NORTHWEST TERRITORIES
GRANULAR RESOURCE
DIRECTORY

TERRITORIAL GRANULAR STRATEGY

_Prepared by:_

Department of Public Works and Services
Department of Lands
Department of Transportation
NWT Housing Corporation

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Granular Resource Directory

Prepared by
The Interdepartmental Granular and Environmental Remediation Committee

With Representatives from:
Department of Transportation
Department of Lands
Department of Public Works and Services
Northwest Territories Housing Corporation
PREFACE

Granular materials are a strategic and valuable resource and should be used in a sustainable manner. For this reason, the Government of the Northwest Territories (GNWT) prepared a Granular Resource Directory (GRD) that was part of a territorial-wide granular strategy committed to the conservation, sustainability and effective management of granular resources within the Northwest Territories (NWT).

The Directory was designed to provide guidance in the identification, acquisition, usage and management of granular material around communities and on Commissioner’s Land. The conservation and effective management of granular reserves are important for future territorial and community infrastructure development throughout the NWT. Post Devolution, the GNWT continues to implement initiatives and strategies to ensure a sustainable granular supply for the benefit of future generations of northerners for approximately 78% of the land mass of the NWT.

The objective of the Directory is to provide a user-friendly way for territorial governments and the public to access granular resource information. The Directory can be accessed on-line and acts as an information management database. The series of guidelines related to the ownership, regulatory requirements, identification, inventory, procurement, production and use of granular materials within the NWT have been updated to reflect new authorities for the GNWT after Devolution. Information about the availability of granular resources, supply and demand models, pit operations, environmental management and the sustainability of this resource are also covered and are largely focused on lands around communities and Commissioner’s Land.

Guidelines are supplemented by a comprehensive bibliography, selected websites and appendices related to granular resource development and management within Federal, Territorial, Commissioner and private lands in the NWT.

The NWT Granular Resource Directory is divided into five chapters, photo and website directories, bibliography and appendices.

- Chapter 1: Introduction
- Chapter 2: Granular Resource Overview
- Chapter 3: Granular Supply and Demand
- Chapter 4: Granular Acquisition and Production
- Chapter 5: Granular Resource Management

- Photo Directory
- Website Directory
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The Appendices A through E contain relevant PDF and Word documents that are hyperlinked to each chapter within the directory.
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- Territorial Granular Resource Forecast Tables – Updated October 2008 (PDF)

Chapter 2 – Appendix B

- Land Use Application – Mackenzie Valley Land and Water Board (Word Doc.)
- Quarry Permit Application – Territorial Lands (Word Doc.)
- Quarry Permit Application – Indian and Northern Affairs Canada (Word Doc.)
- Quarry Administration – Commissioner’s Land (PDF)
- Northern Land Use Guidelines – Pits and Quarries October 2008 (PDF)
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- Bore Hole Logs – examples (PDF)
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1.0 INTRODUCTION

1.1 Background – Territorial Granular Resource Strategy (TGRS)

Granular materials are necessary for government and municipal infrastructure projects in the NWT and a strategic and valuable resource. The GNWT has a responsibility to ensure that granular materials will be available for future generations of northerners, where required and at a reasonable price. It is imperative that the needs of a wide array of stakeholders and interest groups are considered in order to properly develop and manage this important resource. In November 2007, the Interdepartmental Granular Committee (IGC) was tasked with implementing a two part Territorial Granular Strategy by preparing a ‘Territorial Granular Resource Forecast’ (TGRF) and developed a ‘Granular Resource Directory’ (GRD) that was published in 2009.

The Granular Resource Directory (GRD) represented Part 2 of the Territorial Granular Strategy. In September 2006, Indian and Northern Affairs Canada (INAC) hosted a workshop in Yellowknife entitled ‘The NWT Granular Users Forum’. Participants included representatives from Aboriginal organizations, governments, regulators, industry, resource management bodies, and consultants. The forum identified that there was a considerable amount of data on granular resource management in the NWT but it was widely unknown where and how to access the information. As well, it was acknowledged that the quality and quantity of information on granular resources in the NWT needed to be improved. Participants formed a consensus on the necessity for better access to granular resource information on the identification, acquisition and management of granular resources in the North. The GRD was updated in February 2015.

The GNWT has a role to play in ensuring that territorial governments are able to meet this need by improving the availability granular resource information. The GRD, as part of a comprehensive Territorial Granular Strategy, was intended to assist all levels of territorial governments and the public to access and utilize granular resource information. Because of the importance of the guide, it has been updated to reflect the GNWT’s new post devolution authorities. GNWT’s philosophy to devolution was to “first devolve and then evolve”. The GNWT will need time to evolve its knowledge base about granular resources outside communities on lands that were transferred to the GNWT through devolution.

1.2 Scope

The objective of the Directory is to provide a user-friendly means to access information about the identification, acquisition, production, usage and management of granular resources in the Northwest Territories, with a critical regard to a sustainable granular supply for community and territorial infrastructure development.
Current information about the availability of granular resources, including source evaluations, granular inventories and the sustainability of this resource are reviewed. Guidelines to the acquisition, methods of extraction and transporting granular materials in the NWT are also covered, including the environmental and economic impacts of developing this non-renewable resource. The use of granular materials in all types of construction is also examined, including competing demands for granular resources.

1.3 Information Management Tool

Accessible quality information on the procurement, development and management of granular resources in the NWT was seen as a fundamental part of a Territorial Granular Strategy. The Granular Resource Directory (GRD) was prepared as an information management tool to assist all levels of territorial governments, private sector and the public to:

- Access granular resource information;
- Plan for the provision of granular materials;
- Determine granular inventories;
- Prepare a granular demand forecast assessment to assist in the timely acquisition of granular materials;
- Ensure granular materials are available when required and at reasonable cost;
- Deal with environmental and regulatory issues;
- Provide sound management practices and standards for the extraction of this non-renewable resources; and
- Implement management planning techniques to ensure the sustainability of this resource including Geographic Information Technology.

1.4 Territorial Granular Resource Strategy Initiative

1.4.1 Background

To meet the challenges of granular acquisition within the NWT, especially the high costs of obtaining granular materials, the GNWT prepared a Territorial Granular Strategy that involves a coordinated systematic approach to granular acquisition that ensures an economic, reliable, accessible, and sustainable granular supply to meet the continual and increasing demand for this resource (Appendix A – Granular Strategy Report).

Communities within the Northwest Territories are faced with unique challenges with respect to the provision of accessible, adequate supplies of granular material. Inequities exist between communities that have access to granular material supplies and those who don’t. The problems are commonly a combination of many factors and range from geographic location, community production and management capabilities, granular demand and supply (or lack of) and the ability of a supplier to fill this need. There is a need to integrate a Territorial Granular Strategy for the effective management of granular resources.
resources to ensure that these materials will be available for future generations of northerners, where required and at a reasonable price.

Over the years, a Territorial Granular Strategy took many forms to ensure granular materials are available when required and at reasonable cost.

1984-1987:
The Community Granular Priority Program mandate under PWS direction was to produce and stockpile affordable granular materials within all non-tax based communities where the private sector did not provide this service. The Program was funded through capital and proved to be effective.

1989-1992:
Community Granular Program replaced the Priority Program, under PWS direction to provide and stockpile affordable gravel in non-tax based communities through the capital funding process and was made a permanent GNWT Capital Program with specific funding levels. In 1992, the Financial Management Board advised the Department that the Community Granular Program would no longer be treated as a Capital Program. The Department was directed to establish the Program under a revolving fund beginning in 1991/92.

1992-1999:
The Community Granular Revolving Fund (the Fund) was established under PWS mandate to provide the capital resources to identify, produce, stockpile, and manage quality granular materials at a reasonable cost in non-tax based communities. All costs of operating the Fund were recovered by the sale of granular materials. The actual unit selling price ($/m3) of any stockpile was calculated by on-site production costs and adding the annual overhead and administrative costs. No provisions were made for write-offs, write-downs, or monitoring. In 1999, the 'Fund' was repealed by an act of legislation.

2005-2011:
An Interdepartmental Granular Committee (IGC) was established in 2005 with representatives from Municipal and Community Affairs (MACA), the department of Transportation (DOT), Public Works and Services (PWS), and the Northwest Territories Housing Corporation (NWTHC). The IGC was chaired by PWS. The IGC was tasked with developing and implementing a Territorial Granular Resource Strategy by ensuring a coordinated approach to granular supply for the GNWT and community governments. The strategy was implemented in 2007.

