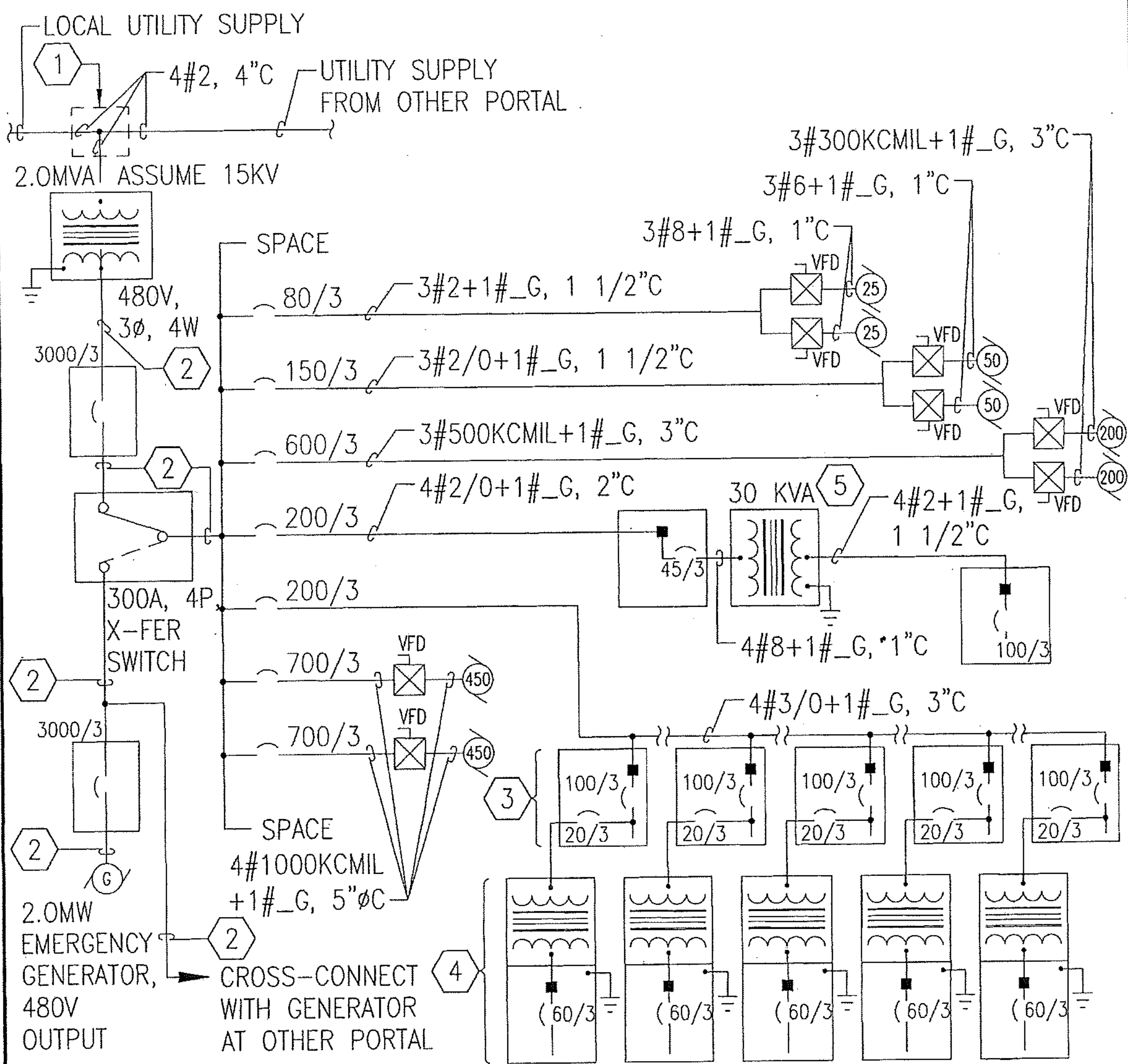
Power

There will be two separate power centers, one at each portal, established to supply electrical power to all tunnel features and loads. Basic assumptions have been made for the purposes of developing this report. They include

- Primary service to each of the power centers will be provided by Ketchikan Public Utilities Electrical Division.
- The "alternate" second primary supply for each of the power centers will also be provided by KPU.
- Each power center will be essentially identical with each power center supplying about ½ of the total tunnel loads and systems.
- Tunnel distribution system will operate at 480/277 V. – 3 Ø, 4 wire "Y".
- Lower voltages and loads will be derived using dry-type transformers at discrete locations where needed throughout the project.
- All mechanical motors 20 HP or larger will be controlled using variable frequency drives.
- All tunnel systems will be provided with "emergency" power during interruption of normal power.
- A full-capacity cross-connection feeder will run between the generators located at each portal to increase reliability.

See the one-line diagram on the next page for the proposed configuration of a typical portal power center.

Each portal should have two independent primary electrical utility services supplying the 2.0 MW service transformer. If there is no reasonable location to connect a second independent utility source, it is recommended a full-capacity primary feeder be run between the two portal transformers. This configuration will permit both portals to be run from the remaining live utility source should either utility supply be interrupted. In a similar fashion, it is recommended a full-capacity interconnecting feeder be run between the outputs of the two emergency generators for the same reason. Within the tunnel, periodic service and supply points will be established to service lighting and other loads within the tunnel, emergency walkway, utility areas, etc.



NOTES:

1. S&C SWITCHING CABINET.
2. 5 EACH IN PARALLEL: 4#1000KCMIL+1#_GND IN 5"Ø CONDUIT.
3. DISTRIBUTED 100A, 277/480V-3Ø, 4W PANELBOARDS – LTG. PWR.
4. DISTRIBUTED 15KVA, 480V Δ: 120/280V, 3Ø 4W "Y" TRANSFORMERS AND 100A PANELBOARDS WITH 60/3 MBS. – GENERAL POWER.
5. SERVICE FOR PORTAL CONTROL FACILITY.

PDC INC. ENGINEERS
2700 Gambell St., Anchorage, Alaska 99503

ELECTRICAL BLOCK DIAGRAM
TYPICAL EACH PORTAL

DESIGN:	JRP
DRAWN:	DLT
CHECK:	JRP
08/15/06	

PROJ. No. A06019
FIGURE 1

Proposed Configuration of Typical Portal Power Center

Communications and Other Electrical Systems

Each portal building will have its own communications system, but the two will be interconnected for flexibility, ease of coordination and such arrangement permits full tunnel operation using one or two portal control systems. Included will be the following systems.

- Fire Detection and Alarm
- Video Surveillance
- Traffic Monitoring and Control
- Communications

These systems will comply with the provisions of NFPA 502 and the NEC. Some notable features include

- Fire detection and alarm systems will automatically notify local authorities of alarms or trouble signals initiated within the system.
- Traffic monitoring and control systems can be intertied with other tunnel features to optimize operations. An example might be limiting traffic flow to minimize fan operations to conserve energy. Another example might be reducing speed limits and spacing between vehicles to avoid possibly overcrowding emergency facilities should an emergency occur.
- Communications systems to provide interactive information and instructions to drivers and/or personnel within the tunnel.

Tongass Narrows Tunnel - Ketchikan/Gravina Island

Ketchikan, Alaska

Mechanical Costs

Job #: A06019
C:\Documents and Settings\Ingrid.ENGINEERING\Local Settings\Temporary Internet Files\OLK72\[Mech-Elec Cost EstimateUpdated8-10-06.xls]Electrical Cost Estimate
PDC Engineer: MJL

Fans

	Fans (4)			Misc		
Material	$400,000			$50,000		
Labor	$200,000			$0		
Sub Total	$600,000	$0	$0	$50,000		
Total fans						$650,000

AirDelivery system

	Ductwork	Diffusers-motorized (21)		Misc		
Material / Labor	$3,000,000	$21,000		$100,000		
				$0		
Sub Total	$3,000,000	$21,000	$0	$100,000		
Total Air Delivery						$3,121,000

Pumps

	Pumps (10)	Controls	3000gpm OWS (2)	Misc		
Material / Labor	$410,000	$100,000	$500,000	$50,000		
				$0		
Sub Total	$410,000	$100,000	$500,000	$50,000		
Total pumps						$1,060,000

Pumped water piping

	12" Weld Steel 400 feet	10" Weld Steel 5000 feet	8" Weld Steel 5250 feet	Misc	
Material / Labor	$102,800	$1,040,000	$887,250	$500,000	
				$0	
Sub Total	$102,800	$1,040,000	$887,250	$500,000	
Total piping					$2,530,050

Sprinkler system

	Piping - (2) 6" Steel, 5250 feet	Connect./Controls			Misc	
Material / Labor	$1,500,000	$500,000			$225,000	
Sub Total	$1,500,000	$500,000	$0	$0	$225,000	
Total sprinklers						$2,225,000

Total	$9,586,050

Note: All numbers initially based off MEANS 2006 mechanical costs, but due to scale of equipment, additional multipliers used as as necessary based upon experience.

Tongass Narrows Tunnel - Ketchikan/Gravina Island
Ketchikan, Alaska
Electrical Costs

Job #: A06019
C:\Documents and Settings\Ingrid.ENGINEERING\Local Settings\Temporary Internet Files\OLK72\[Mech-Elec Cost EstimateUpdated8-17-06.xls]Electrical Cost Estimate
PDC Engineer: JP

Lighting					
	200 250 Watt MH	Contactors	Conduit	Wire	
Material	$168,750	$20,250	$40,500	$27,000	
Labor	$247,500	$16,875	$44,550	$32,400	
Sub Total	$416,250	$37,125	$85,050	$59,400	
Total Lighting					$597,825

Fans and Pumps					
	Motors and Units	Connections	VFD	Misc	
Material	See Mech.	$393,750	$140,625	$60,117	
Labor	See Mech.	$225,000	$112,500	$37,969	
Sub Total	$0	$618,750	$253,125	$98,086	
Total fans					$969,961

Transformers						
	2 - 2000 KVA 480 VAC	12-480/208 DTs	Feeders	Distribution	Misc	
Material	$506,250	$74,250	$121,500	$150,000	$78,975	
Labor	$337,500	$101,250	$160,313	$175,000	$67,395	
Subtotal Total	$843,750	$175,500	$281,813	$325,000	$146,370	
Total transformers						$1,772,432

Gensets						
	2 - 2000 KVA 480 VAC	Connection	Feeders	Disribution	Misc	
Material	$1,350,000	$14,063	$312,188	$200,000	$59,203	
Labor	$900,000	$19,688	$309,375	$200,000	$59,520	
Sub Total	$2,250,000	$33,750	$621,563	$400,000	$118,723	
Total transformers						$3,424,035

Special Systems						
	Fire Detection and Alarm	CCTV	Comm	Traffic	Misc	
Material	$75,000	$50,000	$50,000	$25,000	$22,500	
Labor	$75,000	$50,000	$50,000	$25,000	$22,500	
Sub Total	$150,000	$100,000	$100,000	$50,000	$45,000	
Total transformers						$445,000

Total	**$6,764,253**

Note: All numbers contain a 12.5% contingency. This figure may not be enough to cover estimated costs if bids are solicited after December of this year. Increases in materials and labor will affect the total.

Gravina Tunnel - Estimated Annual Electrical Energy Charges	**$556,793**

at $0.0882 /Kwh and $2.86 per KVA demand charge

Tongass Narrows Crossing - Tunnel

Emergency Ventilation

A06019
C:\Documents and Settings\Ingrid.ENGINEERING\Local Settings\Temporary Internet Files\OLK72\[Tongass Narrows Crossing-calcs 8-17-06.xls]Emergency Vent
MJL
7/28/2006
(modified A03039 work)

Semi-transverse ventilation

Tunnel Length =	3,200	feet
Width (car space) =	30	feet
Height =	17	feet

Vc =	Critical Velocity		Feet/second
Tf =	Average Temperature of Fire site gases (degrees R)		
Ki =		0.606	
Kg =	Grade factor	1.00	
g =	accelleration of gravety (feet/sec^2)	32.2	feet/sec^2
H =	Height of tunnel at Fire Site	17	feet
q =	heat that fire adds directly to air at fire the site	4,722	BTU/sec.
roe =	Average density of approach (up stream) air	0.075	lbs/cu. Ft.
Cp =	specific heat of air (BTU/lb-degree R)	0.24	BTU/lb-degree R
A =	Area perpendicular to air flow	510	Sq. Ft.
T =	temperature of approach air	500	degrees R (40 F)

eqn 1 Vc = K1*Kg*(g*H*q)^0.3333 / (roe*Cp*A*Tf)^0.3333

eqn 2 Tf = q / (roe*Cp*A*Vc) + T

solve for minimum steady state velocity of vent. air moving toward the fire needed to prevent back layering
Chapter 13, 2003 ASHRAE Applications - pg 13.5, 13.6

Tf degrees R	degrees F	Vc feet/sec	CFM
700	240	7.99	244,427
564.395441	104	8.537126	261,236
560.252018	100	8.556630	261,833
560.114680	100	8.557280	261,853
560.110115	100	8.557302	261,853
560.109963	100	8.557302	261,853
560.109958	100	8.557302	261,853
560.109958	100	8.557302	261,853
560.109958	100	8.557302	261,853

Rule of Thumb: Ventilation Capacity = 100 CFM/(lane-foot)***
Lane-feet = 6400
Ventilation Capacity = 640,000 CFM

*** ASHRAE minimum ventilation guideline. Chapter 13, 2003 ASHRAE Applications - pg 13.5

Gravina Tunnel
Estimate of Annual Electrical Energy Costs
Basis of Rates is KPU e-mail of August 11, 2006
by PDC, Inc. Engineers - James R. Pressley, PE

Description of Load	Est. Load KVA	Est.Operating Hrs/Month	Est.Elec. Use KWH/Mo	Est. Elec. Use KWH/Year
Lighting	45	720	32400	388800
Power	15	720	10800	129600
Other	15	720	10800	129600
Fans	534	720	384480	4613760
Portal Pumps	28	180	5040	60480
Mid-Point Pumps	54	15	810	9720
Center Pumps	200	30	6000	72000
Misc. Loads	80	720	57600	691200
Totals	971	3825	507930	6095160

Rate Element	KVA	Current Charge per KVA	Estimated Cost per Year
Estimated Peak Demand	1600	$2.86	$19,200
Estimated Annual KWH Use	6095160	$0.0882	$537,593
Estimated Annual Electrical Energy Costs			$556,793

PND ENGINEERS, INC.

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Fax: 907.586.2099

Seattle
811 First Avenue, Suite 570
Seattle, Washington 98104
Phone: 206.624.1387
Fax: 206.624.1388

APPENDIX 14-D
HATCH-MOTT-MACDONALD TUNNEL REPORT
APRIL 2000

draft

Gravina Access Project
Tunnel Alternatives Study

Draft

Agreement No: 36893013
DOT&PF Project No: 67698
Federal Project No: ACHP-0922(5)

Prepared for:

State of Alaska
Department of Transportation and Public Facilities
6860 Glacier Highway
Juneau, Alaska 99801

Prepared by:

Hatch Mott MacDonald
6215 Sheridan Drive
Buffalo, NY 14221

Under contract to:

HDR Alaska, Inc.
712 West 12th St.
Juneau, AK 99801

April 2000

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADT	average daily traffic
AISC	American Institute of Steel Construction
BART	Bay Area Rapid Transit
CCTV	closed circuit television
CFR	crash and fire rescue
cm	centimeters
CO	carbon monoxide
DOT&PF	Alaska Department of Transportation and Public Facilities
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
ft	feet
ft^3	cubic foot
HMM	Hatch Mott MacDonald, Inc.
IES	Illuminating Engineers Society
in	inches
km	kilometers
m	meters
m^3	cubic meter
MLLW	mean lower low water
MW	megawatt
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
OSHA	Occupational Safety & Health Administration
ppm	parts per million
TEA-21	Transportation Equity Act for the 21^{st} Century
vph	vehicles per hour

1.0 Introduction

1.1 Scope

The Gravina Access Project is a high priority project authorized by the Transportation Equity Act for the 21st Century (TEA-21) to improve transportation access from the City of Ketchikan on Revillagigedo Island across Tongass Narrows to Gravina Island. The intent is to provide access to both the Ketchikan International Airport on Gravina Island as well as other Ketchikan Gateway Borough, State of Alaska, and private lands on the island. Access between the two islands is currently provided via a regular ferry service.

While improved access has been studied in the past, TEA-21 provides sufficient funding for the Gravina Access Project to conduct the evaluation of access alternatives required under the National Environmental Policy Act (NEPA) process. Funding is also available to design the preferred alternative that the Federal Highway Administration (FHWA) approves as a result of the NEPA process.

The Alaska Department of Transportation and Public Facilities (DOT&PF) has retained the services of HDR Alaska to prepare the NEPA document, design the preferred alternative, and if a build alternative is selected, oversee the construction. HDR has subcontracted the development of the tunnel alternatives to Hatch Mott MacDonald, Inc. (HMM). HMM performed this work in general accordance with a subconsultant agreement dated July 16, 1999. HDR provided authorization to proceed with this phase (the tunnel alternatives study) of Phase I by letter dated December 8, 1999.

The information generated during the Phase I study will be used to determine reasonable alternative tunnel types and identify the more promising locations for crossing Tongass Narrows. Phase 1 work is also considering bridge and improved ferry service alternatives in addition to the tunnel.

1.2 Site Conditions

Ketchikan is located in Southeast Alaska at the extreme southern tip of the Alaska Panhandle. This coastal region of Alaska is accessible only by air and water and has a typical wet marine environment with one of the highest annual rainfalls in Alaska. This part of Alaska is also known as the Alexander Archipelago because it consists of a group or chain of islands. Figure 1 presents vicinity maps of Alaska and the Panhandle area. Tongass Narrows borders the City of Ketchikan on the west and separates the city from Gravina Island.

Tongass Narrows is a long narrow waterbody that runs approximately northwest by southeast and is approximately 19 kilometers (km) (11 miles) long in the study area. The channel width varies from about 500 meters (m) or1,500 feet (ft) in the vicinity of the airport to 2,000 m (6,500 ft) near Refuge Cove and at the north end of Pennock Island. Flow within the Narrows is generally from the southeast to the northwest during flood tides and some weak ebb tides, and this flow reverses during strong ebb tides. The velocity ranges from less than 0.5 km/hour (0.3 miles/hour) to about 2.7 km/hour (1.6 miles/hour).

To the south, Pennock Island is approximately 1 to 2 km (½ to 1 mile) wide by 5 km (3 miles) long and separates Tongass Narrows into an east channel and a west channel. Access to Pennock Island is by private boat or floatplane. The west channel to Pennock Island varies from 300 to 600 m (1,000 to 2,000 ft) in width while the east channel to Gravina Island varies from 450 to 800 m (1,500 to 2,600 ft) in width. Typical water depths in the channel at mean lower low water (MLLW) range from 25 to 60 m (80 to 200 ft) between Refuge Cove and Gravina Island and 15 to 60 m (50 to 200 ft) in the West Channel and 20 to 45 m (65 to 150 ft) in the East Channel.

Gravina Island is largely undeveloped and covered with lush vegetation except at the Ketchikan International Airport, which is located on the eastern side directly across from the City of Ketchikan. Ferry service presently provides access to the airport.

1.3 Geography

The localized topography consists of steep mountains plunging into Tongass Narrows. Due to the steepness of the mountains near the shoreline, much of the city is restricted to the corridor along the coast. Additional development occurs to the south in the town of Saxman and beyond and to the north in Ward Cove and beyond. Altitudes reach about 300 m (1,000 ft) within 800 m (2,600 ft) of Tongass Narrows, and near-vertical cliffs exist along much of the coast.

Tongass Narrows in part is a glacially scoured fjord. Bathymetric contours indicate a relatively flat floor with water depths ranging from about 30 to 60 m (100 to 200 ft). The diurnal tidal range is about 4.7 m (15.4 ft). The highest tide on record is 6.3 m (20.7 ft) and the lowest tide is 1.6 m (5.2 ft). The shoreline varies from beach type deposits of mud and sand to steep rocky areas. Much of the coastline on Revillagigedo and Pennock Islands is rocky. Gravina Island's eastern side has several mud and sand coastal areas. Within Tongass Narrows, the bottom conditions range from muddy substrate to rocky pinnacles.

The climate is predominately cool maritime. The area experiences mild winters, cool summers, and heavy precipitation. Average annual precipitation is about 386 centimeters (cm) or 152 inches (in). Strong winds are common especially in winter and cloud cover is persistent. Average annual temperature is about 46 degrees Fahrenheit with a mean January temperature of about 35 degrees and a mean August temperature of almost 59 degrees. The area is a cool rainforest. Vegetation is heavy and dense consisting of Western Hemlock, Sitka Spruce, and Alaska Red Cedar. Tree line is about 450 to 600 m (1,500 to 2,000 ft) above sea level with sedges, mosses, and alpine forbs and shrubs directly above. Many areas on lower slopes are subject to rapid surface runoff or spring seepage, and in valley bottoms, the surfaces are covered with mosses, sedges, and other plants typical of muskegs.

2.0 Tunnel Design Criteria

2.1 Criteria Basis

Due to their high cost, tunnels are normally constructed without shoulders; therefore, this study established a 3.6 m (11.8 ft) lane width and a 0.3 m (0.9 ft) shoulder width, per the American Association of State Highway and Transportation Officials' (AASHTO) "Geometric Design of Highways and Streets" (Figure 10-15,).

While the project has not finished estimating traffic volume for the hard link to Gravina, this study assumes that a single lane in each direction can adequately handle the peak design hour volume. For cost reasons, this study uses a two-lane roadway in a single tube.

For the ventilation analysis, this study uses a design year average daily traffic (ADT) of 5,300 vehicles with a peak hourly volume of 800 vehicles per hour (vph) with 8% trucks. Once the traffic projections are available, the project team will reassess the ventilation analysis. Tables 2-1, 2-2, 2-3, and 2-4 present this study's other criteria and provisions.

Table 2-1
Geometric Criteria

Design Vehicle	AASHTO WB-67
Design Speed	70 km/h (43 mph)
Stopping Sight Distance	94.1 m (308 ft)
Passing Sight Distance	482 m (1,581 ft) (no passing within the tunnel, but allow for emergency passing of disabled vehicles)
Max. Allowable Grade	6.00%
Min. Radius (6% max. super)	225 m (738 ft) desirable -- 195 m (640 ft) minimum
Min. Length of Curve	210 m (689 ft)
Min. K-value Sag Vert. Curves	20-25
Min. K-value Crest Vert. Curves	22-31
Number of Roadways	Two-Lane
Width of Traveled Way	2 @ 3.6 m (11.8 ft) = 7.2 m (23.6 ft) (note reduced shoulder below)
Width of Shoulders (Outside)	Except tunnel – 2.5 m (8.2 ft) In tunnel - 0.3 m (0.9 ft) to face of curb (note: no room for disabled vehicles)
Width of Shoulders (Inside)	n/a (Two-Lane Two-Way)
Min. Clearance from Face of Curb	0.45 m (1.5 ft)
Curb Type	Non-mountable; barrier type
Emergency Walkway Width (both sides)	0.75 m (2.5 ft)
Min. Vertical Clearance	5.0 m (16.4 ft)
Degree of Access Control	To be determined
Median Treatment	None (Two-Lane Two-Way)

Table 2-2
Life Safety Provisions

Design Standard	National Fire Protection Association (NFPA) 502 Standard for Road Tunnels, Bridges, and other Limited Access Highways (1998 Edition)
Design Fire Size	20 megawatt (MW) (roughly equal to heat released from a single bus or truck; excluding flammable cargoes; would require restrictions on cargoes)
Vehicle Restrictions	No placarded loads permitted with normal traffic flow, special permit required for off-hour travel
Emergency Egress	Americans with Disabilities Act (ADA) compliance, except slope of exit route need not be flatter than the adjacent pavement grade
Standpipe	Dry Type
Safety Systems	➢ Closed circuit television (CCTV) to a monitoring station ➢ Two independent alarm systems ➢ Emergency radio coverage ➢ Air quality monitoring ➢ Vehicle control system

2.2 Structural Criteria

A. Tunnels – "Guidelines for Tunnel Design," prepared by the Technical Committee on Tunnel Lining Design of the Underground Technology Research Council.

B. Concrete, structural steel and earth retaining structures - Applicable provisions of AASHTO's "Standard Specifications for Highway Bridges."

C. Concrete - Applicable provisions of American Concrete Institute (ACI) 318, "Building Code Requirements for Reinforced Concrete."

D. Structural steel - Applicable provisions of the American Institute of Steel Construction (AISC) "Manual of Steel Construction."

E. Highway loading on tunnel structures – HS25 plus impact.

F. Loading on tunnels – To be determined after geotechnical investigation.

G. Seismic Design Criteria - To be determined after geotechnical investigation.

H. Cofferdams – Naval Facilities Engineering Command – "Design Manual 7.2: Foundation and Earth Structures."

I. Marine loads on tunnels – To be determined, but will include provision for loads from vessel grounding, vessel sinking, impact from falling anchors and lateral loads from dragging anchors.

Table 2-3
Miscellaneous Criteria

Illumination	Per Illuminating Engineers Society (IES) RP-22
Airspace Clearance	N/A
Shipping Clearance	15.2 m (50 ft) Vertical (below MLLW) (assuming 12 m (40 ft) draft and 1.5 m (5 ft) riprap and 1.5 m (5 ft) spare) for 230 m (750 ft) wide Horizontal Channel
Bicycle Provisions	Bike Lane/ Pedestrian Path required
Pedestrian Provisions	Bike Lane/ Pedestrian Path required

3.0 Criteria Application

3.1 Emergency Egress

NFPA 502 does not contain any explicit requirements for emergency exiting. The only specific provision is 4-2c, which implies that certain provisions of NFPA 502 do not need to be met if "the maximum distance from any point within the tunnel to an area of safety exceeds 400 feet." However, Chapter 9 of NFPA 502 requires the development of an emergency response plan to address any possible incident, of which many would require evacuation.

For comparison purposes, NFPA 130, which applies to urban subways, requires that any point within the tunnel be within either 122 m (400 ft) from an area of safety or within 381 m (1,250 ft) from an exit to the surface. This might be used to justify a decision to not construct any special exiting provisions in tunnels less than 760 m (2,500 ft) long. However, the emergency response plan must consider the fact that in tunnels, road vehicles are a greater risk than trains. The risk arises from the greater number of independent movements in a road tunnel, the lower control that can be exerted over them, and the difficulty in barring dangerous goods. In addition to the NFPA 502 requirements, recent European tunnel fires have resulted in a greater public awareness of tunnel hazards and an increased demand for improved safety provisions.

In larger tunnels, a dividing wall between opposing lanes, or separate tubes for opposing lanes, is often provided. Projects can construct exits to a safe area at minimal cost by installing doors periodically in the center wall, or by constructing cross passages between multiple tubes. However, with lower traffic volumes warranting a twin-lane, single-tube tunnel with bi-directional traffic, the only reliable exiting method for longer tunnels is the construction of an exit route within the tunnel, separated from the roadway by a fire rated wall. The exit route would have an independent air supply at a higher pressure than the tunnel to prevent smoke from infiltrating the exit route.

3.2 Ventilation

The following discussion highlights four common tunnel ventilation systems.

- Natural Ventilation – Natural ventilation relies on meteorological conditions and the piston effect of traffic to ventilate the tunnel. This system is common in short tunnels or long underpasses, but tunnels longer than 240 m (787 ft) must have a mechanical ventilation system for smoke control.

- Longitudinal Ventilation – Longitudinal ventilation systems create a flow of air within the tunnel between the portals, sometimes assisted by one or more intermediate ventilation shaft. This system is most effective with unidirectional traffic. Longitudinal ventilation is not permitted for smoke control in unidirectional tunnels greater than 850 m (2,789 ft) long or in bi-directional tunnels of any length.

- Semi Transverse Ventilation – This system uses a single duct along the entire length of the tunnel to uniformly collect or distribute air. In the case where the duct supplies fresh air to the tunnel, the ventilating airflow moves toward the portals through the main part of the tunnel collecting vehicle emissions as it goes. The resulting longitudinal airflow, ideally from the mid-length of the tunnel towards each portal, is sensitive to external winds and the predominant movement of vehicles in one direction through the tunnel. Under adverse operating circumstances, null points can develop in the tunnel and lead to extremely high concentrations of pollutants within the tunnel. With a tunnel of circular cross section, the natural location for the duct is below the road deck. In the event of a fire, smoke would have to be extracted through the pavement level, breaking down any stratification of smoke that might exist. Disruption of the smoke layer is highly discouraged, and therefore the semi transverse system is not recommended with an under-pavement duct.

- Fully Transverse Ventilation – A fully transverse ventilation system uses separate supply and exhaust ducts throughout the length of the tunnel, and the distribution of ventilating airflows is independent of climatic conditions and the movement of vehicles. A second duct is required at a high level to capture the return air, and this can increase the dimensions of the tunnel cross-section. The resulting arrangement of supply at low level and extract at high level is, however, considerably more robust than the options offered by a semi-transverse ventilation system.

Consequently, this study proposes a fully transverse ventilation system for the Gravina tunnel.

3.3 Design Fire Size

This study used a design fire size of 20 mw to establish minimum ventilation requirements for emergency conditions. The heat output from a single bus or truck is approximately 20 mw. For comparison, the fire load of a single gasoline tanker is approximately 100 mw.

The adoption of the 20 mw fire load assumes that flammable, explosive, or oxidizing loads will not be permitted in the tunnel. Most tunnels prohibit any placarded loads from passage, although some tunnels offer provisions for off-hour access, sometimes with escorts. Regardless of the design fire load and local restrictions on cargoes in the tunnel, it is difficult to enforce any restrictions and the potential for undetected hazardous cargoes to enter the tunnel will always exist.

Once traffic demand estimates are available, the project team will reevaluate the impact of restrictions on cargo. An increase in the design fire load will require a corresponding increase in ventilation capacity, in both fan power and duct area.

3.4 Pedestrian/Bike Path

The required bicycle and pedestrian access is unusual for tunnels, due to the additional cost and low projected utilization. Highway tunnels are noisy environments where pedestrians would be subjected to the unsteady slipstreams of passing vehicles. The presence of pedestrians complicates the emergency response plans and increases the potential for undetected acts of vandalism.

If the tunnel is to accommodate pedestrians, ventilation requirements would increase significantly due to the lower carbon monoxide (CO) concentration limits that correspond to longer exposure to CO. The Environmental Protection Agency (EPA)permits a maximum CO concentration of 120 parts per million (ppm) in tunnels when the exposure time is 15 minutes or less. However, a pedestrian traveling through a 1.5 km (0.9 ft) tunnel at 4 kph (2 mph) would be in the tunnel for 23 minutes. The EPA maximum CO concentration drops to 65 ppm, doubling the required ventilation rate with perhaps a fourfold increase in energy consumption at the main ventilation fans.

3.5 Vertical Clearance

AASHTO guidelines recommend a vertical clearance in tunnels between 4.42 m (14.5 ft) and 5.0 m (16.4 ft), which includes a 0.15 m (0.5 ft) repaving allowance. Due to cost, most tunnels in the lower 48 are at the lower end of that range. The recent Ted Williams Tunnel (I-90) in Boston has a clearance to the ceiling of 4.72 m (15.5 ft), 4.27 m (14 ft) for vehicles and 0.45 m (1.5 ft) for overhead signs and signals. Reducing the volume of the tunnel will have a corresponding reduction in cost. Every cubic meter (m^3) or cubic foot (ft^3) of volume requires 0.78 m^3 (27.5 ft^3) of concrete to overcome buoyant forces.

4.0 Tunnel Cross Sections

4.1 Previous Concepts

The 1981 "Tongass Narrows Crossing Study, Phase II, Alternative Corridor Investigation" (Emps-Sverdrup) considered immersed tube tunnel alternatives in addition to a number of bridge alternatives. The tunnel cross section was based on then-current tunnel design practice for a two-lane, bi-directional tunnel, a safety walk on both sides, and an air duct below the roadway. The cross section was contained within a circular steel shell, encased in concrete on both sides.

The tube would have been constructed in excavated trenches or on newly constructed embankments. In the deeper sections of the channel, an alternative concept to rest the tube on submerged caissons (or piers) would have eliminated excessive embankment heights.

While the proposed resultant structure would have been relatively efficient, it does not meet current project objectives and criteria in the following areas:

- Current practice is to provide a protected egress/intervention route for evacuating motorists and emergency response personnel access.

- Current practice is to install a smoke extraction system to remove smoke as close as practicable to the location of a fire. A smoke extraction duct installed in the tunnel crown, above the vehicle clearance outline, could fulfill this requirement.

- Project design criteria requires pedestrian and bicycle access. The 0.75 m (2.5 ft) safety walk is not considered to be safe for regular use by pedestrians or bicycles.

4.2 Immersed Tube

To meet project objectives as summarized in the draft "Design Criteria Technical Memorandum" (HDR 2000), the project team proposes the following features, as the cross section (see Figure 2) notes.

- Curb to curb width of 7.8 m (25.5 ft); two 3.6 m (11.8 ft) lanes and 0.3 m (0.9 ft) between the curb and fog line. The pavement will have a cross slope to each curb for drainage.

- Vertical clearance of 5 m (16.4 ft) between curbs.

- Emergency walkway 0.75 m (2.5 ft) wide above and behind the non-mountable (barrier) curbs. The 0.75 m (2.5 ft) width shall be maintained for 2 m (6.6 ft) above the walkway.
- Emergency evacuation route, 1.2 m (39 ft) wide on one side of the roadway separated by a concrete wall with a 4-hour fire rating. Entry would be from the emergency walkway through doors at 90 m (295 ft) spacing.

- Full transverse ventilation system with an 18.5 m^2 (199 ft^2) duct supply and 18.5 m^2 (199 ft^2) exhaust duct.

- The proposed cross section provides for access by pedestrians or bicycles. A reinforced concrete fire-rated ceiling would be constructed 2.5 m (8.2 ft) above the evacuation route to allow a 1.8 m (59 ft) wide walkway 3 m (9.8 ft) above the roadway, separated from the roadway by a railing 0.45 m (1.5 ft) beyond the curb line. This provision results in higher ventilation operations cost. The longer exposure times of pedestrians in the tunnel will necessitate higher ventilation rates to reduce CO levels to acceptable levels. A push button could be installed at each end of the tunnel to alert the tunnel operator that a pedestrian was in the tunnel and that ventilation ratios should be increased.

4.3 Conventional Tunnel

In competent rock, to reduce rock excavation quantities in the approaches or as a deep tunnel alternative to the immersed tube, a conventional tunnel, excavated with blasting methods, is an option . The interior cross section (see Figure 3) would be similar to that for the immersed tube. Initial support of the tunnel would most likely be a combination of steel ribs with shotcrete.

For the possible alignments where the conventional tunnel joins the immersed tube, a cofferdam would be constructed. The cofferdam would be located at a depth where the tunnel could be safely constructed with minimal risk of inundation, while minimizing the rock trench excavation for the immersed tube. Pending geotechnical investigations, this study assumes a minimum 20 m (66 ft) rock cover for the tunnel..

4.4 Open Cut Approaches

As the immersed tube approaches the shoreline, or the conventional tunnel approaches the ground surface, a U-shaped retaining wall section is proposed to make the transition from the tube to the surface highway system. The proposed cross section (see Figure 4) consists of the two 3.6 m (11.8 ft) lanes with full 2.5 m (8.2 ft) shoulders. The shoulder widths would transition down to a width of 0.3 m (0.9 ft) just before the tunnel. At the junction of the tube with the open cut would be a ventilation building, housing ventilation and electrical equipment. Therefore, the ventilation ducts above and below the roadway need not be extended beyond the building. To reduce the thickness of the walls, struts can be provided above the roadway clearance line, 5 m (16.4 ft) above the pavement. In the deeper sections, a roof (cut and cover) placed at grade could increase surface use.

4.5 Cut and Cover Tunnel

The fully transverse ventilation system requires that the ventilation intake/exhaust buildings occur some distance from the portal and ideally at the quarter points of the tunnel. This arrangement minimizes the required cross-sectional areas of the supply and return ventilation ducts that extend the full length of the tunnel. Therefore, on some alignments a cut-and-cover section of tunnel is planned for at least 150 m (492 ft) beyond the ventilation buildings at ends of the immersed tube. The cut-and-cover section would also be more structurally efficient than the deep open cut, and it would allow alternative uses for the surface above the tunnel (see Figure 5).

4.6 Ventilation

For reasons already discussed, this study proposes a full transverse system for the Gravina tunnel.

The locations of the buildings that contain the main fans and associated equipment are not critical. The ideal locations are the tunnel quarter points, but due to the channel, they are not available. Moving the buildings toward the portals means that the cross-sectional area of the ducts that connect the two buildings must be increased if the maximum airflow velocity is to be limited to, say, 15 m/s (49 ft/s). The structural design and construction of the tunnel dictate that common duct sizes continue into the portal sections of the tunnel, rather than at reduced sections in accordance with the ventilating airflows that are required in those parts of the tunnel.

The lengths of the tunnel sections in option E are not too far from ideal; the portal sections are of equal length given the overall symmetrical arrangement. The extended portal sections on the Gravina side of options F2 and HMF2 cause an imbalance in the distribution of ventilating airflows, with consequent increases in duct sizes and power demands at the fans. Tables 4-1 and 4-2 summarize the first order estimates of the duct cross-sectional areas and fan powers..