2011- Present:
The IGC was replaced by the Interdepartmental Granular and Environmental Remediation Committee (IGERC) chaired by PWS. In addition to maintaining the territorial-wide granular strategy, the IGERC took on the added role of assisting the Environmental Remediation Committee (ERC) in its role of implementing and monitoring environmental site assessments and remediation projects.
In November 2007, an Interdepartmental Granular Committee (IGC) was established to implement the Territorial Granular Strategy under the direction of the Deputy Ministers of PWS, MACA, DOT and the President of the NWTHC. The Committee was tasked with the preparation of two separate but mutually inclusive documents - the Territorial Granular Resource Forecast (TGRF) and the Granular Resource Directory (GRD).

The TGRF is used as the basis for consultation with community governments, and potentially other stakeholders, who may want to coordinate with the GNWT to achieve economies of scale. The TGRF updates territorial granular supply and demand forecasts biannually (tables are updated and forward internally within the GNWT and circulated to territorial governments in April and October) to facilitate the coordination of granular supply opportunities and assess project required material volumes (Appendix A – TGRF May 2009 Updates).

The Granular Resource Directory (GRD) acts as a public-oriented information tool that compiles information on the supply, acquisition, conservation, sustainability, and effective management of granular resources within the NWT for the benefit of future generations of northerners. The GRD can be accessed on-line by all levels of territorial governments, NGO’s, private sector and northern residents.

The Committee met regularly to review the status of territorial and community granular acquisition in the NWT. As of April 01 2015, inquiries to the IGC as to the acquisition and management of granular resources within the NWT can be directed to:

Janice Lee  
Projects and Geotechnical Officer  
Asset Management Division  
Department of Public Works and Services  
Government of the Northwest Territories  
PH: 867-920-6923  
FAX: 867-873-0226  
Email: Janice_Lee@gov.nt.ca

1.4.2 Current Status – March 2015

In 2011, the IGC was replaced by the Interdepartmental Granular and Environmental Remediation Committee (IGERC), which continues to implement the strategy under the same mandate. PWS chairs the IGERC.
2.0 GRANULAR RESOURCE OVERVIEW

2.1 Challenges

The GNWT is faced with unique challenges with respect to the provision of accessible and adequate supplies of granular materials. Inequities exist between communities that have access to granular material supplies and those who do not. The conservation and effective management of granular reserves are important for future territorial-wide infrastructure and development projects throughout the NWT.

The lack of an adequate supply of granular materials for community and territorial infrastructure, private sector projects and transportation-related demands are serious challenges. The degree of challenge varies according to geographic location, community production and management capabilities, the high costs to supply granular materials on a project-by-project basis and the on-going competition for granular materials. That challenge has increased with the larger quantum of land that the GNWT now has to manage and its expanded role as resource manager for gravel throughout the NWT.

Access to adequate supplies of granular materials is another challenge for the GNWT. There are eight communities that do not have all-season access to granular sources and are required to obtain gravel through seasonal supply operations resulting in higher project costs. Other municipalities face issues associated with local capacity, long distance supply or lack of private sector capacity to obtain gravel.

The cost of granular supply in the NWT is high and dependent on availability. Once a proven source has been depleted, access and development of an alternative site is often difficult and costly. Any significant reduction in granular reserves available to territorial governments and other users will result in higher costs to access and develop potential sources. Some municipalities already require long distance access to borrow pits to meet demand. The following summarizes the challenges related to the acquisition, development and management of granular materials in the NWT:

- Deposits are limited in occurrence and non-renewable;
- Adequacy and accuracy of existing inventories for supply and forecasts of demand has always been a challenge, and has become a greater challenge with Devolution;
- Sources can be remote from established communities;
- High development and production costs;
- Seasonal access often required;
- Reconciling conflicts uses between industry and communities equitably;
- Sustainability of existing reserves.
2.2 Ownership, Acts and Regulations

2.2.1 Ownership

Ownership of land in the north generally includes ownership of granular resources. In the NWT there are seven categories of land ownership. The ownership of lands in the NWT changed significantly as the result of the Devolution Agreement which came into effect on April 1, 2014. Most of the federal lands which used to be administered by Canada were transferred to the GNWT. Some federal lands were retained by Canada. For a list of lands retained by Canada see Schedule 4 (Inventory of Exclusions from Transfer of Administration and Control). (Schedule 4 was put into effect by Privy Council No: 2014 – 0338.)

The GNWT is now responsible for managing public land and waters and resources on lands transferred to it as part of the Devolution Agreement including granular resources. Devolution of these responsibilities was the last major transfer of powers from the federal government to the territorial government.

Legislation

Under the Devolution Agreement the GNWT committed to “substantially mirror” Canada’s statues and regulations that were repealed or made inapplicable to all land except federally retained land (see Schedule 4), transferred to the GNWT through devolution. The GNWT mirrored 26 federal acts and regulations governing public land, water and resource management in the NWT. All were enacted as territorial legislation on April 1, 2014. The GNWT adopted a strict mirroring approach in which changes were made to align with GNWT legal drafting styles, to change federal references to territorial references and to make any other legally necessary changes.

The Department of Lands manages, administers and plans for the sustainable use of Territorial lands in the Northwest Territories. Territorial lands are public lands that transferred from the federal government to the Government of the Northwest Territories on April 1, 2014. These lands are managed under various legislation, policies and procedures to regulate activities taking place on the land and to ensure the protection of human health, property and the environment. The legislation that applies to Territorial lands includes the following:

- *Northwest Territories Lands Act*
- *Northwest Territories Lands Regulations*
- *Northwest Territories Land Use Regulations*
- *Quarrying Regulations*
On April 1, 2014 the responsibility for Commissioner’s lands in the Department of Municipal and Community Affairs was transferred to the newly created **Department of Lands**. **Commissioner’s Land** is also public land and is typically found in and around NWT communities.

The legislation that applies to Commissioner’s lands includes the following:

- *Commissioner’s Lands Act*
- *Commissioner’s Lands Regulations*
- *Area Development Act* including its regulations

For both Territorial and Commissioner’s Lands, the Department of Lands provides a number of services including leases, sales, licences and other tenure issuance and enforcement, approval of surveys, land inventories, land withdrawals, securities and revenue collection.

**Surface Rights Board Act**

The purpose of the Board is to resolve disputes over the terms and conditions of access and the compensation to be paid with respect to that access relating to Gwich’in lands, Sahtu lands, Tlicho lands, Inuvialuit lands or other lands such as private, Commissioner’s, or Crown land in the NWT.

**Mackenzie Valley Resource Management Act – Delegated Responsibilities to the GNWT**

Although the Mackenzie Valley Resource Management Act (MVRMA) remains federal legislation, devolution provided the GNWT with new delegated authorities under the Act – authorities previously exercised by the federal Minister. The Devolution Agreement states that Canada shall delegate to a territorial Minister the following functions of the federal Minister under the MVRMA:

- Approval of Type A Water Licenses
- Approval of securities posted for land use permits
- Designation of inspectors
- Monitoring of cumulative impacts
- Environmental Audits
Certain functions relating to the environmental assessment processes:

- Receipt and distribution of reports from the Mackenzie Valley Environmental Impact Review Board (MVEIRB).
- Participation in and distribution of decisions in consideration of those reports.

In addition to the delegations outlined in the Devolution Agreement, the federal Minister has made the following additional delegations:

- Collection of Administrative monetary penalties, including penalties for violations in relation to development certificates
- Ministerial decisions on time-limit extensions (except extensions granted through Governor-in-Council for development on Commissioner’s or private lands)
- Designation of inspectors and inspectors of development certificates
- Approval of Type B water licenses with public hearings
- Regional studies

**Parallel Land Management Systems**

Devolution left the GNWT with two parallel land management regimes for the NWT (including for granular resources), one for Commissioner’s Land, guided by the Commissioner’s Land Act and one for Territorial Land guided by the Northwest Territories Lands Act.

The contact information is as follows:

Lands Administration:

Yellowknife Location: 1st Floor Gallery Building (4923 – 52nd Street)
Telephone: (867) 765-6701
Fax: (867) 669-8908
E-mail: NWTLands@gov.nt.ca

The different types of land are as follows:

1. **Federal Lands:**

   Federal lands administered by the Department of Aboriginal Affairs and Northern Development
2. **Territorial Lands:**
   - Territorial lands administered by the Territorial Government (*Quarry Permit Application – Territorial Lands (Word Doc.)*)

3. **Commissioner’s Land:**
   - Lands administered by the Territorial Government under the Commissioner’s Land Act (*Appendix B – Quarry Administration - Commissioners Land*)

4. **Private Lands:**
   In the NWT, there are three settled land claims collectively referred to as private lands.
   - Under the Inuvialuit Final Agreement (IFA), Inuvialuit have ownership of 90,649 square kilometres of land, including 13,000 square kilometres with sub-surface rights to oil, gas, and minerals. The four communities in the region are Ulukhoktok, Paulatuk, Sachs Harbour and Tuktoyaktuk.
   - The Sahtu have ownership of 41,437 square kilometres. The five communities in the region are Colville Lake, Fort Good Hope, Tulita, Deline, and Norman Wells.
   - The Gwich’in have ownership of 16,264 square kilometres. The four communities in the region are Aklavik, Fort McPherson, Tsiigehtchic and Inuvik.

5. **Tlicho Lands:**
   - The Tlicho Agreement was negotiated by the Dogrib Treaty 11 Council, the Government of Northwest Territories and the Government of Canada. The Tlicho agreement is the first combined *land claim and self-government agreement* in the territories.
   - The Tlicho have ownership of 39,000 sq. km of land in a single bloc surrounding the four Tlicho communities of Behchoko, Whati, Gameti, and Wekweeti of the North Slave Region of the NWT. On their lands the Tlicho own both the surface and subsurface resources.

6. **Tlicho Community Government Lands:**
   Most of the lands within the boundaries of the 4 Tlicho Community Governments of Gameti, Behchoko, Wekweeti and Whati are owned by the community governments and these lands are separate and distinct from Tlicho lands.

7. **Municipal Lands:**
   - Lands administered by the territorial municipal governments.
2.2.2 Acts and Regulations

The regulations affecting the development of granular resources and the process for obtaining authorization vary across the NWT and depend on land ownership. Land-use guidelines, quarrying rights and permitting differ on private and government lands; also, it is necessary to obtain access agreements from the landowner.

The following Acts and Regulations apply to pit and quarry development in the NWT:

- Mackenzie Valley Resource Management Act (MVRMA) and Mackenzie Valley Land Use Regulations
- Northwest Territories Lands Act, Lands Regulations, Land Use Regulations and Quarrying Regulations
- Commissioner’s Lands Act and Commissioner’s Lands Regulations
- Fisheries Act
- Waters Act and Waters Regulations
- Mine Health and Safety Act Ordinances and Regulation rules

The following regulatory agencies receive and review applications for activities related to the development and removal of granular materials on lands within the NWT:

- Mackenzie Valley Land and Water Board (MVLWB)
- Inuvialuit Land Administration (ILA)
- Gwich’in Land and Water Board
- Sahtu Land and Water Board
- Wek’eezhii Land and Water Board
- Department of Lands
- Aboriginal Affairs and Northern Development Canada (AANDC) – for lands retained by the federal government

- The Mackenzie Valley Resource Management Act (MVRMA) through its Mackenzie Valley Land Use Regulations (MVLUR) empower the MVLWB to regulate the use of land by issuing, amending, extending and suspending land use permits on Territorial and Federal land in the unsettled land claim areas of the Mackenzie Valley. The MVLWB also maintains a public registry that contains applications received by the Board.

- Land Use Permits (LUP) related to granular resource development for all private lands in the Sahtu, Gwich’in and Tlicho geographic areas are issued by the Sahtu Land and Water Board (SLWB), the Gwich’in Land and Water Board (GLWB) and the Wek’eezhii Land and Water Board (WLWB).

- The Inuvialuit Land Administration (ILA) is empowered under the Inuvialuit Final Agreement (IFA) to process and issue permits for any land use activity on Inuvialuit
Lands. On Territorial lands in the Inuvialuit Settlement Area, the Department of Lands issues Land Use Permits.

The GNWT is responsible for the administration of gravel quarries and pits on Territorial lands and Commissioners land within the NWT (Appendix B – Quarry Administration). Under the Northwest Territories Lands Act and regulations and the Commissioner’s Land Act and regulations, the Department of Lands (GNWT) provides regulatory control for maintaining sound environmental practice for any land use activities associated with the planning, development and operation of any quarry and/or gravel pits on these lands. The Commissioners lands are usually in and around communities and also include highways and roads on public lands. They comprise less than one percent of the Northwest Territories.

 Quarry permits (right) are issued by the Tlicho Government for removal of material on private lands and the Wek’eezhii Land and Water Board issues the land use permit for the quarrying, stockpiling and removal of granular resources. Lands administered by the Tlicho Government are regulated by the Wek’eezhii Land and Water Board (WLWB); The WLWB developed guidelines for applications for land use permits and water licenses.

**Land Use Plans**

Land use plans are required in the Gwich’in and Sahtu settlement areas as a result of their comprehensive claims and the process to complete land use plans is set out in the *Mackenzie Valley Resource Management Act* (MVRMA). If you are a developer who will require quarry permits, licenses or land use permits for access to granular resources, please refer to the relevant regional land use plan or community conservation plan as early as possible when developing your project plans.

**Interim Land Withdrawals**

Interim Land Withdrawals are not the same as land selections. Interim Land Withdrawals are a way to prevent the creation of new interests (including quarrying ones) on withdrawn lands while negotiations proceed. An Interim Land Withdrawal does not mean that all lands withdrawn can or will be selected. Land Selection negotiations generally occur closer to the completion of an agreement.

The purpose of this withdrawal is to protect lands of interest from being sold, leased or otherwise disposed of while negotiations are underway. This means that no new interests (including quarrying ones) can be created on the withdrawn lands for the time period of the withdrawal or until a final agreement is reached, whichever comes first. It also ensures that any existing interests on these lands are protected during the period of the withdrawal.
2.2.3 Application Process

Applications for land use and quarry permits should be submitted by the developer concurrently. Generally, the application and review process for all of the above regulatory agencies can take up to 45 days to reach a decision. A developer must obtain a land use permit (from the various Land and Water Boards) and a quarry permit from the appropriate regulatory agency (GNWT or AANDC), depending on the geographic location of the quarry or pit, before any development can occur. Land use permit applications are available on-line through the various regulatory websites. Quarry permit applications are available on-line through the GNWT’s or AANDC’s websites. Note Appendix B for all LUP and Quarry Permit templates, and the website directory for related information.

Both permits will have conditions upon issuance that need to be followed. Also, the quarry permit must be in place before a land-use permit can be issued. Pit operations cannot commence until a valid land use permit and quarry permit have been obtained.

Furthermore, ground truth reconnaissance programs related to granular investigations and advanced exploration of identified granular deposits such as test pits or drilling may require a land-use permit dependent on the type and amount of equipment to be used and the scope of the land-use activity.

**Land Use Permit (LUP):** Authorizes temporary use of land for activities associated with granular resource development for periods of five years with a possible extension of 2 years. They are designed to minimize environmental disturbances and can contain conditions regarding environmental protection, location and area constraints, timing of operations, type and size of equipment, abandonment and clean-up. Often, a security deposit is required. A LUP can be extended for one year upon review.

The entire life-cycle of a pit or quarry from site development to reclamations, single or multiple users, the scope and level of pit operations all need to be considered when applying for a land-use permit.

Also, a spill contingency and response plan must be submitted with the LUP application. Guidelines are available at [www.enr.gov.nt/eps/pdf/spill](http://www.enr.gov.nt/eps/pdf/spill).

**Quarry Permit:** Authorizes the removal of a specific amount of material from a designated quarry or pit. AANDC and the GNWT require a monthly quarrying report during pit operations. The permit expires when the quantity of material stated in the permit has been removed or on the expiry of the permit. Quarry permits may be issued for up to 3 years. Often the permit requires royalties, based on the amount of material to be removed. There are no extensions and operators cannot exceed the material quantities authorized during pit operations. A ‘Final Quarry Pit Return’ form is submitted when the existing permit expires or when total material is quarried.
2.3 Guideline References

The following terms and definitions are provided for quick and easy reference and warrant a brief explanation, as they are important terminology to better understand the Directory:

Active Layer: the layer of ground in permafrost, which thaws each summer and refreezes each fall; acts as insulation that keeps the underlying permafrost frozen.