Table 4-1
Minimum Cross-Sectional Areas of Ducts

Option	Supply duct (m^2)	Extract duct (m^2)
E	7.0 m^2 (75 ft^2)	8.0 m^2 (86 ft^2)
F2	12.0 m^2 (129 ft^2)	18.0 m^2 (194 ft^2)
HMF2	12.0 m^2 (129 ft^2)	18.0 m^2 (194 ft^2)

Table 4-2
Installed Fan Powers, and Power Draws during Normal Operations

Option	Installed (kW)	Normal Operations (kW)
E	850	440
F2	1850	840
HMF2	1400	630

The design locates the supply duct under the roadway, with branch ducts at regular spacing into the tunnel at sidewalk level. The exhaust duct is in the ceiling with motorized dampers. In the event of a fire, dampers near the fire zone would remain open and remote dampers would close to capture smoke from the tunnel.

4.7 Possible Alternatives

4.7.1 Center Wall

This single tube configuration creates a number of safety issues that the detailed design of the crossing must mitigate.

- A vehicle breakdown in the tunnel could be hazardous as drivers attempt to pass the stalled vehicle in the opposite lane.

- Oncoming vehicles at potentially high closure speeds within relatively narrow confines of the tunnel may reduce driver comfort and increase the potential for a head-on collision.

- In the event of a fire with smoke and/or fume, smoke control is complicated by the presence of motorists on both sides of the incident.

- In the event an evacuation is required, people would have to travel at least one half the length of the tunnel to reach the open air.

The conceptual design is based on the two-lane, single-tube configuration, but the project team will reassess the configuration once traffic volumes are projected.

The addition of a center wall would eliminate most of the concerns with the bi-directional tunnel. Doors through the center wall would provide a route from the incident tunnel to the safety of the adjacent non-incident tunnel, avoiding the need for a separate evacuation route. By eliminating the emergency evacuation route, the diameter of the tunnel would not increase significantly. However, with the 3.0 m (9.8 ft) lane and 0.3 m (0.9 ft) shoulders, it would be impossible to pass stalled vehicles, and emergency personnel could only respond to an incident from the exit end. Unless emergency response personnel and equipment is available on the Gravina side during operating hours, the design should allow for the ability to pass a stalled vehicle so that response vehicles from Ketchikan can reach the incident. A 6.1 m (20 ft) roadway each way could provide for safe passing of a stalled vehicle, with a 40% increase in the tunnel size.

Unidirectional traffic in each tube would allow a longitudinal ventilation system, with the elimination of the ventilation buildings at each portal and significantly less energy consumption for operation of the ventilation system.

The project team can revisit this topic in a later phase once a projection of traffic flows is available.

4.7.2 Longitudinal Ventilation

A longitudinal ventilation system is more efficient and less energy consumptive than a fully transverse system. However, the longitudinal system does not necessarily provide conditions for the safe evacuation of vehicle occupants in the event of an incident in a bi-directional tunnel. Consideration can be given to the addition of a longitudinal system for normal operations to supplement the transverse system required for emergency conditions. A life-cycle cost analysis in the next phase can evaluate if this addition would be cost effective.

4.7.3 Pedestrian/Bike Path Alternatives

Alternative approaches to provide for pedestrians and bicycles include:

- ➢ Increasing the width of the safety walk area (roadway level) from 0.75 m (2.5 ft) to 1.7 m (5.6 ft) to accommodate a 1.2 m (3.9 ft) pathway separated from the roadway by a railing 0.45 m (1.5 ft) behind the face of the curb. This increase would increase the tunnel diameter by about 0.3 m (0.9 ft) and the cross sectional area by about 10%.

- ➢ Using the emergency evacuation route. The public, however, would likely perceive this long, narrow passageway as claustrophobic and potentially unsafe, resulting in very low use.

- ➢ Using an alternate transportation system. If the design omitted provisions for pedestrian and bicycle access, the probable extension of the public bus service from downtown Ketchikan to the airport could easily accommodate demand.

4.7.4 Rectangular Cross Section

The project team selected a circular cross section for structural efficiency. However, a rectangular cross section would more closely match the structural enclosure to the rectangular vehicle clearance outlines. The rectangular cross section would also reduce the distance from the top of pavement to top of structure, thereby raising the pavement under the shipping channel and reducing the length of the approaches. A rectangular cross section will be evaluated in the next phase.

5.0 Alignments

In this phase of the project, team members explored three tunnel alignment corridors. The following sections and the attached plans and profiles summarize these corridors.

5.1 Alternative E

Alternative E would cross the channel between Bar Point and Gravina Island south of the airport. It would connect with a proposed road toward the north end of Gravina Island passing the airport on the west. At this location the channel is about 900 m (2,953 ft) wide with a maximum depth of about 46 m (151 ft) below MLLW.

A 750 m (2,461 ft) long immersed tube is proposed under the channel that would require a 12 m (39.3 ft) maximum depth of underwater rock excavation on the west side of the channel and a modest underwater embankment at the center and east side of the channel. On each end would be a 150 m (492 ft) cut and cover tunnel constructed within new cofferdams. A service building would be constructed over the junction of the immersed tube tunnel and cut and cover tunnels to house the ventilation fans and electrical equipment.

5.2 Alternative F2

Alternative F2 would cross from a location near the Coast Guard Base, under the east channel of Tongass Narrows to Pennock Island, connecting with a proposed bridge over the west channel to Gravina. At this location (east channel), the channel is about 650 m (2,133 ft) wide with a maximum depth of about 54 m (177 ft) below MLLW.

A 515 m (1,690 ft) long immersed tube is proposed under the channel between two service buildings constructed on new cofferdams near each shore. To gain the required depth under the navigation channel, underwater rock excavation would be required under most of the tunnel length. A conventional tunnel would be excavated from the east cofferdam under Tongass Avenue, and it would circle upward to the surface, eventually intersecting with Tongass Avenue. On Pennock Island, a conventional tunnel would be excavated to connect with a proposed bridge over the west channel.

5.3 Alternative HMMF2

Alternative HMMF2 would cross Tongass Narrows north of the existing ferry docks. On Gravina, the tunnel would connect with a proposed road north of the airport. At this location the channel is about 450 m (1,476 ft) wide with a maximum depth of about 39 m (128 ft) below MLLW.

A 510 m (1,673 ft) long immersed tube would be constructed with underwater rock excavation required for the full length. On the west end would be a 150 m (492 ft) cut-and-cover tunnel constructed within a new cofferdam. A service building would be constructed over the junction of the immersed tube tunnel and cut-and-cover tunnel to house the ventilation fans and electrical equipment. A conventional tunnel would be excavated from the east cofferdam and service building under Tongass Avenue, circling upward to the surface eventually intersecting with Tongass Avenue.

6.0 Construction Methods

6.1 Tube Fabrication

Immersed tube tunnels are typically constructed in one of two methods: using reinforced/prestressed concrete tubes or steel tubes surrounded and lined with concrete.

Historically, the double steel tube has had greater use throughout the USA, although recent projects in the Boston area are using concrete boxes. The following sections describe each construction method.

6.1.1 Concrete Box

In this method, the tunnel elements are constructed from reinforced concrete in the dry, usually within a custom built dry-dock or casting basin. The units are constructed of reinforced/prestressed concrete, typically made up of a number of sections joined together to form elements around 100 m (328 ft) long.

Once the elements are complete within the casting basin or dry dock, the basin is flooded and the elements are floated out. In the water, the elements can be towed to the tunnel site and positioned above the previously dredged trench. The elements are lowered to their final position by use of ballast tanks, and a sand screed is placed below the invert slab.

6.1.2 Steel Tube

Two categories define steel immersed tube tunnels: single shell tube, and double shell tube.

The single shell tube consists of a continuous external watertight steel plate shell, stiffened with internal transverse members and longitudinal stiffeners. A cast-in-place reinforced concrete lining is formed within the steel shell to act as a composite structure. An example of a single tube steel shell is the Bay Area Rapid Transit (BART) tunnel in San Francisco.

The double shell tube includes an interior steel plate stiffened by external diaphragms and longitudinal stiffeners. The interior of the tunnel is lined with a reinforced concrete lining, again acting as a composite structure. An outer form plate encloses the exterior diaphragms. The space between the exterior form plate and the interior steel shell is filled with tremie concrete to provide the ballast and to protect the interior steel shell from corrosion. An example of a double steel tube is the Second Hampton Roads Tunnel in Virginia.

For better performance during an earthquake, a double shell steel tube was selected, but the selection will be revisited during a detailed comparison in the next phase.

The key feature of steel tube construction is that the relatively light steel shell is fabricated first on land, or in a dry dock, and the concrete interior (ballast) is added later after the tube has been launched and is afloat.

The joints between the units of an immersed tube tunnel enable the connection between the units to be made underwater and also introduce flexibility into the structure. To avoid differential movements at the joints, the continuity of the steel shell and concrete across the joints provides a means of transferring shear forces across the joint. . For these tunnels, it has been assumed that the steel shell and concrete is continued across the joint after placement of the tunnel elements.

6.2 Channel Preparation

A number of methods can install the submerged tube depending on the conditions of a particular alignment. In areas where the tube is below the existing channel bottom, trenches would be dredged or blasted through the rock channel. The trench width varies from 22 m (72 ft) to 45 m (148 ft) for the alignments considered, but a 60 m (197 ft) width of the channel bottom should be considered as "disturbed." The limited geotechnical data available suggests that rock is generally close to the channel bottom, and the rock will have to be broken by blasting methods prior to removal.

Dredging can be undertaken using a number of different techniques, such as cutter dredging, bucket dredger, grab crane and suction dredging. The actual technique selected has to take into account the environmental impact, the soil conditions, shipping movements and density, and the tunnel structure.

The bottom of the dredged trench should be relatively level and clean before the tunnel elements can be placed. These requirements necessitate additional care in the dredging of the deepest part of the trench and in cleaning of the trench to avoid sedimentation and consolidation of the sediment in the trench. The trench for the immersed tube is usually over dredged and a foundation screed placed, upon which the elements are founded.

Where the tube is above the channel bottom, embankments can be constructed. The width of the channel disturbed by the embankment could be as much as 60 m (197 ft) for the alignments considered. In the deeper sections of the channel, the tube can be attached to submerged caissons (or piers) to eliminate excessive embankment heights. It may also be practicable to construct the tube with positive buoyancy and anchor the tube with a network of cables or struts. The possible substitution of submerged caissons or a floating tunnel can be evaluated in the next phase of the study.

Stability of the foundation layer and trench slopes is an important factor in the design and construction of the immersed tube tunnel. Following dredging operations, it is sometimes difficult to maintain the full length and width of the channel, especially in fast moving water. Sedimentation or silting of the trench can occur before the elements can be installed. However, sedimentation is different for every local situation. This will need to be carefully considered and the proper precautions taken before forming the trench or embankment and preparing the foundation for the immersed tube.

In some soft deposits, it has been necessary to replace soft material with competent material or even to provide a piled support to the elements. Within Tongass Narrows, the deposits have been assumed to be firm and require no additional supporting measures.

6.3 Tube Installation

Construction of an immersed tube tunnel requires two distinct facilities:

- Fabrication yards for the units.
- Outfitting piers to install the structural concrete.

Fabrication of the steel shells requires a yard on or very close to the water with sufficient space and facilities to construct a sufficient quantity of elements to meet the construction schedule.

Following the fabrication of the steel shells, the invert and cap structural concrete is placed while the elements are still in the dry. The elements are then launched into the water and towed to an outfitting pier local to the tunnel site for the installation of the internal concrete and some of the ballast concrete.

The immersing of the tunnel elements is the most difficult and risky aspect of constructing an immersed tube tunnel. Immersing requires working with huge elements under relatively difficult conditions, where much of the work is carried out without a direct view of the activities. Therefore, it is critical that the work be as simple as possible.

The tunnel elements are first attached to immersing pontoons, which consist of a set of two or four pontoons with bridges between them. The tunnel element is suspended from these bridges.

Ballast is applied to the elements to cause them to sink and the elements can be lowered using winches on the pontoons. When the tunnel element is close to its final position, it can be lowered against the previous element before being placed on the screeded gravel foundation.

After pumping out the water trapped between the bulkheads of the two units, the water pressure pushes the tunnel element firmly against the previous element (or landward section) at the same time dictating the direction of the tunnel axis.

The elements are joined together underwater by use of a flexible hydrostatic joint system as described above. When the joints have been made watertight, the bulkheads at the ends of the elements can be removed and the joint completed from the inside.

Horizontal control of the tunnel elements is normally created by the use of winches, anchor lines and anchors in the water or onshore. Control of the element can be difficult where high currents exist, and it may then be necessary to have direct control over the element by placing the winches in towers on the tunnel elements.

Following completion of the joints and all other work to the external faces of the elements, backfill is placed around the immersed tube in a pre-determined sequence to provide the long-term stability and protection for the completed tunnel. A protective rock fill layer a minimum of 1.5 m (5 ft) thick is placed above the tunnel.

Some form of cofferdam is required to make the connection between the immersed tube elements and the landward box structures. The cofferdam would be constructed into the water to allow connection with the landward cast-in-place sections of cut and cover tunnel.

7.0 Operational Requirements

7.1 Tunnel Facilities

To facilitate the safe passage of vehicles through the tunnel, the design would include a number of systems , as summarized below.

7.1.1 Ventilation System

The ventilation system was described in Section 4.6. The ventilation system could normally operate in an automatic mode, with air quality monitors adjusting ventilation rates to match demand. The control center and a fire management panel near each tunnel entrance would include the manual controls for the ventilation system.

7.1.2 Drainage

The tunnel low point would contain a sump with associated explosion proof pumps and discharge piping. The design would size the system to handle rain water inflows from the approaches and any fire flows. Hydrocarbon detectors would detect the presence of spilled fuel in the drainage system.

7.1.3 Fire Protection

Hand-held fire extinguishers would occur every 90 m (295 ft). The design would also include a dry standpipe the full length of the tunnel with hose connections every 90 m (295 ft).

7.1.4 Lighting

Tunnel lighting would illuminate the tunnel interior. At the portals photocell controlled transition lighting would gradually adjust the intensity of light for drivers as they enter and leave the tunnel. Certain fixtures would be on an emergency circuit to provide minimum lighting in case of power failure.

7.1.5 Communications

The design would include emergency phones, with automatic ring down at the control room, at 90 m (295 ft) spacing. The design would also include a radio system to permit emergency response and maintenance personnel to communicate.

7.1.6 CCTV

The design would include a closed circuit television (CCTV) system to provide 100% coverage of the tunnel and approaches.

7.1.7 Fire Detection

NFPA 502 requires two methods of fire detection in the tunnel. Possible methods include manual pull stations every 90 m (295 ft), linear heat detectors above the roadway, and incident detection software to monitor the CCTV system. A later phase will determine exact methods of fire detection in conjunction with the development of the emergency response plan.

7.1.8 Vehicle Control

The design would include standard pavement markings and fixed signs to direct vehicles in the tunnel. The design also includes the installation of some combination of traffic signals, gates and variable message signs to close the tunnel to additional traffic as soon as an incident is detected within the tunnel.

7.1.9 Operation Center

All controls and alarms would be routed to an operation center. The center could be located in an existing public safety office shared with the airport crash and fire rescue or a stand alone facility.

7.1.10 Toll Plaza

If a decision is made to collect tolls, a toll plaza would be required.

7.2 Daily Operations

The size, composition, and responsibility of the daily operations staff would depend on if the tunnel is a toll facility and the possible sharing of responsibility for emergency response.

7.2.1 Toll Option

If the tunnel is a toll facility, a staff of toll collectors, supervisors and auditors would be needed to administer the toll collection. The toll collection plaza would be the logical location for the control room, where a tunnel operator would monitor traffic in the tunnel and initiate an appropriate response to any incidents.

7.2.2 No-Toll Option

The tunnel can be designed as a fully automated, unattended facility. Photocells can control lights and feedback from air quality and opacity instrumentation can adjust ventilation rates. However, the emergency phones and any alarms should be transmitted to an attended monitoring station which could be a nearby fire station, police station, trooper station or even the airport CFR (crash and fire rescue). Multiple monitoring stations can be added for little more than the nominal cost of extending the fiber optic communication to each site. This would allow a shared responsibility for monitoring, such as the airport CFR when the airport is open and a public safety office when the airport is closed. The CCTV feeds would also be transmitted to the monitoring station(s) to assist the attendant in any emergency response.

7.3 Emergency Response

If the DOT&PF operation staff was to be designated as the first emergency responders, a minimum of four people would be required on each side of the tunnel whenever the tunnel was open to comply with OSHA's "two-in, two-out" rule for fire fighters. Operating costs could be reduced significantly by sharing responsibilities with other public safety agencies such as the Ketchikan Fire Department or the airport CFR unit.

The minimum cost (to DOT&PF) for emergency response would be for the Ketchikan Fire Department to be the primary responder to any incidents in the tunnel. An agreement with the airport is an option for use of the airport CFR (crash and fire rescue) as a secondary responder, in case tunnel emergency access from Gravina is required. A plan could be developed to transport fire response personnel and equipment by ferry in the event that tunnel emergency access from the Gravina side is required and the airport CFR is not available.

7.4 Maintenance

Periodic inspections of the tunnel (say weekly) would be required to identify routine maintenance requirements such as burned out lamps. More comprehensive monthly and quarterly inspections and/or tests would be required of ventilation equipment, emergency generators, air quality monitoring sensors, alarms, etc.

8.0 Cost Estimates

8.1 Construction Costs

The cost estimates summarized below provide order of magnitude costs for the three tunnel alternatives being considered. These estimates allow for the following:

- ➢ Excavation and dredging of the channel bed
- ➢ Conventional tunnel excavation (where appropriate)
- ➢ Retaining wall structures at tunnel approaches
- ➢ Cut and cover tunnel approaches
- ➢ Ventilation and service buildings
- ➢ Cofferdams
- ➢ Fabrication of tunnel elements, including steel and concrete work
- ➢ Jointing of immersed tube segments
- ➢ Backfill around and over immersed tube, including a 1.5 m (5 ft) thick rock blanket over the tunnel
- ➢ Electrical costs including lighting, communications, alarm and CCTV
- ➢ Mechanical costs including ventilation, fire protection and drainage

Costs have been projected to summer 2003 prices.

	Alternative E	**Alternative HMF2**	**Alternative F2**
Probable Cost (Summer 2003)	**$121 million**	**$168 million**	**$212 million**

The above costs do not include any contingencies which will be added when other project costs are added, including:

- ➢ Design development contingencies
- ➢ Geotechnical contingencies
- ➢ Estimating and bidding contingencies
- ➢ Environmental mitigation contingencies
- ➢ Roads and intersections to connect tunnel approaches with Tongass highway and the airport
- ➢ Right of way acquisition
- ➢ Engineering and administration
- ➢ Construction management

The geotechnical contingency should be in the 30% to 50% range to reflect the following issues:

- The thickness of sedimentary material on the channel bottom is not known, except at a few points. Variations of the rock line can have a significant effect on the underwater rock excavation quantities.
- A fault is know to exist at the center of the channel, but little is known of its composition or width through the project area.
- Not one boring has been taken near the tunnel alignment.

8.2 Operating Costs

Operating costs have been estimated for the tunnel, broken down by labor, energy, maintenance and equipment replacement.

8.2.1 Labor

The largest component of the operating cost is labor, which is highly influenced by the plans that need to be developed for emergency response. The project team evaluated three cases.

The least cost assumes that the DOT&PF enters into agreements with the Ketchikan Fire Department and the Airport Crash and Fire Rescue. The DOT&PF would be responsible for providing emergency response equipment and training to the responders. The DOT&PF's operations would be a 24-hour tunnel operator and a day-time maintenance crew. The estimated annual labor cost is $400,000 in year 2005.

Since the airport CFR may not be on duty during the night-time hours, the DOT&PF may have to fund the cost of the emergency response team when the airport closes, with an estimated annual cost of $770,000 in year 2005.

In the event that cooperative agreements with other emergency responders cannot be reached, the DOT&PF may have to fund the entire emergency response team at an estimated annual cost of $2,460,000 in year 2005.

If tolls are implemented, additional labor costs would be incurred for toll collection, although the toll collectors could also be trained as emergency responders, offsetting those labor costs.

8.2.2 Energy

The next largest expense is energy for ventilation, lights, and pumps. Because the ventilation and lighting costs are a function of tunnel length, the team developed costs for each alignment. The estimate energy costs (year 2005) are $240,000, $450,000 and $340,000 for alignments E, F2 and HMF2, respectively.

8.2.3 Maintenance

An allowance of $200,000 per year is estimated for maintenance or repairs by outside resources and miscellaneous inspections and testing, consumables, parts, etc.

8.2.4 Equipment Replacement

An allowance of $200,000 per year is estimated to replace major equipment, such as fans, dampers, light fixtures, etc., as they reach their useful lives.

8.2.5 Operations Totals

Total estimated operations cost for alignment E in year 2005 is $1.04 million assuming cooperative agreements with other emergency responders or $3.1 million without. Add $0.2 million and $0.1 million for alignments F2 or HMF2, respectively.

9.0 References

Emps-Sverdrup. December 1981. "Tongass Narrows Crossing Study, Phase II, Alternative Corridor Investigation."

HDR Alaska. 2000. Draft "Design Criteria Technical Memorandum." For the Alaska Department of Transportation and Public Facilities.

APPENDIX 14-E
ROADWAY AND TUNNEL CONSTRUCTION ESTIMATE

draft

40 Foot Road to Tunnel

GRAVINA ACCESS PROJECT ALTERNATIVE TUNNEL FROM STA 70+91 - 157+85 excluding Tunnel
PROJECT CONSTRUCTION AND DEVELOPMENT COST ESTIMATE

8/14/2006

LINE	NUMBER	PAY ITEM	PAY UNIT	UNIT PRICE	QUANTITY	AMOUNT
		DIVISION 200 -- EARTHWORK				
a	201(3A)	CLEARING AND GRUBBING	ACRE	$4,000	12	$48,000
b	203(2)	ROCK EXCAVATION	YD^3	$10	0	$0
c	203(3)	UNCLASSSIFIED EXCAVATION	YD^3	$8	150,000	$1,200,000
d	203(4)	MUCK EXCAVATION	YD^3	$8	0	$0
e	203(6A)	BORROW, TYPE A	TON	$10	75,200	$752,000
f	203(20)	BLASTING CONSULTANT	LUMP SUM	$0	All Req'd	$0
		DIVISION 300 -- BASES				
g	301(1)	AGGREGRATE BASE COURSE, GRADING D-1, (6")	TON	$20	7,400	$148,000
		DIVISION 400 -- ASPHALT PAVEMENTS & SURFACE TREATMENTS				
h	401(1)	ASPHALT CONCRETE, TYPE II, CLASS A (2")	TON	$60	2,100	$126,000
i	401(2)	ASPHALT CEMENT, GRADE PG 58-28	TON	$400	120	$48,000
j	401(5)	ANTI-STRIP ADDITIVE	CS	$6,960	All Req'd	$6,960
k	401(6)	ASPHALT PRICE ADJUSTMENT	CS	$6,960	All Req'd	$6,960
l	402(1)	STE-1 ASPHALT FOR TACK COAT	TON	$650	8	$5,200
		DIVISION 500 -- STRUCTURES				
m	501(1)	CLASS A CONCRETE	LUMP SUM	$0	All Req'd	$0
n						$0
o						$0
p	511(1)	MECHANICALLY STABILIZED EMBANKMENT RETAINING WALLS	FT^2	$65	0	$0
		DIVISION 600 -- MISCELLANEOUS CONSTRUCTION				
q	602, 603, 604, 605, 616	DRAINAGE MEASURES (2.5% of Lines a thu p & r thru v)	LUMP SUM	$60,000	All Req'd	$60,000
r	606(1)	W-BEAM GUARDRAIL	LIN FT	$40	0	$0
s	606(11)	EXTRUDER TERMINAL (ET-2000)	EACH	$4,000	0	$0
t	606(12)	GUARDRAIL/BRIDGE RAIL CONNECTION	EACH	$4,000	0	$0
u	609(2)	CURB AND GUTTER, TYPE 1	LIN FT	$15	0	$0

v	614(2)	CONCRETE BARRIER (HALF)	LIN FT	$175	0	$0
w	615, 660, 661, 670	PERMANENT TRAFFIC CONTROL / INTERSECTIONS / LIGHTING (2% of Lines a thu p & r thru v)	LUMP SUM	$50,000	All Req'd	$50,000
x	618, 619, 620	LANDSCAPING (1% of Lines a thu p & r thru v)	LUMP SUM	$30,000	All Req'd	$30,000
y	631, 633, 641	EROSION, SEDIMENT & POLLUTION CONTROL (1.5% of Lines a thu p & r thru v)	LUMP SUM	$40,000	All Req'd	$40,000
z	642(1)	CONSTRUCTION SURVEYING (2.5% of Lines a thu p & r thru v)	LUMP SUM	$60,000	All Req'd	$60,000
aa	643	CONSTRUCTION TRAFFIC CONTROL (1% of Lines a thu p & r thru v)	LUMP SUM	$30,000	All Req'd	$30,000
ab	644	CONTRACTOR FURNISHED (2.5% of Lines a thu p & r thru v)	LUMP SUM	$60,000	All Req'd	$60,000
ac		**ROADWAY CONSTRUCTION SUBTOTAL** (Lines a thru ab)				$2,671,120
ad		**ROADWAY CONTINGENCY** (30% of Line ac)				$801,336
ae		**ROADWAY CONSTRUCTION TOTAL** (Lines ac & ad)				$3,472,456

ESTIMATE for 40 FOOT WIDE TUNNEL	
Construction Cost Estimate for 30 foot wide tunnel:	$239,796,000
Construction Cost Estimate for 40 foot wide tunnel [(30 foot tunnel cost) x (40/30)]:	$319,728,000

TONGASS NARROWS CROSSING CONCEPT STUDY

Mid-Range Cost Details. Mid-range capital construction costs can be summarized as follows using quantities and unit prices developed by various parties and checked for general accuracy:

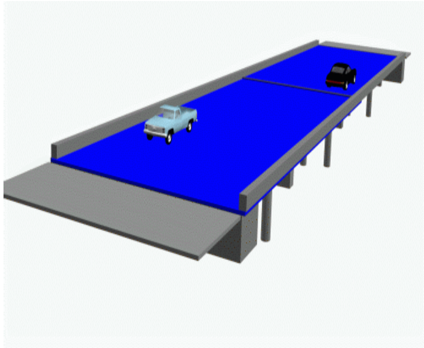
ITEM	QUANTITY	UNIT PRICE	TOTAL COST
Mobilization & Miscellaneous	All	LS	$ 15,000,000
Seabed Muck Excavation	40,000 CY	$ 10.00	400,000
Rock Excavation	200,000 CY	20.00	4,000,000
Shot Rock Fill Below Tube	310,000 CY	20.00	6,200,000
Shot Rock Tube Cover Fill	200,000 CY	20.00	4,000,000
Shot Rock Fill Vibracompaction	40,000 SY	25.00	1,000,000
Open Cell Fill	160,000 CY	15.00	2,400,000
Open Cell Fill Vibracompaction	12,000 SY	20.00	240,000
Open Cells	3,500 Tons	2400.00	8,400,000
Cell perimeter Grouting	3,200 LF	500.00	1,600,000
CIP Closure Concrete	3,000 CY	1000.00	3,000,000
CIP Concrete Paving	3,500 CY	600.00	2,100,000
Paving Leveling Layer	3,500 CY	25.00	880,000
Barrier Rails, Signs, etc	All	LS	200,000
Dry Dock or Graving Dock Costs	All	LS	3,600,000
Tube Structural Steel w/Coatings	4,200 Tons	5000.00	21,100,000
Tube Reinforced Concrete	85,000 CY	1200.00	102,000,000
Tube Placement	All	LS	3,000,000
Tube Grouting	All	LS	1,000,000
Tube CIP Reinforced Concrete	5,600 CY	600.00	3,360,000
Drainage Systems w/Pumps, Lighting System, Ventilation System, Buildings, Security System w/connection to Police and Airport Security, Sensors, Alarms, Backup Generator System, etc	All	LS	16,350,000
20% Contingencies			$39,966,000
Estimated Total Mid-Range Construction Cost:			**$ 239,796,000**

Note: This estimate covers a project extending approximately one mile in length including about 3,200 feet of tube tunnel and is based upon criteria that present the lowest cost. Tunnel widening, for example, will increase cost. Location of tube construction may have a significant impact on cost. For purposes of this estimate the most cost-effective case was assumed.

BridgeLCC 2.0
Reports

Ketchikan Gravina Island Access -- M and T Alignments

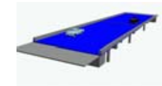
02/11/2009



Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD

Analysis: Summary of Life-Cycle Costs

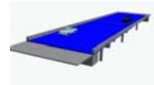
02/11/2009



	Name	Base Case	Alternative #1	Alternative #2
	Total Life-Cycle Cost	**$388,208,335**	**$442,183,826**	**$445,097,447**
By Cost Bearer:	Agency Costs	$388,208,335	$442,183,826	$445,097,447
	User Costs	$ 0	$ 0	$ 0
	Third-Party Costs	$ 0	$ 0	$ 0
By Cost Timing:	Initial Construction Costs	$335,514,454	$354,766,017	$369,540,473
	OM&R Costs	$ 52,693,881	$ 87,417,809	$ 75,556,974
	Disposal Costs	$ 0	$ 0	$ 0
By Cost Component:	Elemental Costs	$388,208,335	$442,183,826	$445,097,447
	Non-elemental Costs	$ 0	$ 0	$ 0
	New-Technology	$ 0	$ 0	$ 0

Data: Project Parameters

02/11/2009



Study Period

Base Year	2008
Length of period	80
Last Year	2088

Currency

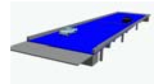
U.S. Dollars ($)

Interest Rates

Inflation	2.05%
Real Discount	2.80%

Elements

#1	Bridge
#2	Tunnel
#3	Paved Road
#4	Gravel Road
#5	
#6	Non-elemental
#7	New technology



M1 (20' to 200')

Lanes on	2	Length of roadway (ft)	1,640.00
	0	Length of bridge (ft)	1,400.00

Alignment M1. Provide a flat low-profile minimal-clearance (20-foot) movable bridge (600-foot vertical lift span) over Tongass Narrows between the existing ferry terminals on Revilla and Gravina islands. Span will open to provide 200 feet of vertical and 550 feet of horizontal navigational clearance.

T1

Lanes on	2	Length of roadway (ft)	25,314.00
	0	Length of bridge (ft)	3,200.00

Alignment T1. Provide a tunnel under Tongass Narrows between Peninsula Point on Revilla Island and Lewis Point on Gravina Island. Connect with a new paved road from Lewis Point portal up the hill to the Seley Road. Upgrade and pave the Seley Road, pave the Lewis Reef Road and Airport Access Road to the KTN passenger terminal. Channel will provide 550 feet of horizontal navigational clearance, and 40 feet of vessel draft at MLLW.

M2 (60' to 200')

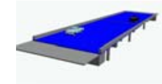
Lanes on	2	Length of roadway (ft)	2,720.00
	0	Length of bridge (ft)	1,700.00

Alignment M2. Provide a curvilinear low-clearance (60-foot) movable bridge (600-foot vertical lift span) over Tongass Narrows near the existing ferry terminals on Revilla and Gravina islands. Span will open to provide 200 feet of vertical and 550 feet of horizontal navigational clearance.

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Base Case									
Agency									
Initial Construction									
Construction cost	<no event>	5	5	1.0000	1.000	LS	$374,700,000	$374,700,000	.
Disposal									
Disposal cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	.
O, M, and R									
M&O Bridge	<no event>	5	80	1.0000	1.000	LS	$ 1,050,000	$ 1,050,000	
M&O Paved Road	<no event>	5	80	1.0000	1640.000	LS	$ 4	$ 7,052	
M&O Gravel Road	<no event>	5	80	1.0000	34408.000	LS	$ 4	$ 147,954	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Bridge	<no event>	10	80	5.0000	1400.000	Length of	$ 23	$ 32,200	
Guardrail Paved Road	<no event>	10	80	5.0000	100.000	LS	$ 117	$ 11,700	
Guardrail Gravel Road	<no event>	10	80	5.0000	3441.000	LS	$ 117	$ 402,597	
Replace Pavement Bridge	<no event>	15	80	10.0000	1400.000	Length of	$ 102	$ 142,800	
Replace Pavement Road	<no event>	15	80	10.0000	200.000	LS	$ 102	$ 20,400	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Bridge	<no event>	20	80	15.0000	1400.000	Length of	$ 5	$ 7,000	
Signs/Illumination Paved	<no event>	20	80	15.0000	100.000	LS	$ 5	$ 500	
Signs/Illumination Gravel	<no event>	20	80	15.0000	6882.000	LS	$ 5	$ 34,410	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Bridge Rehabilitation	<no event>	30	80	25.0000	1.000	LS	$ 5,000,000	$ 5,000,000	
Bridge Major Rehabilitation	<no event>	55	80	50.0000	1.000	LS	$ 35,000,000	$ 35,000,000	
Alternative #2									

Data: Individual Costs

02/11/2009



Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Agency									
Initial Construction									
Construction Cost	<no event>	5	5	1.0000	1.000	LS	$412,700,000	$412,700,000	
O, M, and R									
M&O Bridge	<no event>	5	80	1.0000	1.000	LS	$ 1,800,000	$ 1,800,000	M&O=2800/1640
M&O Paved Road	<no event>	5	80	1.0000	2720.000	Length of	$ 4	$ 11,696	
M&O Gravel Road	<no event>	5	80	1.0000	34408.000	LS	$ 4	$ 147,954	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Bridge	<no event>	10	80	5.0000	1700.000	Length of	$ 23	$ 39,100	
Guardrail Paved Road	<no event>	10	80	5.0000	1360.000	LS	$ 117	$ 159,120	
Guardrail Gravel Road	<no event>	10	80	5.0000	3441.000	LS	$ 117	$ 402,597	
Replace Pavement Bridge	<no event>	15	80	10.0000	1700.000	Length of	$ 102	$ 173,400	
Replace Pavement Road	<no event>	15	80	10.0000	1020.000	LS	$ 102	$ 104,040	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Bridge	<no event>	20	80	15.0000	1700.000	Length of	$ 5	$ 8,500	
Signs/Illumination Paved	<no event>	20	80	15.0000	510.000	LS	$ 5	$ 2,550	
Signs/Illumination Gravel	<no event>	20	80	15.0000	6882.000	LS	$ 5	$ 34,410	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Bridge Rehabilitation	<no event>	30	80	25.0000	1.000	LS	$ 5,000,000	$ 5,000,000	
Bridge Major Rehabilitation	<no event>	55	80	50.0000	1.000	LS	$ 35,000,000	$ 35,000,000	
Disposal									
Disposal Cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	

Alternative #1

Agency

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Initial Construction									
Construction cost	<no event>	5	5	1.0000	1.000	LS	$396,200,000	$396,200,000	.
O, M, and R									
M&O Tunnel	<no event>	5	80	1.0000	1.000	LS	$ 1,500,000	$ 1,500,000	
M&O Paved Road	<no event>	5	80	1.0000	23514.000	LS	$ 4	$ 101,110	
M&O Gravel Road	<no event>	5	80	1.0000	16714.000	LS	$ 4	$ 71,870	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Paved Road	<no event>	10	80	5.0000	11057.000	LS	$ 117	$ 1,293,669	
Guardrail Gravel Road	<no event>	10	80	5.0000	1671.000	LS	$ 117	$ 195,507	
Replace Pavement Tunnel	<no event>	15	80	10.0000	3200.000	Length of	$ 102	$ 326,400	
Replace Pavement Road	<no event>	15	80	10.0000	22114.000	LS	$ 102	$ 2,255,628	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Tunnel	<no event>	20	80	15.0000	3200.000	Length of	$ 5	$ 16,000	
Signs/Illumination Paved	<no event>	20	80	15.0000	11057.000	LS	$ 5	$ 55,285	
Signs/Illumination Gravel	<no event>	20	80	15.0000	3343.000	LS	$ 5	$ 16,715	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Tunnel Electrical	<no event>	5	80	1.0000	1.000	LS	$ 550,000	$ 550,000	
Tunnel Repairs and	<no event>	5	80	1.0000	1.000	LS	$ 200,000	$ 200,000	
Disposal									
Disposal cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	.