Blend: A type of granular material, usually within the sand sizes containing over 10% fines, which is used in the processing of select grade materials to improve grain-size gradation and compaction.

Bore Hole: A small diameter hole drilled from the ground surface to collect granular samples (Photo 31).

Boulder: A sub-rounded to rounded rock with a diameter exceeding 250 mm (ten inches).

Common Grade: Normally refers to naturally occurring pitrun within an identified borrow source that can be used for various types of construction such as rip-rap, general fill, structural fill or embankment, or for use in the processing select grades (Photo 4).

Concrete Aggregate: Granular material that meets the specifications for the production of cement (clean, hard, free of ‘fines’ or contaminates).

Fines: Very fine particles such as silts and clays, which can pass through a standard No. 200 sieve. Normally, material that consists of over 15% fines is undesirable for construction but a lower limit of 5% or less is acceptable to aid in compaction.

Granular Extraction: The physical act of removing pitrun material from the undisturbed ground, as part of developing a granular deposit forming a borrow pit (Photo 6 and Photo 17).

Gravel Haul: The physical act of transporting granular materials, normally from the borrow source to the project site. The haul distance is a major consideration in the total costs of acquiring gravel for a specific construction project (Photo 21).

Granular Materials: Often used to describe sands and gravels but technically granular materials include natural sizing from silts to sand, gravel, and cobbles to boulders.
**Note:** When comparing the granular particle sizes within a grain size curve, the No 4 size (5 mm) represent the separation of gravel and sand percentages passing. Similarly, the No 200 (0.075 mm) shows the separation of sand and ‘fines’ (silt and clays) passing.

**Ground Penetrating Radar:** GPR is a technique used to delineate subsurface features by passing electromagnetic energy into the ground and back to a receiving antenna.

**Ground-truth Reconnaissance:** The physical act of acquiring information on the ground to assess or prove geotechnical assumptions, especially with respect to determining the suitability of an identified granular deposit for future development (Photo 9 / Photo 10).

**In-Situ:** Refers to the natural, undisturbed position and characteristics of granular materials in which they were originally formed or deposited (Photo 11).

**Permafrost:** Defined as ground that stays below 0 °C for more than one year. There are discontinuous and continuous zones throughout the NWT. Discontinuous permafrost may or may not be underlain by permafrost. Special operating techniques are required when developing a gravel deposit underlain by permafrost.

**Pit:** A land location (Photo 1) where granular materials, not including consolidated rock, is being or has been extracted (Photo 6) (often interchangeable with quarry).

**Pitrun:** Raw, extracted, granular materials accessed directly from a naturally occurring source/deposit. The term is generic and not associated with material gradation or quality.

**Poorly Graded:** The granular borrow source material has an excess of some particle sizes, a shortage or lack of others, or has nearly all particles the same size. This type of material is less stable than well graded materials and should not be used in projects where load bearing or structural support is required. It is suitable for backfill, berm construction or landscaping.

**Bedrock Quarry:** An open excavation related to extraction of bedrock (Photo 2).

**Select Grade:** Material that has been processed from raw pitrun to specific, well-graded granular sizes required for a specific use i.e. 50 mm minus, 20 mm minus, etc. Specialized equipment is needed: grizzly screener, power screener, or crusher to process the pitrun material. Material often referred to as ‘crushed’ or ‘screened’ once processed (Photo 5).

**Slumping/Solufluction:** A type of landslide owing to the downward slipping of a mass of debris/material into an irregular shaped pile at the bottom of an incline; often occurs along borrow pit walls if not sloped/contoured correctly (can be slow moving or sudden).

**Thermokarst:** The undulating, irregular, surface topography due to differential thaw settlement or caving of the ground because of the melting of ground ice (Photo 29).
Well Graded: An important material engineering term indicating that the granular deposit has an equal amount of each gravel and sand size and little or no ‘fines’. These deposits are referred to as ‘clean’ and are excellent quality materials for construction purposes, especial where load bearing or structural support is required (Photo 3)
2.4 GRD INFORMATION FLOW CHART

As outlined by the following flow chart, chapters three through five of the GRD discuss issues relate to accessing information on the identification, development, acquisition, and management of granular resources in the NWT.

IDENTIFICATION
Granular Inventory

EVALUATION
Optimum use

REGULATORY
Permitting

OPTIONS

DEVELOPMENT
Supply & Demand
Granular Needs
- quantities
- type and grade

COSTS

ACQUISITION
Pit Operations

MANAGEMENT PLAN
Sustainability

RESTORATION
Environmental

GIS / DATABASE
Monitoring
3.0 GRANULAR SUPPLY AND DEMAND

3.1 Granular Supply

3.1.1 Granular Inventory

A comprehensive granular resource inventory for the NWT is not currently available in terms of a territorial-wide geographic information system or digital integrated surface mapping. However, granular inventories are available through the collection of subsurface data from numerous geotechnical reports and granular investigations, especially around NWT communities. A number of resource databases and bibliographies are available that review and summarize the granular resources studies undertaken in the NWT (Bibliography Directory).

In the past, granular procurement and management were linked to the GNWT capital programs and maintenance requirements on a project-by-project basis. The changing roles and responsibilities of territorial governments, the impact of large scale, multi-phase, resource development projects, the growth of communities, GNWT granular programs and strategy initiatives, the emphasis on land use planning and resource management have all contributed to the extensive exploration, regulation, development and management of granular resources in the NWT. As a result, a large number of granular sources have been identified for use in community-based and territorial-wide infrastructure projects. Much of this ‘granular inventory’ information is already available within various but separate Geographic Information Systems (GIS).

A ‘Granular Resource Inventory’ includes a review of all pertinent geotechnical information on existing and potential granular sources and material evaluations (either on a local, regional or territorial level). To prepare a granular resource inventory, a record of all depleted, active and potential granular sources is catalogued in terms of material quantity and quality. A resource inventory is the first step in preparing local to territorial-wide granular supply and demand models.

Quantity:

The availability of granular materials throughout the NWT is extremely variable, especially high quality material. Geotechnical methods are used to determine quantities of useable granular materials associated with specific identified landforms. To prepare a community or regional granular resource inventory, the quantities of material are determined for a number of granular sources/deposits around a community or within a specific land area. The quantity information is then used in supply and demand models as part of a granular management plan for a specific community or region.

Quality:
Deposits of material may be uniform or ‘pure’ such as sand pits or clay pits, but in the NWT most granular deposits are composed of combinations of material types. It is the proportion of these types within a granular source that make it suitable or high quality for a specific use during construction. Different uses require a different type or quality of material. For most construction purposes in the NWT, a mixture of grain sizes is preferred rather than a ‘pure’ deposit. Material quality information determines the end use of the material and is used in supply and demand models as part of a granular management plan for a specific community or region.

As a large number of granular investigations and terrain analysis have been completed around NWT municipalities and regions, a review of available information is the first step in preparing a granular resource inventory by:

1. Accessing geographic information systems and databases
2. Reviewing northern granular resources bibliographies and references
3. Considering local and traditional knowledge

### 3.1.2 Granular Investigation *(Appendix C - Terms of Reference)*

A granular investigation is conducted to determine existing and potential granular sources near a specific community, or over a much larger land area involving a number of communities. Existing sources are reviewed to determine remaining reserves before abandonment is necessary. Potential sources are identified through a detailed terrain analysis and air photo interpretation study that detect specific land forms that commonly contain granular materials and are evaluated in terms of material quantity and quality.

The identification of potential granular sources employs a number of different techniques using air photos *(Photo 8)*, topographical and surficial geological maps, satellite imagery and Ground Penetrating Radar (GPR) information. Also, access to an identified potential gravel source is an important consideration in terms of distance and difficulty to assess potential development, and is determined from the same techniques.

The composition and quality of a gravel source can be directly related to specific land forms and their mode of origin, which is a specific physical science referred to as ‘geomorphology’. Some typical northern landforms that can be identified on topographical maps and air photos that are proven sources of granular materials are:

1. **Alluvial Fans**

   An outspread, gently sloping mass of fluvial (sand and gravel)) deposited by a stream. Viewed on an airphoto it has the shape of an open fan.

2. **Eskers *(Photo 7)***

   On an airphoto, noted as a serpentine, narrow ridge of stratified gravel and sand.
Eskers are very common in the north and an excellent source of granular materials. On a topographical map, indicated by linear, closely spaced contours. Length can range from less than 100 metres to more than 500 km, and in height from 3 metres to more than 300 metres.

3. Raised Beaches/Terraces

Are ancient beaches occurring above the present shoreline of an existing or ancient lake or ocean, either caused by local uplift of the land or lowering of sea level. A series of raised beaches form a terraced or step-like landscape easily identified on topographical maps or airphotos.

4. Outwash Plain (Photo 17)

A broad gently sloping sheet of sand and gravel size material deposited from meltwater streams flowing in front of or beyond a retreating glacier.

5. Kames

A mound, knob or short irregular ridge on an air photo or small, dense, circular contours on a topographical map; composed of stratified sand and gravel.

6. Moraines

Rolling mounds or ridge like accumulation of glacially deposited materials that often cover a large lateral area; composed of glacial till (nonsorted, shallow, bony angular gravel size material mixed with sand, silt and clay).

7. Drumlins

A low, smoothly rounded, elongated hill (or chain of hills) composed of glacial till. The average size is 30 metres in length and from 8 – 60 metres in height.

8. Bedrock Ridge

A massive, solid, irregular shaped bedrock that lies above the ground surface. Associated with rock quarry (Photo 2) drill, blast and crush operations to obtain all sizes of granular materials from rip-rap (blast rock) to select grade (screening or crushing of blast rock).

3.1.3 Ground Truth Reconnaissance

The suitability of a granular source for development is based on the following ground-truth reconnaissance guidelines:
- **Determine lateral size and depth of deposit and evaluate site conditions;**

- Prepare test pitting grid/layout (**Photo 15**);

- Estimate recoverable quantity volume (**Photo 12**);

- Obtain material samples for engineering testing (**Photo 13**);

- Estimate development costs based on site conditions;

- Determine environmental concerns related to site conditions; and

- Verify optimum access routes.

Material samples are obtained and subjected to a number of engineering tests to determine the type, quality, and optimum use of the source material (**Photo 14**). Also, GPR can be used to determine the extent and depth of a deposit. Development options are then considered as part of an overall granular management based on available access, optimum use of material, processing required, recoverable volumes and costs.

### 3.1.4 Investigation – Test Pitting/Bore Holes

Typically a potential borrow source is located through a terrain analysis and/or air photo interpretation. This is followed by a ground-truth reconnaissance: a grid pattern of test pits is positioned over the source area (**Photo 15**). Surveyor or field person with a hand held GPS locates the test pits in the field. An excavator or drill completes a test pit or bore hole at each location, where a technician classifies the different soil encountered, logs the test pit or bore hole, and grabs bulk samples for testing. Typically a test pit is photographed upon completion with a cloth tape over one of the sides to indicate depth of soil layers (**Photo 12**). Depth of termination is typically around 6 metres below grade (or as far as excavator can reach or to the water table). In some instances using a shovel to dig a test pit (**Photo 10**) is acceptable; however, the deeper the test pit the better the volume estimate can be.

When all the test pits or bore holes are completed the information is reviewed. Each test pit log provides a depth to where each different soil type was encountered (**Photo 31**). From recorded depths and lateral area a recoverable volume can be estimated.

**Equipment needed**: D4 or larger for clearing and access; medium size excavator or drill for subsurface investigation and a GPS.

If the investigation shows that a granular deposit is suitable for development in terms of quantity, engineering laboratories can conduct tests to determine the optimum use of the source material (**Note Section 4.3: Basic Material Testing**). Laboratory testing consists
mostly of sieve analysis and moisture content. A sample is often crushed to a certain size to determine the material’s suitability for processing.

3.1.5 Quantity Estimates

Granular material quantity estimates related to inventory studies are classified as proven, probable or prospective. Often, prospective and probable quantity estimate information are available within the geotechnical reports for a given borrow source.

A proven volume is one where extent, thickness, and quality is supported by ground-truth information such as test-pitting, exposed stratigraphic sections, bore hole logs, and sampling (Photo 11 and Photo 12).

A probable volume is one where extent, thickness and quality are inferred on the basis of direct and indirect evidence such as airphoto interpretation, geophysical data, terrain analysis, and limited sampling.

A prospective volume is one where existence, extent, thickness and quality is inferred on the basis of limited direct evidence such as airphoto interpretation or satellite imaging but without sampling or ground-truth reconnaissance.

3.1.6 Source Evaluation Guidelines

Once a granular source has been identified:

- Site conditions are used to determine pit planning and design. A site-specific investigation determines any topographical constraints with regard to pit development and a visual inspection of source material. Permafrost distribution, slope, groundwater conditions, depth to bedrock, vegetation and drainage are examined that may impact on source development.

- The site area is staked and flagged (Photo 9) to delineate the pit development boundaries to contain operational activities and limit the amount of land that is to be disturbed.

- The evaluation involves excavations of test pits, sampling, and material tests to determine the extent and construction potential of the granular materials within the deposit. Representative samples at different depths are required (Photo 13).

A granular source can contain material ranging in size from boulders to clay. The evaluation will determine if the source material is well graded or poorly graded, which impacts on the end use of the material. Well graded material is easier to compact.

- A well graded granular deposit contains equal amounts of each gravel and sand size (Photo 3).

- A poorly graded granular deposit contains all particles the same size or a lack of certain particle sizes, have more voids and are thus less stable.
In geotechnical reports, a borrow source evaluation is often discussed in terms of five classes of materials, as noted in Table 1 (AANDC reference).

Table 1: Classification of Granular Resources

<table>
<thead>
<tr>
<th>Classification</th>
<th>Quality</th>
<th>Gradation</th>
<th>Use/Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Excellent</td>
<td>- Clean – less than 5% fines</td>
<td>- surfacing materials/roads/airstrips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Well graded sands and gravels</td>
<td>- concrete aggregate and asphalt production</td>
</tr>
<tr>
<td>Class 2</td>
<td>Good</td>
<td>- Well graded sands and gravels with fines</td>
<td>- General fill for roads, foundation pads and staging areas</td>
</tr>
<tr>
<td>Class 3</td>
<td>Fair</td>
<td>- Poorly graded sands and gravels with fines</td>
<td>- Road base and sub-base, Structure supporting fill</td>
</tr>
<tr>
<td>Class 4</td>
<td>Poor</td>
<td>- Poorly graded, sands and gravels with high percentage of fines (silt)</td>
<td>- non-structural general fill such as berms and covering material</td>
</tr>
<tr>
<td>Class 5</td>
<td>Bedrock</td>
<td>- rip-rap, armour rock, broken rock</td>
<td>- Erosion control, Potential for quarry and crush</td>
</tr>
</tbody>
</table>

3.1.7 Material Testing

Test pitting displays the stratified gravel layers of the source (Photo 11) and locates the water table. Normally an excavator or a front end loader is used to excavate a test pit but hand excavation is prevalent (Photo 6 and Photo 10). Material samples are taken at various test pit locations (Photo 12).

Geotechnical tests are used to classify granular materials, based on material characteristics and the engineering properties of the material. The Unified Soil Classification (USC) system is used to identify various types of granular materials through a visual in-situ description and engineering tests (Appendix C – USC System). Classification in this manner ultimately determines the various end use of the pit material and thus the acquisition and production options of the source.

The following material engineering tests provide all the information about the quality and suitability of granular materials sampled from a borrow pit or rock quarry:

1. Grain size analysis
2. Atterberg Limits
3. Proctor
4. Specific Gravity
5. Petrographic Analysis
6. Percent Crushed
7. Natural Moisture Content
8. Fractured Face Count
9. Flat and Elongated Particles
10. Colour Test

However, the following three tests provides a significant evaluation about the suitability of a borrow source material for construction purposes:

**Washed Sieve Analysis:**

The WSA uses specific racks of sieves from 4.75 mm (No 4 Sieve) to 0.075 mm (No 200 Sieve). Test results are prepared on a standard form. This test gives the actual particle size distribution of each of the size ranges in the sample i.e. percentage of gravel, sand and ‘fines’ (silts and clays).