APPENDIX 14-F
TUNNEL CONSTRUCTABILITY REPORT

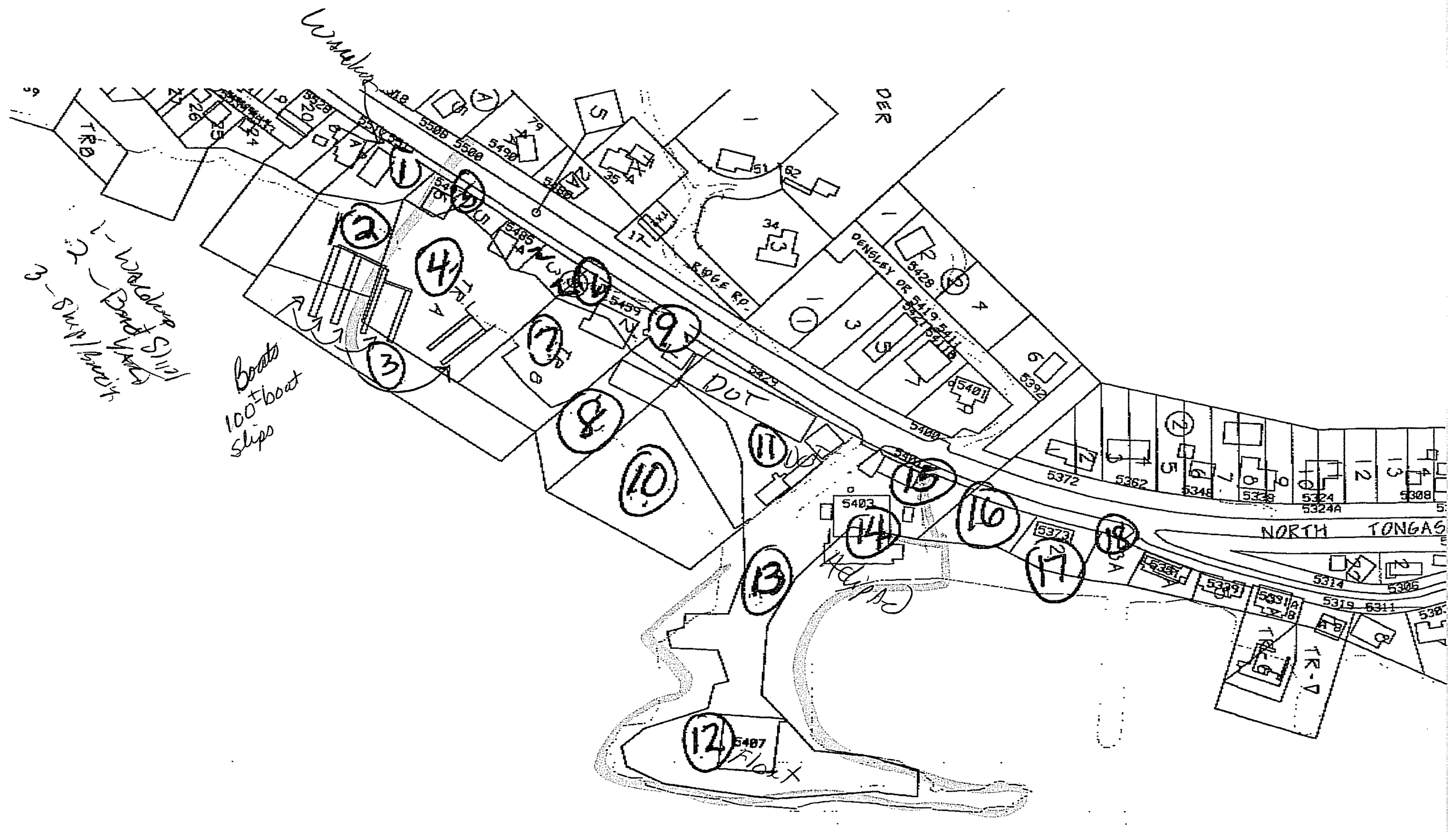
draft

APPENDIX 14-G
RIGHT-OF-WAY

draft

Gravina Tunnel
8/18/2006
Acquisition/Relocation Estimate

Parcel #	Name	Tax Parcel #	Land Value	Improvement Value	Total Value	Acquisition Estimate	Relocation Estimate	Admin/Labor/Subs	Total Estimate	PPT Alt 1	PPT Alt 2
1	Spears, R Wayne & Connie L	038-200	$159,300	$138,900	$298,500	$417,900	$65,000	$15,550	$498,450		
	Spears, R Wayne & Connie L	038-200	$13,700	$4,100	$17,800	$24,920	$20,000	$15,550	$60,470		
2	State of Alaska-Lessor	038-200	$11,200	$4,100	$15,300	$21,420	$20,000	$15,550	$56,970		
	Seaborne Marine Services-Lessee	037-000	$24,200	$0	$24,200	$33,880	$0	$15,550	$49,430		
3	City of Ketchikan-Lessor										
	Seaborne Marine Services-Lessee	037-000	$20,000	$0	$20,000	$28,000	$20,000	$15,550	$63,550		
3	City of Ketchikan-Lessor										
4	Seaborne Marine Services	037-000	$233,500	$164,600	$398,100	$557,340	$30,000	$15,550	$602,890		
5	Seaborne Marine Services	038-100	$53,800	$263,500	$317,300	$444,220	$30,000	$15,550	$489,770		
6	Seaborne Marine Services	037-000	$200,900	$471,600	$672,500	$941,500	$40,000	$15,550	$997,050	x	
7	Seaborne Marine Services	037-000	$195,000	$0	$195,000	$273,000	$20,000	$15,550	$308,550	x	
8	Temsco Helicopters Inc.-Lessee	036-000	$90,500	$0	$90,500	$126,700	$0	$15,550	$142,250	x	x
	City of Ketchikan-Lessor										
9	Temsco Helicopters Inc.	036-000	$47,100	$46,800	$88,900	$124,460	$20,000	$15,550	$160,010	x	x
10	Temsco Helicopters Inc.	035-000	$213,900	$0	$213,900	$299,460	$0	$15,550	$315,010		x
11	Temsco Helicopters Inc.	035-000	$371,400	$1,268,400	$1,639,800	$2,295,720	$100,000	$15,550	$2,411,270		x
12	PMI Holding LLC - Lessee	035-500	$417,400	$490,400	$907,800	$1,270,920	$50,000	$15,550	$1,336,470	x	x
	State of Alaska - Lessor										
13	State of Alaska DNR	035-500	$994,300	$0	$994,300	$1,392,020	$1,000	$15,550	$1,408,570		x
14	Temsco Helicopters Inc	035-500	$227,500	$219,600	$447,100	$625,940	$50,000	$15,550	$691,490		x
	State of Alaska-Lessor	035-500	$197,400	$219,600	$417,100	$583,940	$20,000	$15,550	$619,490		x
15	City of Ketchikan	035-500	$76,500	$162,500	$239,000	$334,600	$50,000	$15,550	$400,150		x
	State of Alaska - Lessee										
16	State of Alaska DNR	044-000	$97,700	$0	$97,700	$136,780	$1,000	$15,550	$153,330		
17	State of Alaska DNR	044-200	$172,200	$57,000	$229,200	$320,880	$20,000	$15,550	$356,430		
18	State of Alaska DNR	044-500	$121,300	$0	$121,300	$169,820	$1,000	$15,550	$186,370		
	TOTAL:								**$11,307,970**	**$2,944,330**	**$7,484,710**


NORTH TONGAS
DOT
RIDGE RD.
DENSLEY DR
TR-7
5407
5403
5401
5373
5372
5362
5392
5429
Boats
100± boat
slips

01 3230 038 200
SPEARS R WAYNE & CONNIE L

PO BOX 9203
SYLMAR CA 91392
14369 Sq. FL City RL SWD 199/145 12/23/1991
01 1417 008 007 CUSTOMER NO 604434
LOCATION N TONGASS HWY 5511
YEAR BUILT 1975 NO. UNITS 1
EXEMPT1 None PROP CLASS 111 SEPTIC IndOf
ALSO LOT 8
ADL# 33925

V

25 Property Class
146 Septic Type
36 Year Built
Foundation

Date Construction/Permits Comments:

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL	REMARKS		C/E	
01 3230 038 200				143,900	123,700	0	267,600	APR
2005 None		604434		143,900	123,700	0	267,600	AS
10/06	159,300	138,900	300	298,500				
01 3230 038 200				159,300	138,900	300	298,500	APR
2006 None		604434		159,300	138,900	300	298,500	AS

COPY
FOR ASSESSMENT PURPOSES ONLY
KETCHIKAN GATEWAY BOROUGH
ASSESSMENT DEPARTMENT
344 FRONT STREET
KETCHIKAN, ALASKA 99901

Rev. 6

01 3230 038 200 ATS1
SPEARS R WAYNE & CONNIE L
STATE OF ALASKA - LESSOR
15853 OLDEN ST
SYLMAR CA 91392
30361 Sq. Ft. City RL LEASE 252/221 11/16/1995
01 0ATS 000 693 CUSTOMER NO 608004
LOCATION N TONGASS HWY 5500 BLK
YEAR BUILT 1975 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 905 SEPTIC Other
ADL 33826
ATS 693

2

25 Property Class
146 Septic Type
36 Year Built
Foundation

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL	REMARKS		C/E	Date Construction/Permits Comments:
01 3230 038 200 ATS1				13,700	8,100	0	21,800	APR
2005 StateAl 608004				11,400	8,100	0	19,500	AS
06	13,700 11,200	4,100 4,100	-0-	17,800 15,300			✓	
01 3230 038 200 ATS1				13,700	4,100	0	17,800	APR
2006 StateAl 608004				11,200	4,100	0	15,300	AS

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KETCHIKAN GATEWAY BOROUGH
ASSESSMENT DEPARTMENT
344 FRONT STREET
KETCHIKAN, ALASKA 99901

Rev. 89

3

01 3230 037 000 ATS2
SEABORNE MARINE SERVICES - LESSEE
CITY OF KETCHIKAN - LESSOR
PO BOX 5183
KETCHIKAN AK 99901
53709 Sq. Ft. City IL LA2003-004579 07/31/2003
01 0ATS 001 509 CUSTOMER NO 609115
LOCATION N TONGASS HWY 5459
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 CitKet PROP CLASS 905 SEPTIC Other
PLAT 2001-23; 8/31/01
ATS 1509; ADL 105881
LEASE PENDING

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3230 037 000 ATS2			24,200	0	0	24,200	APR
	2005 CitKet 609115			20,400	0	0	20,400	AS
	06	24,200 / 20,000			24,200 / 20,000			✓
	01 3230 037 000 ATS2			27,800	0	0	27,800	APR
	2006 CitKet 609115			23,000	0	0	23,000	AS

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(4)

01 3230 037 000 ATS1
SEABORNE MARINE SERVICES

PO BOX 5183
KETCHIKAN AK 99901
71724 Sq. Ft. Ctw IL SWD 208/892 11/10/1992
01 0ATS 000 048 000A CUSTOMER NO 607986
LOCATION N TONGASS HWY 5459
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 None PROP CLASS 900 SEPTIC Other
ADL 2780
ATS 48 TRACT A

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL	REMARKS	C/E
01 3230 037 000 ATS1		372,800	168,200	0	541,000	APR
2005 None 607986		372,800	168,200	0	541,000	AS
06	233,500	164,600	0	398,100		
01 3230 037 000 ATS1		268,500	189,300	0	457,800	APR
2006 None 607986		268,500	189,300	0	457,800	AS

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01 3230 038 100
SEABORNE MARINE SERVICES

PO BOX 5183
KETCHIKAN AK 99901
8862 Sq. Ft. Ctiv 1L QC 194-941 11/10/1991
01 1417 008 005 CUSTOMER NO 604433
LOCATION N TONGASS HWY 5497
YEAR BUILT 1979 NO. UNITS 1
EXEMPT1 None PROP CLASS 411 SEPTIC IndOf

5

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3230 038 100			80,000	234,900	0	314,900	APR
	2005 None	604433		80,000	234,900	0	314,900	AS
	06	53,800	263,500	-0-	317,300			
	01 3230 038 100			61,900	303,000	0	364,900	APR
	2006 None	604433		61,900	303,000	0	364,900	AS

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(6)

01 3230 037 000
SEABORNE MARINE SERVICES

PO BOX 5183
KETCHIKAN AK 99901
22710 Sq. Ft. City IL SWD 206/892 11/10/1992
01 1417 00B 002 CUSTOMER NO 604432
LOCATION N TONGASS HWY 5459
YEAR BUILT 1981 NO. UNITS 0
EXEMPT1 None PROP CLASS 441 SEPTIC IndOf
LOTS 2, 3, & 4

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
01 3230 037 000			200,900	422,900	0	623,800	APR
2005 None	604432		200,900	422,900	0	623,800	AS
06	200,900	471,600	-0-	672,500			
01 3230 037 000			231,000	542,300	0	773,300	APR
2006 None	604432		231,000	542,300	0	773,300	AS

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7

01 3230 037 000 ATS3
SEABORNE MARINE SERVICES

PO BOX 5183
KETCHIKAN AK 99901
43470 Sq. Ft. City IL SWD 208/892 11/10/1992
01 0ATS 000 048 000B CUSTOMER NO 609132
LOCATION N TONGASS HWY 5459
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 None PROP CLASS 900 SEPTIC Other
ADL 2780
ATS 48 TRACT B

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
01 3230 037 000 ATS3			170,000	0	0	170,000	APR
2005 None 609132			170,000	0	0	170,000	AS
106	195,000			195,000			
01 3230 037 000 ATS3			224,200	0	0	224,200	APR
2006 None 609132			224,200	0	0	224,200	AS

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(8)

01 3230 036 000 ATS1
TEMSCO HELICOPTERS INC - LESSEE
CITY OF KETCHIKAN - LESSOR
PO BOX 5057
KETCHIKAN AK 99901
32747 Sq. Ft. City IL LEASE 03/03/1980
01 OATS 000 719 CUSTOMER NO 608190
LOCATION N TONGASS HWY 5459
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 CitKet PROP CLASS 905 SEPTIC Other
PLAT 2003-27; 9-15-03
ATS 719
ADL 57277

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL	REMARKS	C/E
	01 3230 036 000 ATS1		80,900	0	0	80,900	APR
	2005 CitKet 608190		80,900	0	0	80,900	AS
	06	90,500	—	90,500			
	01 3230 036 000 ATS1		90,500	0	0	90,500	APR
	2006 CitKet 608190		84,700	0	0	84,700	AS

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01 3230 036 000
TEMSCO HELICOPTERS INC

PO BOX 5057
KETCHIKAN AK 99901
8833 Sq. Ft. City IL WD 47-657 09/06/1973
01 1417 00B 001 CUSTOMER NO 604431
LOCATION N TONGASS HWY 5459
YEAR BUILT 1975 NO. UNITS 1
EXEMPT1 None PROP CLASS 411 SEPTIC IndOf

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3230 036 000			47,100	44,300	0	91,400	APR
	2005 None	604431		47,100	44,300	0	91,400	AS
	06	47,100	41,800	-0-	88,900			
	01 3230 036 000			54,200	48,100	0	102,300	APR
	2006 None	604431		54,200	48,100	0	102,300	AS

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ASSESSMENT DEPARTMENT
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(10)

01 3230 035 000 ATS1
TEMSCO HELICOPTERS INC

PO BOX 5057
KETCHIKAN AK 99901
44000 Sq. Ft. City IH PATENT 34650 08/13/1975
01 0ATS 000 700 CUSTOMER NO 608191
LOCATION N TONGASS HWY 5459/5485
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 None PROP CLASS 900 SEPTIC Other
ADL 34650
ATS 700

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	P/P	TOTAL		REMARKS	C/E
01 3230 035 000 ATS1			96,100	0	0	96,100	APR
2005 None 608191			96,100	0	0	96,100	AS
06	213,900	—	—	213,900			
01 3230 035 000 ATS1			246,000	0	0	246,000	APR
2006 None 608191			246,000	0	0	246,000	AS

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KETCHIKAN, ALASKA 99901

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01 3230 035 000
TEMSCO HELICOPTERS INC

PO BOX 5057
KETCHIKAN AK 99901
44213 Sq. Ft. City IH SQC 03-000733 02/12/2003
01 1258 000 000 CUSTOMER NO 604425
LOCATION N TONGASS HWY 5429
YEAR BUILT 1973 NO. UNITS 0
EXEMPT1 None PROP CLASS 551 SEPTIC IndOf
WATERFRONT NP

11

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
01 3230 035 000			300,500	1,219,900	0	1,520,400	APR
2005 None	604425		300,500	1,219,900	0	1,520,400	AS
06	371,400	1,268,400	-0-	1,639,800			
01 3230 035 000			427,100	1,458,700	0	1,885,800	APR
2006 None	604425		427,100	1,458,700	0	1,885,800	AS

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ASSESSMENT DEPARTMENT
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KETCHIKAN, ALASKA 99901

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(12)

01 3230 035 500 LH02
PM HOLDING LLC - LESSEE
STATE OF ALASKA - LESSOR
PO BOX 6440
KETCHIKAN AK 99901
67034 Sq. Ft. City CG WD2005-002701 04/01/2005
01 00LH 000 002 CUSTOMER NO 604426
LOCATION N TONGASS HWY 5407
YEAR BUILT 1982 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 910 SEPTIC IndOf
ADA 04441
LEASEHOLD INT LOT 1 BLK 100
AVIATION HANGER #4

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/F
01 3230 035 500 LH02			491,900	466,900	0	958,800	APR
2005 StateAl 604426			63,300	83,600	0	146,900	AS
06	417,400 15,800	490,400 27,700	-0-	907,800 43,500			✓
01 3230 035 500 LH02			480,000	564,000	0	1,044,000	APR
2006 StateAl 604426			18,200	31,900	0	50,100	AS

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ASSESSMENT DEPARTMENT
344 FRONT STREET
KETCHIKAN, ALASKA 99901

v. 8/89

(13)

Construction & Permits:

Date - Comment

01 3230 035 500
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
560 W 7TH AVE STE 1050A
ANCHORAGE AK 0
166835 Sq. Ft. City CG CD 2/382 04/26/1955
01 1259 000 000 000C CUSTOMER NO 604430
LOCATION PENINSULA POINT
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 300 SEPTIC Wfig
LEASE AREA BLOCK 100
ALL WATERFRONT AREA OFF N TONGASS H
INCL 1744-001-001:ZIP 99501

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3230 035 500			219,500	0	0	219,500	APR
	2005 StateAl 604430			0	0	0	0	AS
	06	994,300			994,300			
	01 3230 035 500			1,143,400	0	0	1,143,400	APR
	2006 StateAl 604430			0	0	0	0	AS

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(14)

01 3230 035 500 LH03
TEMSCO HELICOPTERS INC
STATE OF ALASKA - LESSOR
PO BOX 5057
KETCHIKAN AK 99901
44213 Sq. Ft. City CG LEASE 07/01/1976
01 00LH 000 003 CUSTOMER NO 604427
LOCATION N TONGASS HWY 5407
YEAR BUILT 1976 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 910 SEPTIC IndOf
ADL 02899
LEASEHOLD INCL LOTS 5,6,11 BLK 200
STATE OWNED

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3230 035 500 LH03			160,600	280,800	0	441,400	APR
	2005 StateAl 604427			12,700	32,500	0	45,200	AS
	06	227,500 / 227,400	219,600 / 219,600	-0-	447,100 / 447,100			
	01 3230 035 500 LH03			~~261,600~~	~~252,500~~	0	514,100	APR
	2006 StateAl 604427			227,000	252,500	0	479,500	AS ✓

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344 FRONT STREET
KETCHIKAN, ALASKA 99901

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15

01 3230 035 500 LH04
CITY OF KETCHIKAN
STATE OF ALASKA - LESSOR
334 FRONT STREET
KETCHIKAN AK 0
0 Sq. Ft. City CG LEASE
01 00LH 000 004 CUSTOMER NO 604428
LOCATION N TONGASS HWY 5401
YEAR BUILT 1977 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 910 SEPTIC IndDr
SHORELINE FIRE HALL
LEASEHOLD INTEREST
STATE OWNED