**Proctor Test:**

A proctor test determines the moisture-density relationship of the material. This information is the criteria upon which compaction specifications are based. Ultimately the test represents the load-bearing capacity of the material, which is especially important for road construction and structural pads.

**Colour Test:**

Specifically relates to the production of asphalt and concrete aggregate. Five standard colours are used – the colour number should not exceed (3) for use as concrete aggregate.

### 3.2 Granular Demand

**Note:** *Strategy Report in Appendix A.*

3.2.1 On-going Demand

A wide range of projects requiring granular materials are initiated by GNWT departments, crown corporations, municipalities and the private sector. There is an on-going granular demand for:

1. Public Infrastructure
2. Transportation Infrastructure
3. Housing Lots/Building Pads
4. Industrial Development
5. Resource Development

3.2.2 Forecast Analysis

Granular demand forecast assessments assist territorial governments:
To plan and implement granular acquisition operations to ensure granular materials are available in a timely manner and at reasonable cost;

To focus coordination of a granular supply where gravel shortages exist, as future infrastructure and O&M needs are identified on an annual and/or five-year basis;

To act as a basis for consultation with all potential stakeholders to achieve economies of scale; and

To assist in the preparation of a granular management plan.

Territorial and community granular demand forecast assessments are based on:

- The “Granular Material Breakdown” of capital projects (Table 2), now a responsibility of community governments, is used to obtain the granular needs of a given asset or project for any given year;
- Include O& M granular materials for highways, roads, land fills, and general requirements;
- Both common and select grade requirements in cubic metres;
- All project quantity estimates are ‘bulk volumes’ that reflect maximum granular material requirements and earliest project initiation;
- Analysis of the GNWT 2008 - 2011 Infrastructure Acquisition Plan;
- Review of the NWTHC Affordable Housing Initiative;
- GNWT 20-year Needs Assessment;
- Granular estimates related to territorial resource development projects where appropriate; and
- Granular requirements based on the Municipal Government Capital Plan.

3.2.3 Granular Material Requirements by Asset

Table 2 represents the volume of granular materials required for various assets or construction projects normally associated with community infrastructure. Municipalities can estimate granular requirements by project annually or over a 3 - 5 year time horizon. This information is especially useful to communities that are not self-sufficient in granular materials and require seasonal and/or long distance granular supply operations to meet project needs.

Estimating granular material quantities then becomes a simple calculation of total volumes based on the number and type of project/asset proposed over a given year. However, it should be noted that the granular quantities as noted in Table 2 are ‘bulk volumes’.

A bulk volume is the quantity of granular material that has to be extracted from a pit/quirry to meet the ‘in-place’ volume for any given construction project. Bulk volumes are up to 30 % higher to account for losses due to loading, shrinkage, compaction, side slope, etc.

Bulk volumes should be used for:
- Estimated calculation of granular quantities for construction projects,
- For pit management to monitor the removal of recoverable materials from a borrow pit or rock quarry.

Table 2: Granular Material Requirements by Asset - Bulk Volumes

Bulk volumes are for Class ‘D’ budget estimates only and not to be used for design.

<table>
<thead>
<tr>
<th>Project/Asset</th>
<th>Common m³</th>
<th>Pit run</th>
<th>Select</th>
<th>Processed m³</th>
<th>Concrete Agg.</th>
<th>Rip-Rap m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airstrip (new 900x60)</td>
<td>81,000</td>
<td>21,600</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Airstrip Resurface</td>
<td>0</td>
<td>5,400</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Airstrip Maintenance</td>
<td>0</td>
<td>1,700</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Air Terminal</td>
<td>675</td>
<td>425</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Apron Expansion</td>
<td>2,500</td>
<td>1,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arena (large)</td>
<td>850</td>
<td>475</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arena (medium)</td>
<td>675</td>
<td>425</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arena (small)</td>
<td>500</td>
<td>375</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Community Hall (l-440sq.m.)</td>
<td>675</td>
<td>425</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Community Hall (m-390sq.m.)</td>
<td>500</td>
<td>375</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Community Hall (sm -250sq.m.)</td>
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<td>300</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Firehall</td>
<td>350</td>
<td>300</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Garage (1-3 bays)</td>
<td>600</td>
<td>400</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gas Station (in town)</td>
<td>600</td>
<td>400</td>
<td>50</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Group Home</td>
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<td>Gymnasium (l-440sq.m.)</td>
<td>675</td>
<td>425</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Gymnasium (m-390sq.m.)</td>
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<td>375</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Gymnasium (sm-250sq.m.)</td>
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<td>300</td>
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<td>Health Center</td>
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<td>0</td>
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<tr>
<td>Housing (single)</td>
<td>250</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Housing (duplex)</td>
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<td>150</td>
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</tr>
<tr>
<td>Housing (fourplex)</td>
<td>675</td>
<td>200</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Museum (l)</td>
<td>350</td>
<td>225</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Museum (sm)</td>
<td>200</td>
<td>150</td>
<td>50</td>
<td>0</td>
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<td>Office (l)</td>
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<td>0</td>
</tr>
<tr>
<td>Office (m)</td>
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<td>Office (hamlet)</td>
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<td>375</td>
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<td>0</td>
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<td>Park Development (l)</td>
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<td>100</td>
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<td>0</td>
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<tr>
<td>Park Development (sm)</td>
<td>600</td>
<td>1,400</td>
<td>0</td>
<td>50</td>
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<td>0</td>
</tr>
<tr>
<td>Rink (outdoor)</td>
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<td>375</td>
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<tr>
<td>R/S/L-lot development</td>
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<td>180</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Road (25m) &amp; 1 Lot</td>
<td>300</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Road Construction (1km.)</td>
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<td>1,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Road Resurfacing (1km.)</td>
<td>600</td>
<td>1,400</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Road Upgrade (1km.)</td>
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<td>1,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Satellite Base</td>
<td>300</td>
<td>300</td>
<td>250</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>School (new)</td>
<td>400</td>
<td>300</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>School (addition)</td>
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<td>150</td>
<td>100</td>
<td>0</td>
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</tr>
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<td>Sewage Lagoon</td>
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<td>0</td>
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<td>Shoreline Protection</td>
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<td>600</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Solid Waste Site</td>
<td>9,000</td>
<td>6,000</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Solid Waste Improvements</td>
<td>6,000</td>
<td>4,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tankfarm</td>
<td>3,000</td>
<td>5,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Granular demand information can be projected (in this case a ‘pie chart’) and used as a planning tool to provide a territorial, regional or municipal overview of the estimated, total, granular demand quantities over time, within a specific geographic or political region of the NWT. The Inuvik region is used in the following example.

<table>
<thead>
<tr>
<th>Project</th>
<th>Common m³</th>
<th>Select m³</th>
<th>Conc Agg. m³</th>
<th>Rip-Rap m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor Center</td>
<td>500</td>
<td>375</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Above Ground Pool</td>
<td>500</td>
<td>375</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wharf</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>650</td>
</tr>
<tr>
<td>Breakwater</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7,500</td>
</tr>
<tr>
<td>Curling Rink (1-4 sheets)</td>
<td>350</td>
<td>250</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ATB Expansion</td>
<td>250</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lagoon Upgrade</td>
<td>5,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water Treatment Plant</td>
<td>675</td>
<td>425</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Airport Lighting Rehab</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

CHART 1: INUVIK REGION

Regional Granular Material Forecast Estimates

2007 - 2010
3.2.4 Table 3: Territorial Granular Demand Estimates 2008 - 2011
3.2.5 Territorial Granular Demand Summary