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
01 3230 035 500 LH04		76,500	130,100	0	206,600	APR	
2005 StateAl 604428		0	0	0	0	AS	
06	76,500	162,500	0	239,000			
01 3230 035 500 LH04		88,000	186,900	0	274,900	APR	
2006 StateAl 604428		0	0	0	0	AS ✓	

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ASSESSMENT DEPARTMENT
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(16)

01 3240 044 000
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
550 W 7TH AVE STE 1050A
ANCHORAGE AK 0
22230 Sq. Ft. North CG
01-1744 001 001 CUSTOMER NO 608846
LOCATION N TONGASS HWY 5400 BLK
YEAR BUILT NO. UNITS
EXEMPT1 StateAl PROP CLASS 300 SEPTIC Other

FORMERLY LEASE ADA 04111
ZIP 99501

Construction & Permits:

Date - Comment

OWNER:

YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
01 3240 044 000		97,700	0	0		97,700	APR
2005 StateAl 608846		0	0	0		0	AS
06	97,700	—		97,700			
01 3240 044 000		112,400	0	0		112,400	APR
2006 StateAl 608846		0	0	0		0	AS

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ASSESSMENT DEPARTMENT
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KETCHIKAN, ALASKA 99901

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01 3240 044 200
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
550 W 7TH AVE STE 1050A
ANCHORAGE AK 0
12496 Sq. Ft. City CG
01 1744 001 200 CUSTOMER NO 604539
LOCATION N TONGASS HWY 5381
YEAR BUILT 1978 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 331 SEPTIC IndOf
DOT OFFICE
ADL #04111
ZIP 99501

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3240 044 200			295,800	26,800	0	322,600	APR
	2005 StateAl 604539			0	0	0	0	AS
	06	172,200 ~~0~~	57,000 ~~0~~	-0-	229,200 ~~0~~			
	01 3240 044 200			198,000	65,600	0	263,600	APR
	2006 StateAl 604539			0	0	0	0	AS

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ASSESSMENT DEPARTMENT
344 FRONT STREET
KETCHIKAN, ALASKA 99901

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01 3240 044 500
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
550 W 7TH AVE STE 1050A
ANCHORAGE AK 0
6188 Sq. Ft. City IH
01 1744 001 003 000A CUSTOMER NO 608059
LOCATION N TONGASS HWY 5300 BLK
YEAR BUILT 0 NO. UNITS 0
EXEMPT1 StateAl PROP CLASS 100 SEPTIC Other
DOT OFFICE PARKING

ZIP 99501

Construction & Permits:

Date - Comment

OWNER:	YEAR	LAND	IMPS	B/P	TOTAL		REMARKS	C/E
	01 3240 044 500			88,100	0	0	88,100	APR
	2005 StateAl 608059			0	0	0	0	AS
	06	121,300 A			121,300 A			
	01 3240 044 500			139,500	0	0	139,500	APR
	2006 StateAl 608059			0	0	0	0	AS

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APPENDIX 14-H
RESUMES

draft

Dennis NOTTINGHAM, P.E. | Principal-in-Charge

Registered Civil Engineer: Alaska, 1963; Washington, 1979
Registered Professional Land Surveyor: Alaska, 1972
M.S. Civil Engineering, 1960, Montana State University
B.S. Civil Engineering, 1959, Montana State University
Certified Scuba diver, 1971
Fellow, American Society of Civil Engineers

Mr. Nottingham has 45 years of experience with design and construction of large projects in Alaska and northern environs, primarily with bridges and marine projects. His efforts in these fields include nationally prominent projects.

Mr. Nottingham has an historic engineering knowledge of Ketchikan dating to 1962, to include:

- Ketchikan Front Street design
- GSA parking structure (dock) design
- State ferry terminal reconstruction design following ship collision
- Various shuttle ferry marine design
- Shuttle ferry Gravina port
- Construction consultation on marine repair facility bulkhead
- Construction consultation and design on drydock
- Tongass Narrows Crossing studies, 1972, 1992, 2004 (bridges and tunnels)
- NOAA dock upgrade
- Various past and ongoing port, harbor and marine improvements
- Working knowledge of underwater construction

Of particular importance with this study will be PND's knowledge of the area, local contractors, drydock operators, and costs relating to a project of this type (i.e., the practical side). Our team includes association with engineers who have studied the Tongass Crossing previously. In addition, the project would make use of a PND development termed the "Open Cell™." This important structure would "ring" each tunnel portal with a top elevation of +30 and extend some distance into Tongass Narrows to approximately El -30. Used for erosion control, wave resistance, soil retention and seepage control, the "Open Cell" is an important, critical and cost-effective element in the crossing solution. Only PND has experience with this needed cost-effective structure, patented by Mr. Nottingham.

Mr. Nottingham is known for fast completion of projects with a "no nonsense" approach to problem identification and solution, using the best technical solutions. He has managed and designed many significant projects in Alaska and on the West Coast. His innovative designs show a thorough understanding of special conditions related to design and construction, including heavy-civil and industrial structures and foundations, and rapid construction techniques.

Mr. Nottingham holds numerous patents relating to bridges, foundations and ports, including the Open Cell™ bulkhead. In 1998 his development of Open Cell™ technology earned the prestigious Nova Award, given to engineers to recognize the pinnacle of technical achievement each year. He is a 15-time award winner in the James F. Lincoln Arc Welding Foundation awards program for innovation in designing structural design of bridges and marine facilities.

He lectures at the University of Alaska and many technical conferences.

Michael C. HARTLEY, P.E. | Vice President

Registered Civil Engineer: Washington, 1989; Alaska, 1983; Oregon, 1997
M.S. Civil Engineering – Oregon State University, 1979
B.S. Civil Engineering, Oregon State University, 1977
Associate Degree, Surveying Technology, University of Alaska, Anchorage, 1973

Mr. Hartley has over 24 years of civil, transportation, and geotechnical experience. He has extensive experience in the planning, PS&E design, contract administration, and inspection for civil design of trails, parking facilities, rural and urban roads. In his career, he has designed over 800 miles of road and completed over 200 geotechnical investigations in the Pacific Northwest, California, Alaska, and Russia.

Project Manager, Pebble Copper Project. This project was a planning study in Cominco, Alaska for an 800-mile road providing access to Tidewater. The project included 4 alignments with a 1,800 foot tunnel through a mountain.

Project Manager, Whitter Tunnel. Provided preliminary planning for tunnel improvements to combined train and passenger car passageways for Alaska Railroad.

Project Engineer, Bradley Lake Hydroelectric Plant. As a sub to Becthel, Mr. Hartley worked on this 500-foot long Penstock project near Homer, Alaska.

Project Manager, Debarr Road Rehabilitation. Mr. Hartley managed the surveys, geotechnical, pavement management evaluation, safety evaluation and economic assessments, design study report preparation, right of way and easements, public meetings, and PS&E preparation for this 3-mile urban arterial project. The design study provided recommendations to bring the road and intersecting road level of service to C or better. He also managed services of the electrical subconsultant which provided assessments and PS&E preparation for the lighting improvements and traffic signal modifications along the 3-mile urban arterial project for ADOT. Lane configurations were modified to allow dual left turn lane movements and right only turn movements at several of the arterial intersections.

Project Manager, 4th Avenue Rehabilitation. Mr. Hartley served as project manager for the surveys, geotechnical assessment, design study preparation, PS&E and inspection for this 1-mile urban arterial project in downtown Anchorage, Alaska for the Municipality of Anchorage. The concepts included 0.5 mile of cold milling and overlays and 0.5 miles of dig-out and replacement of the structural section; intersection improvements and pedestrian crossing improvements, construction traffic sequencing and replacement of wood-stave storm drain system.

Project Manager, Old Highway 30 Reconstruction. Mr. Hartley managed the surveys, geotechnical assessment, and PS&E preparation of the a.c. paved road, three intersecting road grade and approach modifications, retaining wall and bridge overlay for this highway project near Astoria, Oregon.

Project Manager, Highway 101 Safety Improvements. Mr. Hartley provided the concepts and PS&E preparation for two intersection modifications in downtown Astoria, Oregon on Highway 101. The safety improvements provided improved delineation of sidewalks and cross-walks using stamped and colored concrete and included ADA improvements.

Project Manager, SR520 Improvements. Mr. Hartley served as project manager for the geotechnical assessment of utilities for the SR520 project from the Evergreen floating bridge and east along this 5-mile corridor.

Project Manager, Lewis and Clark Road. Mr. Hartley served as project manager in the concept assessment of 2.2 miles of a.c. paved road realignment for Clatsop County in 2001.

Project Manager, Dalton Highway Mile 209S, 111S, and 100S. Mr. Hartley served as project manager for the rehabilitation (3R) of 55 miles of road rehabilitation for ADOT near Fairbanks, Alaska. Work included surveys, hydraulic assessment of stream crossings and drainage structures settling due to permafrost thaw consolidation; development of design study reports and PS&E documents.

John PICKERING, P.E. | Road Layout and Design

Registered Civil Engineer, Alaska, 1995, CE 8986
American Welding Society Certified Welding Inspector, 1994

M.S. Environmental Quality Engineering, (thesis pending), University of Alaska, Anchorage
M.B.A. Management & Finance, 1979, University of Oregon
B.S. Forest Engineering, 1973 Oregon State University
B.A. Mathematics & Physics, 1965, Willamette University

Mr. Pickering has 25 years of construction, engineering, environmental, permitting, operations and international experience and has performed in the capacity of project manager, operations manager, designer, and construction project engineer. His experience includes:

Project manager for Western Alaska development – Provided conceptual development alternatives for barge docks, bridges and road locations to access and supply a proposed development in Western Alaska. The transportation concepts were routed over a 60-mile corridor to the Yukon River and a 20-mile corridor to the Kuskokwim River.

Northwestern Russia transportation development – Team member responsible for road, bridge and barge dock layout and design for a 60-mile road system in northwestern Russia.

Prince William Sound facility – Provided civil design, administration and construction inspection for two multi-million dollar Alaska Department of Transportation and Public Facilities dock and equipment facility projects. These projects involved wetlands issues, site assessments, access road design, permitting, and utility design.

Tudor Trail Overpass and Tunnel – Provided civil design, shop drawing and fabrication review, field construction engineering, inspection, surveying, ISTEA documentation, and permitting assistance. Mr. Pickering assisted in the design and construction of the Tudor Road Trail Crossing in Anchorage, consisting of a half-mile of asphalt-paved pedestrian and bike trail, roadway tunnel, various trailside amenities and a national award winning bridge/overpass. This project resolved a longstanding transportation problem for the Municipality of Anchorage & Alaska Department of Transportation and Public Facilities.

Forest Products Development, Kenai Peninsula – Project Manager for this $6 million development, responsible for log transfer facilities; site engineering; support facilities; road transportation network; product specifications, storage and ship loading; marketing; equipment specification and purchasing; government and public relations; personnel evaluation; permit acquisition and economic analysis.

Forest Products Operations Manager – Managed Southeast Alaska forest products firm, responsible for operational oversight of road and bridge design and construction activities among other duties.

Mike HUGGINS, P.E. | Senior Engineer

University of Washington, Bachelor of Science, Civil Engineering, 1985
Technical University of Denmark, Valle Scholar, Marine Engineering, 1987
University of Washington, Masters of Science, Civil Engineering, 1988
Registered Professional Engineer in WA, OR, CA, & AK, 1989 First Registry

Mr. Huggins has 20 years of construction related design experience holding the positions of Chief Engineer, Project Field Engineer, and Estimator in regards to a full range of marine, heavy civil construction. His construction experience includes projects throughout the western United States and Scandinavia. His technical capabilities include design/development and detailed estimating of broad scope engineering systems, providing technical expertise and constructability review in design-build projects, and managing multi-discipline engineering work. Mr. Huggins served as the Chief Engineer/Senior Construction Engineer for General Construction Company from 1996 – 2003, under which many of the following listed projects were completed.

Mr. Huggins has worked on the design, detailing, fabrication, installation and operation of systems that are typical to Immersed Tube Tunnel Construction. These common task are such things as heavy forming, systems for luanching, outfitting, towing and sinking of tube elements. Of particular relevance is Mr. Huggins' work at Tacoma Narrows which encompassed the casting, outifting and sinking of the new caissons for the second crossing at the Tacoma Narrows. Mr. Huggins has designed lifting catamarran typical to the process of setting heavy elements on the sea-bed, high capacity bulkhead systems (the temporary ends of tube elements), and heavy mooring systems for securing equipment and foundation elements in a current flow.

His specific experience includes the following construction engineering work related to tube tunnel construction:

Anchor Testing Barge Retrofit, Tacoma Narrows Constructors, Gig Harbor, Washington, 2005.
The project included a fast-paced design and retrofit effort to configure an aging barge for direct pull testing of 3-1/2" diameter chain connected to sub-sea anchors. Initial work and fabrication were executed from detailed sketches on a fast schedule, with formal documentation issued after completion.

Howard Hanson Dam/Fish Bypass Cofferdam, U.S. Army Corps, Traylor Pacific Inc., Palmer, Washington, 2004.
Mr. Huggins performed supplementary engineering and analysis of a 150-foot vertical rock slope to support a Manitowoc 4100 Series 2 Ringer Crane. Total gross loading was 1.7 million pounds. Work was completed under a compressed schedule to accommodate reservoir filling and discharge requirements of the main contract.

Pine Street Bus Tunnel /Sound Transit, Balfour Beatty Inc., Seattle, Washington, 2004.
Mr. Huggins designed specific components for the 70-foot deep excavation support system used to extend the existing Seattle Bus Tunnel.

SBX Band Radar Submersible Platform, Deep Sea-bed Moorings, United States Missile Defense Command, 2004.
Given Mr. Huggins construction engineering experience, he was retained by Glosten Associates (Naval Architects) to prepare design documents for drag embedment anchors, clump weights, attachment hardware, and deployment concept for the submersible platform moorage

Caisson Construction Engineering, Tacoma Narrows Constructors, Gig Harbor, Washington, 2002–2003.
While employed directly by the joint venture, Mr. Huggins prepared the design of a 60' tall sacrificial steel cofferdam that rises from the top of the caisson cutting shoe. Of equal importance was a 2800 kip capacity moveable strut system used to brace the caisson exterior walls at extreme draft conditions prior to touchdown on the seabed. He prepared detailed designs for subsea anchors, temporary false-bottom alternatives, caisson anchor line attachments, and coordinated work with outside design firms. Mr. Huggins was tasked with resolving dimensional and operating coordination between exterior face cantilever forming and anchor line handling systems. His interaction with Parson Transportation Group in San Francisco enabled rapid resolution of discrete design issues relating to carrying high temporary construction loadings from sea-bed anchor lines.

Pier D Replacement, Design/Build Project, United States Navy, Bremerton, Washington, 2000–2002.
Construction engineering for this project covered straightforward and complex forming/shoring of cast-in-place concrete and pre/post proposal driving analysis of large diameter pre-stressed concrete foundation piles. Mr. Huggins completed the engineering package to enable pre-casting large 30' x 25' utilidor sections for the exterior

perimeter of the new pier. Segment handling stresses, rigging, casting sequence, and heavy lift spreader bars were designed to speed construction via offsite casting and transporting/setting the section at the new pier site.

Ice Harbor Dam, Navigation Coffercells-Existing Guidewall Extension, U.S. Army Corps, 1999.

Mr. Huggins provided construction engineering for this follow-on contract to the spillway flow deflector project from 1996. Three mid-river cellular fill coffer structures were installed along with an 80' extension of the existing stilling basin guide wall. A multilevel template was required for the cellular structures, which were made more complex given a river foundation of fractured bedrock. The guidewall extension used re-configured bulkheads from the John Day Dam project. The bulkheads combined with heavy forming panels created a double sided 65-foot tall by 80' box form with substantial above water deck area for access and materials.

Wanapum Dam, Phase 2 - Adjustable Overflow Control Gate, Grant County PUD, 1996.

Mr. Huggins was tasked with the effort to design a one-time use catamaran barge to lift, transport, and erect a 650,000 pound steel overflow control gate on the upstream face of Spillway #1. The modular barge was fitted with winches and overhead gantry beams to maintain control of the 85' tall gate as it swung from beneath the transport cradle, and into the vertical position for setting at the face of the dam. Grant County purchased the entire crane system as a supplementary change order to the contract. The control gate was subsequently removed, reconfigured and reinstalled by General Construction Company using the same catamaran on two other occasions.

Lacey V. Murrow Floating Bridge, 1992 -1993.

As a construction engineer on the project, Mr. Huggins was involved in project start-up, coordinated detailing of all custom wood forms, management of outside consultants, and acted as the technical representative at project meetings. He designed an innovative frame system for deep-water setting of bridge cable anchors. Midway through the project, Mr. Huggins was reassigned to the Tacoma pontoon-casting site to manage the engineering staff during the critical weeks prior to the first float out of pontoons, and remained in that role through all subsequent production cycles.

Alsea Bay Bridge, Waldport, Oregon, 1988–1992.

Mr. Huggins was responsible for designing complex forms and falsework systems for construction of a twin post-tensioned concrete box-girder bridge across the Alsea River. Mr. Huggins provided professional engineering services to Charleston South Slough Bascule Bridge project in Coos Bay, Oregon, concurrent with design/field work at Alsea. Mr. Huggins also managed the Alsea project for six months during final concrete and site work, demolition of the old structure, and demobilization.

Technical University of Denmark, Virum, DK, 1986-1987

Mr. Huggins was selected for a full scholarship to the Danish Technical University, under the University of Washington sponsored Valle Program. While in Denmark, Mr. Huggins departed the normal track of university research and opted to work for four Danish engineering/construction firms. The series of three-month internships began at the Danish Harbor Administration in Frederikshaven, and then onto a private materials testing laboratory in Copenhagen, a cement fabrication plant in Aalborg, and concluded with a job as a site surveyor on the Guldborgsund Immersed Tube Tunnel project between the islands of Falster and Lolland.

Doug KENLEY, P.E. | Principal Civil Engineer

Professional Engineer (CE 8176), Alaska, 1989
B.S. Civil Engineering, 1986, Brigham Young University, Provo, Utah

Mr. Kenley has more than 17 years of experience in a broad range of civil and structural projects throughout Alaska. His experience includes all phases of design, from site selection and development to construction administration. His assignments have included military, institutional and commercial projects. He is proficient with a variety of computer modeling and analysis techniques for civil/structural engineering including earthwork. Representative project experience includes:

Port MacKenzie Bulkhead Dock – Mr. Kenley served as project engineer for the Open Cell sheet pile bulkhead dock for the Matanuska-Susitna Borough at Port MacKenzie. This project included a study of available material sources in the area to facilitate construction of the gravel fill dock. An extensive geotechnical investigation program was conducted in the area of the port to evaluate soils and quantities of available fill.