<table>
<thead>
<tr>
<th>Community/Region</th>
<th>GNWT Capital m3</th>
<th>Municipal Capital m3</th>
<th>Municipal O&amp;M m3</th>
<th>Total 3-Year Estimate m3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INUVIK</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tuktoyaktuk</td>
<td>7,000</td>
<td>18,000</td>
<td>30,000</td>
<td>55,000</td>
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<tr>
<td>Sachs Harbour</td>
<td>1,000</td>
<td>5,000</td>
<td>7,500</td>
<td>13,500</td>
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<tr>
<td>Paulatuk</td>
<td>3,500</td>
<td>19,000</td>
<td>9,000</td>
<td>31,500</td>
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<tr>
<td>Uulukhaktok</td>
<td>4,000</td>
<td>13,000</td>
<td>10,500</td>
<td>27,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15,500</strong></td>
<td><strong>55,000</strong></td>
<td><strong>57,000</strong></td>
<td><strong>127,500</strong></td>
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<tr>
<td><strong>GWICH’IN</strong></td>
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<td></td>
</tr>
<tr>
<td>Aklavik</td>
<td>9,000</td>
<td>25,000</td>
<td>12,000</td>
<td>46,000</td>
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<tr>
<td>Ft. McPherson</td>
<td>7,500</td>
<td>11,500</td>
<td>24,000</td>
<td>43,000</td>
</tr>
<tr>
<td>Tsiigehtchic</td>
<td>4,000</td>
<td>10,000</td>
<td>7,500</td>
<td>21,500</td>
</tr>
<tr>
<td>Inuvik</td>
<td>35,000</td>
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<td>105,000</td>
<td>140,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>55,500</strong></td>
<td><strong>46,500</strong></td>
<td><strong>148,500</strong></td>
<td><strong>250,500</strong></td>
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<tr>
<td><strong>SAHTU</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deline</td>
<td>8,000</td>
<td>21,500</td>
<td>19,500</td>
<td>49,000</td>
</tr>
<tr>
<td>Fort Good Hope</td>
<td>5,000</td>
<td>5,300</td>
<td>22,500</td>
<td>32,800</td>
</tr>
<tr>
<td>Norman Wells</td>
<td>2,500</td>
<td>N/A</td>
<td>N/A</td>
<td>2,000</td>
</tr>
<tr>
<td>Tulita</td>
<td>19,700</td>
<td>20,000</td>
<td>13,500</td>
<td>53,200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40,200</strong></td>
<td><strong>46,800</strong></td>
<td><strong>61,500</strong></td>
<td><strong>148,500</strong></td>
</tr>
<tr>
<td><strong>SOUTH SLAVE</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Deline</td>
<td>8,000</td>
<td>21,500</td>
<td>19,500</td>
<td>49,000</td>
</tr>
<tr>
<td>Fort Good Hope</td>
<td>5,000</td>
<td>5,300</td>
<td>22,500</td>
<td>32,800</td>
</tr>
<tr>
<td>Norman Wells</td>
<td>2,500</td>
<td>N/A</td>
<td>N/A</td>
<td>2,000</td>
</tr>
<tr>
<td>Tulita</td>
<td>19,700</td>
<td>20,000</td>
<td>13,500</td>
<td>53,200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40,200</strong></td>
<td><strong>46,800</strong></td>
<td><strong>61,500</strong></td>
<td><strong>148,500</strong></td>
</tr>
<tr>
<td><strong>NORTH SLAVE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behchoko</td>
<td>1,500</td>
<td>5,300</td>
<td>30,000</td>
<td>36,800</td>
</tr>
<tr>
<td>Gameti</td>
<td>1,000</td>
<td>20,000</td>
<td>13,500</td>
<td>34,500</td>
</tr>
<tr>
<td>Whati</td>
<td>6,500</td>
<td>N/A</td>
<td>15,000</td>
<td>21,500</td>
</tr>
<tr>
<td>Wekweeti</td>
<td>Nil</td>
<td>2,500</td>
<td>12,000</td>
<td>14,500</td>
</tr>
<tr>
<td>Lutsel K’e</td>
<td>3,500</td>
<td>N/A</td>
<td>12,000</td>
<td>15,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12,500</strong></td>
<td><strong>27,800</strong></td>
<td><strong>82,500</strong></td>
<td><strong>122,800</strong></td>
</tr>
<tr>
<td><strong>DEHCHO</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fort Liard</td>
<td>4,000</td>
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<td>15,000</td>
<td>28,000</td>
</tr>
<tr>
<td>Fort Simpson</td>
<td>10,000</td>
<td>9,000</td>
<td>36,000</td>
<td>55,000</td>
</tr>
<tr>
<td>Jean Marie River</td>
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<td>9,500</td>
</tr>
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<td>Nahanni Butte</td>
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<td>6,000</td>
<td>22,000</td>
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<tr>
<td>Trout lake</td>
<td>6,000</td>
<td>13,000</td>
<td>6,000</td>
<td>25,000</td>
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<tr>
<td>Wrigley</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Fort Providence</td>
<td>4,000</td>
<td>N/A</td>
<td>21,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Kakisa</td>
<td>4,500</td>
<td>N/A</td>
<td>N/A</td>
<td>4,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>39,000</strong></td>
<td><strong>41,500</strong></td>
<td><strong>88,500</strong></td>
<td><strong>169,000</strong></td>
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<tr>
<td><strong>TOTALS</strong></td>
<td><strong>219,500 m3</strong></td>
<td><strong>221,600 m3</strong></td>
<td><strong>502,500 m3</strong></td>
<td><strong>943,600 m3</strong></td>
</tr>
</tbody>
</table>
For 2008 – 2011 Territorial and Municipal governments will require approximately:

- 220,000 m$^3$ of granular materials for GNWT capital projects;
- 222,000 m$^3$ of granular materials for Municipal capital projects; and
- 503,500 m$^3$ of granular materials for Municipal O&M needs.*

*Municipal O&M requirements are based on the annual estimated quantity of granular materials needed to maintain and sustain public infrastructure such as road maintenance (based on the total linear length of community roads), erosion control, landfill maintenance, as well as general landscaping.

As of May 2008, there is a projected drawdown of 950,000 m$^3$ from existing NWT granular reserves from 2008 – 2011 (do not include GNWT O&M requirements).
3.3 Resource and Infrastructure Development – Sustainable Supply

3.3.1 Mackenzie Gas Project – Granular Supply and Demand

Resource development and exploration projects depend on the availability of granular resources. Anticipating a region’s granular needs in advance will ensure that granular resources are available now and in the future for community and territorial-wide infrastructure. The Mackenzie Gas Project (MGP) is a good example. The MGP is being developed by Imperial Oil Resources Ventures, Conoco Phillips Canada, Shell Canada Limited, ExxonMobil and the Mackenzie Valley Aboriginal Pipeline Group (Proponents). The purpose of the MGP is to develop natural gas in the Mackenzie Delta from three anchor fields and transport the gas by pipeline to Alberta. The National Energy Board granted final approval in March, 2011. The National Energy Board issued a Certificate of Public Convenience and Necessity for the pipeline project, which expires on Dec. 31, 2015. The MGP proponent may file a request to extend the expiration date another 5 years.

If the MGP proceeds, construction of the gathering system and pipeline will require an estimated 10 million m$^3$ of borrow material. About 74 primary and 50 alternate borrow sites have been identified for development along the project right-of-way. Although some of these sites and related access already exists, construction of new winter and all-weather roads will be required to develop some of the identified potential sites.

Table 4 summarizes the borrow sites being considered for MGP use that are located near communities or known to be used by communities along the pipeline right-of-way. Agreements have been reached by the Proponents and Territorial Governments on the use of these sources for the MGP, to ensure a sustainable granular supply for the benefit of affected communities.

The eight communities noted in Table 4 have opportunities to coordinate municipal granular requirements with the development of the listed borrow sources during the construction phase of the MGP. This would include use of new winter and all-weather access roads for granular supply operations. The Proponents will haul and stockpile material extracted from these sources for MGP infrastructure and facility sites. Furthermore, crushing for select grades will be required at some of these sites for the MGP. As the three-year construction phase proceeds, the communities listed in Table 4 should consider joint venture supply operations with the Proponents to acquire and stockpile both select and pitrun materials for municipal requirements.

The Departments of Transportation (territorial-wide infrastructure), Energy and Natural Resources (tower replacement/upgrades) and Industry, Tourism & Investment (park development) could also benefit from the development and access of borrow sources along the pipeline right-of-way, where granular material is required for capital projects or O&M, but is either not currently available or difficult to obtain at reasonable cost. The following table and maps are referenced from the MGP Environmental Impact Statement (EIS), Volume 2: Project Description, submitted to the National Energy Board.
and the Joint Review Panel, by Imperial Oil Resources Ventures Limited, August 2004. The table has been edited for the NWT Granular Resource Directory.