Port MacKenzie Deep Draft Dock– Mr. Kenley was involved in all phases of design development of this $15 million Matanuska-Susitna Borough project. Site selection considered preliminary layouts already accomplished, as well as geotechnical and environmental reviews. Use assessment was coordinated with port planning.

Petersburg Cabin Creek Road – Mr. Kenley served as project manager for this 8-mile gravel road project. As part of the project, a geotechnical investigation was conducted on various potential borrow sources along the route. Borings were drilled and a determination of material and quantities were estimated as part of the design effort.

Whittier Access Tunnel – Mr. Kenley served as lead civil designer for PND's role in design-build project, which enlarged and modified an existing 2.5-mile railroad tunnel to accommodate vehicular traffic. PND's primary responsibilities included pre-design topography and as-builting, staging area design, access road design, and structural design for a wide variety of facilities.

Whittier Intermodal Development Inspections – Under a contract with the Alaska Railroad Corp., Mr. Kenley was the project manager for various inspection services performed during the summer and fall of 2002. Inspection services performed by PND included excavations, backfills and compaction of large earthwork operations.

Chenega Dock and Equipment Facility – Mr. Kenley led site civil work and road work that was complicated by the need to minimize impacts to wetlands and near shore rookeries and yet minimize road grades on the steeply sloping terrain. Mr. Kenley used site civil design software and applied shrink/swell factors to the materials, adjusting the top of pad elevation, ditches and road to balance cuts and fills. Plans, specifications and engineer's estimate were prepared for bidding. Work also included rehabilitation of disturbed areas during construction for aesthetics and control of siltation.

Kennecott Minerals Corp. Arctic Region Transportation Study – Mr. Kenley assisted in preparing costs and identifying logistical concerns for the construction of 170 miles of double-lane gravel access road extending from a proposed mine site to a proposed port. The access road crossed five major stream and rivers and hundreds of small drainage's. The final study including a report of findings, schematic drawings, concept level construction and operating cost estimates.

CURRICULUM VITAE

Name	Jesper Skourup
Date of birth	26 June 1961
Nationality	Danish
Education	1986: MSc in Civil Engineering, Technical University of Denmark, Lyngby, Denmark. 1989: PhD in Civil Engineering, Institute of Hydrodynamics and Hydraulic Engineering (ISVA), Technical University of Denmark, Lyngby, Denmark.
Awards	1990. Bequest in memory of Director P Gorm Petersen
Key qualifications	Wave hydrodynamics and kinematics, fluid structure interaction, numerical modelling, model testing

Employment record

Year	***Firm***	***Position and responsibilities***
2003-	DHI Water & Environment	Senior Research Engineer. Ports & Offshore Technology.
2000-02	DHI Water & Environment (formerly Danish Hydraulic Institute)	Research Engineer. Offshore Technology Department.
1993-98	International Research Centre for Computational Hydrodynamics (ICCH)	Research Engineer. Part-time employee. Boundary element modelling of wave/ current/structure interaction and wave evolution in a numerical wave tank.
1990-date	Technical University of Denmark	Lecturer in wave hydrodynamics at the Department of Hydrodynamics and Water Resources (ISVA). Supervisor on MSc and PhD projects.
1989-99	Danish Hydraulic Institute	Research Engineer at the Offshore Technology Department. Mathematical and numerical modelling of wave/structure interaction. Wave hydrodynamics and kinematics. Model testing in 3D wave basin.
1987-89	Technical University of Denmark, and University of Delaware, (USA)	PhD student at ISVA. Boundary element modelling of non-linear water waves and their interaction with structures.
1986	Technical University of Denmark	Research Fellow at ISVA. Mathematical and numerical computation of wave fields around offshore structures.

Experience record

Year	*Project*	*Position and activities*
2005	Horns Rev 2, Denmark	Project Manager. Hindcast study of wave (MIKE 21 SW), current and water level (MIKE 21 FM) conditions for an offshore wind farm at Horns Rev.
2005	Baltic Connector, Finland	Project Engineer. Hindcast study of wave (MIKE 21 SW), current and water level (MIKE 21 FM) conditions for a pipeline crossing the Gulf of Finland.
2005	Port of Gioia Tauro, Italy	Project Engineer. Numerical wave modelling (MIKE 21 BW) of modifications of the Port of Gioia Tauro.
2005	Lynn & Inner Dowsing, UK	Project Manager. Model tests of wave and current loads and scour protection of the foundation of an offshore wind mill.
2005	Pars, Persian Gulf	Project Manager. Hindcast study of current and water level (MIKE 21 FM) conditions for establishing design data for a pipeline in the Persian Gulf, Iran.
2005	Ras Laffan Port Extension Project, Qatar	Project Engineer. Hindcast study of current (MIKE 21 FM) conditions for Ras Laffan Port.
2004	Shin Kori Power Plant, South Korea	Project Manager. Model tests of submerged discharge structures for a nuclear power plant.
2004	Borkum Riff, Germany	Project Engineer. Hindcast study of wave (MIKE 21 SW), current and water level (MIKE 21 FM) conditions for an offshore wind farm at Borkum Riff.
2004	REBASDO	Project Manager. Research project on design data for floating oil production systems.
2004	PERGOS	Project Manager. Establishment of a hindcast database of current and water level covering 20 years and 100+ storms for the entire Arabian/Persian Gulf.
2003	Yell Sound Current Forecast	Project Manager. Current forecasts for pipe laying project in Yell Sound, the Shetland Islands.
2002-03	Valhall Metocean Design Criteria	Project Manager. Metocean design conditions for Valhall oil field, Norway.
2002-03	REBASDO	Project Engineer. Research project on design data for floating oil production systems.

Year	*Project*	*Position and activities*
2002-03	Saipem Platform Installation	Project Engineer. Model test of jacket and top-side installation in the Caspian Sea.
2002	Cooper River	Project Engineer. Numerical and physical model testing of ship collision on a bridge pier.
2001-02	Bluewater	Project Engineer. Model testing of moored FPSO and tanker motions.
2001	DK-UK Pipeline	Project Manager. Metocean design data for offshore pipeline.
2001	DONG Nini/Cecilie Development Project	Project Manager. Metocean design data for two offshore platforms, Denmark.
2001	Klasården, Sweden	Project Engineer. Metocean design conditions and operational conditions for offshore wind farm.
2000	Chestnut	Project Engineer. Model tests with an FSO system. Responsible for wave calibration and data analysis.
2000	ISIS FPSO	Project Engineer. Model tests with an FPSO system. Responsible for wave calibration and data analysis.
2000	Yell Sound Current Study	Project Engineer. Current simulations for loading calculations on a proposed pipeline.
1999	Venice Water Level Forecast	Project Manager. Updating of statistical model for water level forecast in Venice, Italy.
1999	MIKE Zero OSW	Project Engineer. Implementation of DHI's 3G wind wave model OSW into a MIKE Zero environment.
1993-98	ICCH	Research Engineer. Development of 2D and 3D boundary element programmes for simulation of waves and structures in numerical wave flumes and wave tanks.
1993-94	Extreme Waves	Project Manager. Research project involving data analysis, numerical modelling, and model tests for identifying, simulating, and reproducing freak waves.
1993	Brent ROLF	Project Engineer. Model tests with flexible riser. Software development for data analysis.
1992	Dunbar	Project Engineer. Model tests with jacket installation. Responsible for data analysis, wave generation, and calibration.

Year	*Project*	*Position and activities*
1992	Ekofisk Design Data	Project Engineer. Development of programme for diffraction of 2D/3D irregular waves around a large vertical circular cylinder.
1991	BRITE P-2146. Rational Procedures for Advanced Non-Linear Analysis of Floating Structures	Project Engineer. Model tests with a ship and a TLP in 2D and 3D waves, wave generation, data logging and analysis.
1991-92	Great Belt East Bridge, Denmark. Ship Collision	Project Engineer. Numerical modelling of ship impact on protection island around a bridge pier.
1991	Arctic Offshore	Project Engineer. Literature surveys concerning: Floating production concepts and iceberg gouging.
1991	EVA. Extreme Value Analysis Programme	Project Engineer. Updating and enhancements of programme for extreme value analysis.
1990	Umm Shaif. Extreme Value Analysis of Wave Heights	Project Engineer. Determination of extreme wave heights, based on wave height measurements from the Umm Shaif oil field offshore Abu Dhabi.
1990	Igelsta Bridge, Sweden. Ship Collision	Project Manager. Numerical modelling of collisions between a moving ship and the protection island around a bridge pier.
1989-90	BRITE P-2146. Rational Procedures for Advanced Non-Linear Analysis of Floating Structures	Project Engineer. Responsible for development of a 3D boundary element programme for non-linear wave/structure interaction.
1989	Ice Loads on The Great Belt Western Bridge	Project Engineer. Extreme value analysis of ice loads on the Great Belt Western Bridge.

Languages	Danish	English	German	French	Spanish	Italian
Speaking	5	5	2	2	2	4
Reading	5	5	3	3	3	4
Writing	5	5	2	2	2	4

(Mother tongue/excellent: 5; Average: 3-4; Poor: 1-2)

Examples of Publications

Skourup, J; Sterndorff MJ; Smith SF; Cheng, X; Ahilan, RV; Guedes Soares, C; and Pascoal, R (2004). Model tests with an FPSO in design environmental conditions. Proceedings of the 23rd International Confernence on Offshore Mechanics and Arctic Engineering (OMAE'04), Vancouver, British Columbia, Canada.

Skourup, J; Sterndorff MJ; Smith SF; Cheng, X; Ahilan, RV; Guedes Soares, C; and Pascoal, R (2004). Experimental study of loads on an FPSO in design environmental conditions. Proceedings of OMAE-FPSO 2004, OMAE Specialty Symposium on FPSO Integrity, Houston, Texas, USA.

Skourup, J; and Sterndorff, MJ (2002). *Deterministic reproduction of nonlinear waves*. Proceedings of the 21st International Conference on Offshore Mechanics and Arctic Engineering (OMAE'02). Oslo, Norway.

Sterndorff, MJ; and Skourup, J (2001). *Experimental study of irregular wave diffraction by a vertical circular cylinder*. Proceedings of the 20th International Conference on Offshore Mechanics and Arctic Engineering (OMAE'01). Rio de Janeiro, Brazil.

Büchmann, B; Ferrant, P; and Skourup, J (2000). *Run-up on a body in waves and current. Fully non-linear and finite-order calculations*. Applied Ocean Research, Vol 22, pp 349-360.

Skourup, J; Cheung, KF; Bingham, HB; and Büchmann, B (2000). *Loads on a 3D body due to second order waves and a current*. Ocean Engineering, Vol 27, No 7, pp 707-727.

Büchmann, B; and Skourup, J (1999). *Stability of time-domain boundary element models; Theory and applications*. Proceedings of the 14th International Workshop on Water Waves and Floating Bodies, Port Huron, Michigan, USA.

Skourup, J; Sterndorff, MJ; and Dahl, CS (1998). *Kinematics in a diffracted wave field*. Proceedings of the 17th International Conference on Offshore Mechanics and Arctic Engineering (OMAE'98), Lisbon, Portugal.

Grilli, ST; and Skourup, J (1998). *Depth inversion for non-linear waves shoaling over a barred beach*. Proceedings of the 26th International Conference on Coastal Engineering (ICCE'98), Copenhagen, Denmark.

Büchmann, B; Skourup, J; and Kriebel, DL (1998). *Second order wave interaction with a large structure*. Proceedings of the 26th International Conference on Coastal Engineering (ICCE'98), Copenhagen, Denmark.

Skourup, J; and Schäffer, HA (1998). *Simulation with a 3D active absorption method in a numerical wave tank*. Proceedings of the 8th International Offshore and Polar Engineering Conference (ISOPE'98), Montreal, Canada, Vol 3, pp 248-255.

Büchmann, B; Skourup, J; and Cheung, KF (1998). *Runup on a structure due to second order waves and a current in a numerical wave tank*. Applied Ocean Research, Vol 20, No 5, pp 297-308.

Skourup, J; Cheung, KF; Bingham, HB; and Büchmann, B (1998). *Second order wave forces on 3D bodies in a current*. Proceedings of the Symposium: Wave '98. Ocean Wave Kinematics, Dynamics and Loads on Structures, Houston, Texas, USA, pp 108-115.

Büchmann, B; Ferrant, P; and Skourup, J (1998). *Runup on a body in waves and current. Fully non-linear and finite order calculations*. Proceedings of the 13th International Workshop on Water Waves and Floating Bodies, Alphen aan den Rijn, The Netherlands, pp 9-12.

Skourup, J; Büchmann, B; and Bingham, HB (1997). *A second order BEM for wave-structure interaction*. Proceedings of the 12th International Workshop on Water Waves and Floating Bodies, Marseille, France.

Skourup, J; and Schäffer, HA (1997). *Wave generation and active absorption in a numerical wave flume*. Proceedings of the 7th International Offshore and Polar Engineering Conference (ISOPE'97), Honolulu, Hawaii, USA, Vol 3, pp 85-91.

Büchmann, B; Skourup, J; and Cheung, KF (1997). *Runup on a structure due to waves and a current*. Proceedings of the 7th International Offshore and Polar Engineering Conference (ISOPE'97), Honolulu, Hawaii, USA, Vol 3, pp 48-55.

Schäffer, HA; and Skourup, J (1996). *Active absorption of multidirectional waves*. Proceedings of the 25th International Conference of Coastal Engineering, Orlando, Florida, USA.

Skourup, J; Ottesen-Hansen, N-E; and Andreasen, KK (1996). *Non-Gaussian extreme waves in the central North Sea*. Journal of Offshore Mechanics and Arctic Engineering, Vol 119, No 3, pp 146-150. See also Proceedings of the 15th International Conference on Offshore Mechanics and Arctic Engineering (OMAE'96), Florence, Italy, Vol 1, part A, pp 25-32.

Skourup, J (1996). *Active absorption in a numerical wave tank*. Proceedings of the 6th International Offshore and Polar Engineering Conference (ISOPE '96), Los Angeles, USA, Vol 3, pp 31-38.

Skourup, J; and Bingham, HB (1996). *Active absorption of radiated waves in a 3D boundary element model*. Proceedings of the 11th International Workshop on Water Waves and Floating Bodies, Hamburg, Germany.

Skourup, J (1995). *Analytical second order wavemaker theory verified in a numerical wave flume*. Proceedings of the 2nd International Conference COASTAL 95, Computer Modelling of Seas and Coastal Regions, Cancun, Mexico, pp 167-174.

Skourup, J; and Schäffer, HA (1995). *Active absorption in boundary element modelling of non-linear water waves*. Proceedings of the 3rd International Congress on Industrial and Applied Mathematics, ICIAM 95, Hamburg, Germany.

Skourup, J (1994). *Evolution and kinematics of a modulated wave train by use of the boundary element method*. Proceedings of the International Symposium: Waves-Physical and Numerical Modelling, Vancouver, Canada, pp 871-880.

Skourup, J (1994). *Diffraction of 2D and 3D irregular seas around a vertical circular cylinder*. Proceedings of the 13th International Conference on Offshore Mechanics and Arctic Engineering (OMAE'94), Houston, Texas, USA. Vol 1, pp 293-300.

Høgedal, M; Skourup, J; and Burcharth, HF (1994). *Wave forces on a vertical smooth cylinder in directional waves*. Proceedings of the 4th International Offshore and Polar Engineering Conference (ISOPE '94), Osaka, Japan.

Skotner, C; Jonsson, IG; and Skourup, J (1994). *Wave forces on a large, horizontal, submerged cylinder*. Ocean Engineering, Vol 21, No 8, pp 711-731.

Sterndorff, MJ; and Skourup, J (1992). *Experimental investigation of the low-frequency behaviour of floating offshore structures in long-crested and short-crested waves*. Proceedings of the 6th International Conference on Behaviour of Offshore Structures (BOSS 92), London, United Kingdom. Vol 2, pp 1193-1206.

Skourup, J; and Jonsson, IG (1992). *Computations of forces on, and particle orbits around, horizontal cylinders under steep waves*. Ocean Engineering, Vol 19, No 6, pp 527-553.

Skourup, J; Sterndorff, MJ; and Hansen, EA (1992). *Numerical modelling of wave/structure interaction by a 3D non-linear boundary element method. A step towards the numerical wave tank*. Ocean Engineering, Vol 19, No 5, pp 437-460.

Skourup, J; Sterndorff, MJ; and Hansen, EA (1991). *A 3D non-linear boundary element model for wave-structure interaction*. Proceedings of the 2nd International Conference on Computer Modelling in Ocean Engineering (CMOE '91). Barcelona, Spain. pp 57-68.

Christensen, FT; and Skourup, J (1991). *Extreme ice properties*. Journal of Cold Regions Engineering. Vol 5, No 2, pp 51-58.

Skourup, J; and Jonsson, IG (1990). *Forces on and particle motions around submerged structures in steep waves*. Proceedings of the 22nd Coastal Engineering Conference, Delft, The Netherlands. Vol 2, pp 1389-1402.

Skourup, J; Jonsson, IG; Grilli, ST; and Svendsen, IA (1989). *Computational modelling of velocities and accelerations in steep waves*. In Water Wave Kinematics (eds A Tørum and OT Gudmestad), pp 297-312. Kluver Academic Publishers, Dordrecht.

Skourup, J (1989). *A boundary integral equation model for the development of nonlinear water waves and their interaction with structures*. PhD dissertation. Series paper No 47, xvi + 158 pp. Institute of Hydrodynamics and Hydraulic Engineering (ISVA). Technical University of Denmark.

Skourup, J; Jonsson, IG; Svendsen, IA; Grilli, ST; and Larsen, J (1989). *Non-linear water wave modelling by a boundary integral equation method*. Proceedings of the XXIII Congress of International Association for Hydraulic Research (IAHR). Ottawa, Canada, pp C-359 - C-366.

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21 December 2005

PDC INC. ENGINEERS

JAMES R. PRESSLEY, PE
Principal Electrical Engineer
Vice President

- Registered in the state of Alaska
- Fire Detection/Alarm Systems/Security
- Lightning Protection and Grounding Systems
- Communications and Integrated Controls Systems

Education:

- University of Texas at Arlington BS, Electrical Engineering

Registration:

- PE, Electrical Engineering Alaska #3835
- PE, Electrical Engineering Oregon #10900
- PE, Electrical Engineering Hawaii #4421
- PE, Electrical Engineering Washington #21745
- PE, Electrical Engineering Guam #1146

Professional Affiliations:

- Institute of

Jim Pressley has 39 years experience and is a Vice President and the Principal Electrical Engineer for PDC. Jim pioneered the electrical engineering department for PDC and has designed electrical systems (power generation, transmission/distribution, instrumentation, monitoring and control, EMCS, lighting, communications, fire detection and security systems) for educational, institutional, industrial and commercial projects since 1967. Mr. Pressley's 39 years of experience includes 35 years in the state of Alaska and 29 years with PDC.

Mr. Pressley designs systems that include generation and electrical services, standby and emergency power systems, lighting and lighting control systems, automatic control, sound systems, fire alarm, security, communications, and dimming systems.

Project experience includes:

- ***Eielson Substation,*** *Eielson AFB, Alaska.* Principal In Charge and Principal Engineer. Modernization of the original Eielson CHPP which was constructed in the early 50's. This project consisted of constructing two separate switchgear enclosures, one for power plant supply and another for building and feeder distribution. Included in the project are interconnections with all existing 7200 V. generators and feeders. Provisions were made to permit energizing existing 7200 V. feeders at 12470 V. when the system is upgraded in the future.

- ***Eielson CHPP Baghouse,*** *Eielson AFB, Alaska.* Principal Electrical Engineer. Two baghouse structures were added to this cogeneration facility. Extensive relocation of existing 7200 V. distribution lines were required to clear areas for the new structures.

- ***Ft. Wainwright Ammunition Surveillance Building,*** *Ft. Wainwright, Alaska*. Principal Electrical Engineer. This project included extending the base's existing 7200 volt power distribution system about three miles to reach this remote facility. Overhead construction was used and the challenges included building the new line within the same cleared area of the inadequate existing line it was replacing while keeping the existing line in operation.

- ***New Power Plant Design, Amundsen-Scott Station,*** *South Pole, Antarctica.* The design of this 7,000 sf power plant includes engine generators, switchgear, distribution control, SCADA, control room, fire suppression and water treatment. Design challenges included dimensional constraints, weight restrictions for shipping, environment, climate and other logistics. Outlying buildings were supplied using 5 KV distribution lines buried in the ice. Step up and step down transformers were provided at each end of the distribution lines.

- ***Elmendorf Central Heating and Power Plant,*** *Alaska.* Provide electrical design and specifications to provide a new large exhaust gas air-air heat recovery unit on power plant steam boiler exhaust in order to increase overall plant efficiency.

- ***Clear Central Heating and Power Plant Coordination Study,*** *Clear AFS, Alaska.* Field investigation, data collation, computer modeling of existing and recommended basewide primary electrical distribution system from prime mover protective relays through secondary service overcurrent protective devices throughout the system. Provided computer based fault analysis, selectivity and coordination studies.

- ***Wainwright Generation Analysis,*** *Wainwright, Alaska.* Examination of several concepts for new 1200 KW diesel-fired prime power plant, present schematic designs and cost estimates.

- ***Elmendorf Hospital,*** *Elmendorf AFB, Alaska.* Performed field work, research, preliminary designs for 6 different alternatives for supplying energy to a new 430,000 sq. ft. hospital.

- ***Nenana Cogeneration Facility,*** *Nenana, Alaska.* Planning, conceptual designs, cost estimates for new 68 MW coal-fired cogeneration plant near Fairbanks, Alaska.

- ***Kotzebue Hospital,*** *Kotzebue, Alaska.* Emergency diesel power plant (3 -400 KW) units with automatic paralleling/synchronizing/sequencing switchgear.

- ***Seward Marine Industrial Park.*** *Seward, Alaska.* Principal In Charge and Principal Engineer. Provided complete distribution system design for this heavy industrial facility just of Resurrection Bay. Medium voltage distribution lines were provided to several integral substations throughout the site for use by private enterprises in building and repairing marine vessels of all sizes and types. A large ship lift was included for dry docking vessels. Site lighting and flexibility in power supplies were integrated into the individual work sites.

- ***Bethel*-Nyac *Transmission Line Feasibility Study.*** Principal Engineer. A study was commissioned to investigate the possibility of building a 69 KV transmission to interconnect Bethel and Nyac along the Kuskokwim River. Bethel had excess generation capacity and Nyac had been identified as a potential small hydro site. The customers included 5 villages located between the two termination points. Various routes, construction configurations and installation methods were studied and cost estimates prepared for each alternative.

- ***Add Neutral to Overhead and Underground Distribution System,*** *Eielson AFB, Alaska.* Principal In Charge and Principal Engineer. This project included two large sections of distribution lines within this Base's overhead primary power system. The existing system operates at 7.2 KV, but a future project is planned to convert it to 12.47 KV. This project included windshield surveys, documentation of each individual pole and its construction and appurtenances and creation of schedules identifying existing conditions and modifications necessary to install neutral conductors for use when the future upgrade occurs. A large segment included making the same provisions for an underground primary distribution system's future upgrade. The original design had not considered the future upgrade, so all underground primary feeders required replacement and designs were prepared for those changes.

Charles Pool, PE, LS

Education
B.S. Civil Engineering, Colorado State University
Graduate work, Colorado State University
Certificate of Engineering, Fort Lewis A & M

Registrations
Registered Alaska Land Surveyor 3248-S
Registered Alaska Professional Engineer 2127-E

Experience
Charles Pool has directed the operation of Pool Engineering, Inc. since its inception in 1970. Prior to entering private practice he was a construction engineer for the Alaska Department of Highways, and for various construction companies in Alaska.

Mr. Pool is actively involved in facilities planning, construction engineering, cost estimating and project management.

Design experience includes water and sewer systems, grading, drainage, retaining walls, foundations, and street paving projects.

MICHAEL R. TOOLEY, P.E.

EDUCATION B.S., Engineering Science, University of Alaska Fairbanks, 1970

REGISTRATION Professional Engineer, Civil Engineering: Alaska, (CE-4246); Washington (24253, Inactive); Oregon (13581, Inactive); Guam, MI (380, Inactive)

EXPERIENCE Mike is a professional engineer specializing in horizontal civil designs, with more than 35 years engineering experience, predominately in the public sector as the manager of Sections supervising the developmental phases of highway projects. He retired from the Alaska Department of Transportation and Public Facilities (DOT&PF) in 2003 after working in all three regions. Beginning while in college in the late 1960s, his experience includes locations, reconnaissance, design, and construction. Michael was a part of the tremendous growth in the Central Region for most of his career with the Department. He served as the Reconnaissance Engineer for preparation of the 5-Year Construction Plan before there was a Planning section; the Road Design Engineer during the period of heavy state-funded building; the Assistant Design Chief during the large growth in federal-aid funding; and finally, the Highway Construction Engineer during one of the Department's biggest building booms.

Highway and Bridge Design

Senior Design Engineer, Seward Highway, MP 75-90, Ingram Creek to Girdwood, DOT&PF, AK. Lead engineer for the reconstruction of the Seward Highway at the head of Turnagain Arm. Was responsible for the preliminary design to support the environmental efforts, and then the final design after approval of the environmental document. Proposed to build a causeway across the Arm between Ingram Creek and MP 83 near Johnson Creek, thereby cutting off nearly an 8 mile loop of Kenai travel.

Project Manager, Ketchikan Gravina Island Access, DOT&PF, AK. Managed the startup of the design phase of this new bridge in Ketchikan. Wrote the *Design Criteria* and *Design Study Report* that was accepted by the Department, and performed the QC Review of the preliminary alignment of the approved road between the Ketchikan International Airport on Gravina Island, across Tongass Narrows and Pennock Island, and ending at the Tongass Highway on Revilla Island. Coordinated the surveying and geotechnical efforts supporting permit preparation for the Project, and assisted in the obtaining the necessary permits. The Project is currently being considered for design-build procurement contracting.

QA/QC Reviewer: Five Mile Road, Franklin to Fairview, Ada Highway County District, Idaho. Performed the QC review for this urban arterial construction project for HDR's Boise office.
I-405 Corridor GEC Contract, Tukwila to Renton, WA, HNTB Corp. Performed a review of the QC Manual for this major road project.
US-20 Holbrook Interchange, ITD Headquarters, ID. Performed the QC review of this interchange design for HDR's Boise office.

Senior Design Engineer, Glenn Highway Rehabilitation, Gambell to McCarrey Streets, DOT&PF, AK. Assisted in the development of various early alternatives for the upgrade of the Glenn Highway between Gambell Street and McCarrey Street. Wrote supporting documents for the upgrade of the existing alignment and potential new alignments. Developed the alignment and construction cost estimate for a proposed new controlled-access facility (the *Anchorage Parkway*) between McCarrey Street on the Glenn Highway and 36th Avenue on the New Seward Highway.

Senior Design Engineer, Dowling Road Minnesota Drive to Old Seward Highway, AK, DOT&PF. Project goal was to extend an urban arterial from the Old Seward Highway west to Minnesota Drive. Prepared the *Design Criteria*, alternatives summary, and construction cost estimates for alternatives. Developed the route alignment to connect International Airport and Raspberry Roads to Dowling Road.

Senior Design Engineer, Eklutna River Bridge Project, Municipality of Anchorage (MOA), AK. Reviewed roadway design and wrote the Design Study Report for rehabilitating an existing half-mile steel spandrel arch bridge over the Eklutna River on the Old Glenn Highway north of Anchorage, AK.

Senior Design Engineer, Akutan Airport Access Road, DOT&PF. Reviewed the proposed alignment and assisted in the development of the construction cost estimate for a proposed 14-mile road to link the City of Akutan to the site of a proposed new airport location.

Project Manager, Chignik Lake Road Repair, Alaska Dept. of Military & Veterans Affairs, AK. Managed the analysis of designs to repair the only road leading from the Village of Chignik Lake's to its barge landing, which sustained severe flood damage in 2002. HDR recommended a corrective design to repair the road, and provided construction inspection of the final design.

Senior Design Engineer, Juneau Second Channel Crossing, DOT&PF, AK. Provided a new access from North Douglas Island to the mainland near the Juneau International Airport. Reviewed the work performed in the 1984 Study, and assisted in the development of the *Design Criteria* and location of the new crossing concepts. Developed the *Life-cycle Cost Summary* for crossing options, and wrote part of the *Current Conditions Summary*. Upon approval, will prepare the *Reconnaissance Study Report*.

Senior Design Engineer, Chignik Area Connectors, DOT&PF, AK. Project is to develop new access roads connecting the three Chignik villages on the Alaskan Peninsula. Developed the *Design Criteria* for the connector roads for the Department's acceptance, and started working on the route locations. Wrote the draft *Reconnaissance Study Report.*

Senior Design Engineer, Sterling Highway, MP 45-60, Quartz Creek to Skilak Lake Road, DOT&PF, AK. Developed the *Design Criteria*, provided document review, and designed preliminary wildlife crossings for the environmental effort to reconstruct the Sterling Highway around Cooper Landing.

Alaska Department of Highways / Transportation

Some of Mike's proudest accomplishments with DOT&PF include:

- The reconnaissance development of the Minnesota Drive Extension, and the design of the reconstruction of Dimond Boulevard and the A-C Couplet.
- Roadway features to benefit the public including: six lanes on Dimond Boulevard, the split median on Boniface Parkway (consultant design) and Raspberry Road (in-house design) to accommodate difficult access, and the addition of dual left-turn and right-turn lanes at various intersections.

- Wrote the preconstruction procedures for local agencies for the initial *Community Transportation Program*.
- Wrote the Region's construction administration procedures for consultants and local government agencies.
- Developed the *Rural Sanitation Roads* construction oversight procedures.
- Created the Construction *NAVIGATOR* program, which has won major awards.

Construction

Highway Construction Engineer, Construction Branch, DOT&PF, Anchorage, AK. Responsible for directing the operations of the Highway Construction section with a staff of 7 in the Administrative unit and about 80 in the Construction unit, and some consultants. The section administered approximately $100 million a year in contractor payments. Michael oversaw the construction administration for the Central Region of all roadway work both locally and in bush Alaska, including the following major contracts:

- The first phase of the four-laning of the Parks Highway from its junction with the Glenn Highway to Church Street.
- The last segment of the Seward Highway reconstruction along Turnagain Arm from Girdwood to Bird Point.
- The Canyon Creek Bridge construction on the Seward Highway and the reconstruction of the segment of the Sterling Highway from the Seward Highway to Kenai Lake.
- Developed procedures and managed contracts with the Alaska State Troopers and the Anchorage Police Department to enforce the traffic laws, double fine speed limits, and place construction signing within the construction work zone.

Design

Assistant Design Chief, Highway Design, DOT&PF, Anchorage, AK. Responsible for directing the operations of the Highway Design section with a staff of 35, which involved one or more engineering disciplines, including the work performed by engineering consultants, for an annual construction program designed by the Section of approximately $40 Million. Also was an active member of the AMATS *Technical Advisory Committee*, the local Municipal Planning Organization transportation planning organization. Michael supervised the design development on the following major projects:

- The consultant design of the new Canyon Creek Bridge on the Seward Highway.
- Reconstruction of Raspberry Road from Jewel Lake Road to Minnesota Drive, and then the interchange at Minnesota Drive.
- The new construction of the A-C Couplet, from Tudor Road to 9th Avenue.
- The Minnesota Drive extension, Phase I International Airport Road to Dimond Boulevard, and Phase II Dimond Boulevard to Old Seward Highway.
- The reconstruction along Turnagain Arm from McHugh Creek to Girdwood, which completed the widening and straightening of one of the most difficult stretches on the Seward Highway.

Reconnaissance

Reconnaissance Engineer, Reconnaissance, Department of Highways, Anchorage, AK. Supervised the Reconnaissance and Locations sections consisting of 15 people charged with preliminary planning and analysis of all proposed projects within the Region. Work included project development from the initial studies of the concept and location to obtaining public involvement, and relating traffic and need for the community good. Projects included:

- Supervised the preliminary development of the corridor extension of Minnesota Drive, New Seward Highway to Tudor Road. Wrote the Design Study Report.
- Laid out the interchanges on the New Seward Highway (O'Malley, Huffman, and DeArmoun Roads) and the Glenn Highway (Boniface Parkway, Hiland Road, the Birchwood Loops, and Peters Creek).
- Involved in several major recon/planning efforts including the Super Seward Highway, Tidewater Freeway, Northside Corridor, Fire Island Freeway, Knik and Turnagain Arm Crossings, and many more.

Project Management

Design Project Manager, Dimond Boulevard Reconstruction, Jewel Lake Road to the New Seward Highway, DOT&PF, Anchorage, AK. This project was an in-house design.

Design Project Manager, Boniface Parkway Reconstruction, Tudor Road to DeBarr Road, DOT&PF, Anchorage, AK. The project was designed by a consultant.

Design Project Manager, *Community Transportation Program*, DOT&PF, Anchorage, AK. Oversaw the administration of the Borough Transportation Program as it related to the other local managing agencies (Municipality of Anchorage, Department of Natural Resources, etc). Also developed procedures for this program.
Construction Project Manager, *Rural Sanitation Roads Program*, DOT&PF, Anchorage, AK. Developed procedures to be followed by the various agencies (PHS, VSW, BIA, etc.) that would actually administer the projects in the Bush, made prior approval of change documents, and conducted the final inspection of the completed projects.

Guam Department of Public Works

Prior to his last residency, Michael was a contract engineer for the Government of Guam's Department of Public Works, where he helped set up a design and a construction branch after the Military turned over responsibility for the off-base infrastructure to the local government.

Territorial Construction Engineer, DPW, Guam, MI. During the initial stages, oversaw 10 employees in manning and updating procedures and equipment within the section to supply support to existing maintenance and engineering divisions, and future construction operations. Hired, trained, and supervised employees to become project engineers for the first projects. Determined all necessary procedures, books, forms, and recommend guidelines for highway construction.

Design Engineer, DPW, Guam, MI. Responsible for reorganizing the survey and drafting section in preparation for an expanded highway program necessitated by the turnover to local responsibility. Prepared requests for federal-aid participation on various projects, and review plans and specifications as submitted by consultants prior to development of an in-house design capability. Controlled the setting up of a construction program to administer all construction let out to bid for both locally and federally funded utility, highway and airport projects.

CHRIS M. HUGHES, P.E.

EDUCATION

B. S., General Engineering, Mechanical Specialty, Colorado School of Mines.
M.S., Mechanical Engineering, University of Colorado at Denver, incomplete.

PROFESSIONAL REGISTRATION

Professional Civil Engineer (CE-11537, 2006)

PROFESSIONAL ASSOCIATIONS

American Society of Civil Engineers (ASCE)

EXPERIENCE

Chris, a Professional Engineer with HDR, has a diverse 6 year background in civil and mechanical engineering. As a forensic engineer, he performed investigations ranging from residential structural problems stemming from construction defects to accident avoidance analysis concerning roadway geometric design and guardrail application issues. His experience also includes management of an AASHTO certified materials testing (both field and laboratory) facility that supported geotechnical analysis and provided quality control for new construction projects. The following projects represent Chris's experience:

Engineering

Design Engineer, Knik Arm Crossing Environmental Services, Knik Arm Bridge and Toll Authority (KABATA), Anchorage, AK. Providing engineering support for alignment alternatives between the city of Anchorage and the South Bridge abutment. Analyzing environmental impact avoidance alternatives and designing adequate interchange scenarios to meet project demands. The Knik Arm Crossing project would provide a new transportation connection from the Municipality of Anchorage to the Matanuska-Susitna Borough.

Design Engineer, Gravina Access Project, DOT&PF, AK. Chris is supporting the subsequent phases of project development, including preparation of roadway plans, bridge layout drawings, permit applications, and advanced geotechnical and surveying reconnaissance programs. Future work items include the preparation of a final Plans and Specifications and Estimate package for construction.

Design Engineer, Chignik Lake Road Repair, Alaska Department of Military and Veterans Affairs, Division of Homeland Security and Emergency Management (DMVA and DHS&EM), Chignik Lake, AK. Analyzed prior construction attempt to repair approximate 3 mile section of roadway that was damaged from severe flooding in 2002. Also provided corrective design recommendations to bring the roadway back to its pre-disaster condition. Future work includes construction inspection of the final design.

Inspection Engineer, Quinhagak Airport Project, Native Village of Quinhagak, AK. Conducted construction inspection for HDR's designed airport relocation for the City of Quinhagak. Project included road improvements, runway extension, and lighting improvements.

Training

Completed both Applying Inroads and Advanced Inroads (40 hours) for use with Microstation, September, 2005.

National Highway Institute, NHI Course 135056, Culvert Design, (21 hours) November, 2005.

Publications

Rose, N.A., Fenton, S.J., Hughes, C.M., Integrating Monte Carlo Simulation, Momentum-Based Impact Modeling, and Restitution Data to Analyze Crash Severity, 2001-01-3347, Society of Automotive Engineers, Warrendale, PA, 2001.

Fenton, S., Neale, W., Rose, N., Hughes, C., Determining Crash Data Using Camera-Matching Photogrammetric Technique, 2001-01-3313, Society of Automotive Engineers, Warrendale, PA, 2001.

Rose, N.A., Hughes, C.M., Optimum Chord Length for Critical Speed Analysis, Issue 31, Accident Investigation Quarterly, Accident Investigation Journal, Summer 2002.