Table 4: MGP Granular Acquisition Located Near or Used by Communities

<table>
<thead>
<tr>
<th>Source</th>
<th>Material</th>
<th>Ownership</th>
<th>Community</th>
<th>Status</th>
<th>Proposed Construction</th>
<th>Estimated Volume Source (1000 m³)</th>
<th>Estimated Volume Required (1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.008P</td>
<td>Granular</td>
<td>Private</td>
<td>Tuktoyaktuk</td>
<td>Existing</td>
<td>2009 - 2011</td>
<td>4,200</td>
<td>370</td>
</tr>
<tr>
<td>1.009P</td>
<td>Granular</td>
<td>Private</td>
<td>Tuktoyaktuk</td>
<td>Existing</td>
<td>2009 - 2011</td>
<td>1,900</td>
<td>70</td>
</tr>
<tr>
<td>2.051P</td>
<td>Rock</td>
<td>Private</td>
<td>Inuvik</td>
<td>Proposed</td>
<td>2009 - 2012</td>
<td>500</td>
<td>137</td>
</tr>
<tr>
<td>6.077P</td>
<td>Granular</td>
<td>Municipal</td>
<td>Fort Good Hope</td>
<td>Proposed</td>
<td>2009 - 2011</td>
<td>2,000</td>
<td>186</td>
</tr>
<tr>
<td>6.080P</td>
<td>Granular</td>
<td>Municipal</td>
<td>Fort Good Hope</td>
<td>Proposed</td>
<td>2009 - 2011</td>
<td>2,500</td>
<td>33</td>
</tr>
<tr>
<td>7.049P</td>
<td>Granular</td>
<td>Municipal</td>
<td>Norman Wells</td>
<td>Proposed</td>
<td>2009 - 2011</td>
<td>850</td>
<td>20</td>
</tr>
<tr>
<td>7.054P</td>
<td>Granular</td>
<td>Private</td>
<td>Norman Wells</td>
<td>Proposed</td>
<td>2009 - 2011</td>
<td>615</td>
<td>14</td>
</tr>
<tr>
<td>7.057P</td>
<td>Granular</td>
<td>Municipal</td>
<td>Norman Wells</td>
<td>Proposed</td>
<td>2009 - 2011</td>
<td>To Be Determined</td>
<td>243</td>
</tr>
<tr>
<td>7.155AP</td>
<td>Granular</td>
<td>Crown Private</td>
<td>Tulita</td>
<td>Existing</td>
<td>2010 - 2012</td>
<td>112,000</td>
<td>73</td>
</tr>
<tr>
<td>10.043P</td>
<td>Granular</td>
<td>Crown</td>
<td>Wrigley</td>
<td>Existing</td>
<td>2010 - 2012</td>
<td>19,700</td>
<td>50</td>
</tr>
<tr>
<td>10.033P</td>
<td>Granular</td>
<td>Crown</td>
<td>Wrigley</td>
<td>Proposed</td>
<td>2010 - 2012</td>
<td>5,600</td>
<td>6</td>
</tr>
<tr>
<td>11.071P</td>
<td>Granular</td>
<td>Crown</td>
<td>Fort Simpson</td>
<td>Proposed</td>
<td>2010 - 2012</td>
<td>500</td>
<td>18</td>
</tr>
<tr>
<td>11.174P</td>
<td>Granular</td>
<td>Crown</td>
<td>Fort Simpson</td>
<td>Existing</td>
<td>2010 - 2012</td>
<td>3,000</td>
<td>32</td>
</tr>
<tr>
<td>20.057P</td>
<td>Granular</td>
<td>Crown</td>
<td>Jean Marie</td>
<td>Existing</td>
<td>2010 - 2012</td>
<td>To Be Determined</td>
<td>14</td>
</tr>
</tbody>
</table>
MAP 1: MGP Granular Acquisition - Inuvialuit Settlement Region

Opportunity to initiate a collaborative approach to granular acquisition for GNWT and municipal granular requirements, with the construction phase of the MGP within the ISR. This is especially relevant for the community of Tuktoyaktuk and Inuvik.
MAP 2: MGP Granular Acquisition - Sahtu/Gwich’in Settlement Areas

Opportunity to initiate a collaborative approach to granular acquisition for GNWT and municipal granular requirements, with the construction phase of the MGP within the SSA and GSA. This is especially relevant for the communities of Inuvik, Norman Wells, Fort Good Hope, and Tulita.
MAP 3: MGP Granular Acquisition - Deh Cho Region

The opportunity exists, to initiate a collaborative approach to granular acquisition for GNWT and municipal granular requirements, with the construction phase of the MGP within the DCR. This is especially relevant for the communities of Wrigley, Fort Simpson, and Jean Marie River.
3.3.2 Transportation Infrastructure – Granular Supply and Demand

In 2000, the Department of Transportation prepared a Highway Strategy report (Appendix C); the infrastructure projects under consideration will have an impact on granular reserves throughout the NWT. The proposed construction of the Inuvik-Tuktoyaktuk road is an example where a large scale development project will have significant drawdown on available granular resources within the NWT, in this case, the Inuvik region. In general, transportation infrastructure supporting NWT communities requires large quantities of granular materials, and has a major impact on granular reserves within a specific region.

It is estimated that the 140-km Inuvik-Tuktoyaktuk road, using a standard road design would require approximately 5 million m$^3$ of bulk material that would be extracted and hauled from local borrow sources along the alignment or from other sources or about 3.8 million m$^3$ in-place. This represents a significant share of the forecasted demand of granular reserves in the region.

The Mackenzie Valley Highway extension from Wrigley to the proposed junction at the Dempster Highway has an approximate alignment distance of about 800 km. A generic roadway design of the Wrigley to Dempster Highway shows that the alignment requires upwards of 10 million m$^3$ of granular material. Again this represents a significant share of the forecasted demand on granular reserves within the Sahtu and Deh Cho regions of the NWT.

3.3.3 Resource Development - Competition

Territorial-wide and community infrastructure projects may need to share with the Mackenzie Gas Project (MGP) and other resource development projects, available granular reserves within the NWT.

With regard to territorial-wide infrastructure, AANDC examined the overlap of the proposed access corridor for the MGP and the Mackenzie Highway extension and found that, if material extraction occurred from within 5 km of the pipeline centre line, the granular resource development would share or compete with highway construction any granular sources within 1 km of the highway for about 46% of that 1 km highway buffer.

Further, new potential resource development projects within the NWT might result in an increase in demand for granular materials to support resource access, drilling and camp facilities.

The supply and demand for granular materials can only be met through the continual development of existing borrow pits and quarries, and the access and development of identified potential reserves. The GNWT is committed to a sustainable and cost-effective granular supply in the NWT. However, the sustainability of granular resources for territorial government’s granular requirements may be jeopardized by the anticipated
demands that the large scale development projects will place on existing and potential granular resources in the NWT (Appendix E – Paper to Joint Review Panel).

**4.0 GRANULAR ACQUISITION AND PRODUCTION**

### 4.1 Granular Acquisition

#### 4.1.1 Borrow Source Development (Appendix B – Northern Land Use Guidelines)

Once a suitable granular source has been identified and permits have been acquired from the appropriate regulatory authority, development can begin. Ultimately, the sustainable development of any pit or quarry is dependent on:

1. Planning
2. Design
3. Operation
4. Restoration

Quarry development involves pit operations from the design phase throughout resource extraction, processing and reclamation. The following quarry planning and design guidelines are dependent on:

1. Granular Requirements (type and gradation)
2. Site Conditions (terrain, drainage, permafrost, vegetation, access, etc.)
3. Extraction Methodology (maximize recoverable material)
4. Extraction Sequence
5. Resource Processing (if required)
6. Access Type (all weather or seasonal) – governs timing of pit operations
7. Minimizing environmental impact
8. Remediation

A proper design will ensure that the borrow source will be developed in an orderly and efficient manner to maximize granular extraction and minimize environmental damage.

Upon the extraction of granular material the following scenarios can occur:

- The naturally occurring material is hauled to a specific location and stockpiled, or spread and compacted on site depending on the end use of the material. This raw material is referred to a ‘pitrun’ or ‘common grade’;
  
  or

- The pitrun is screened or crushed by processing equipment to a specific size and/or gradation, and hauled to a specific site and stockpiled. This material is now referred to as ‘processed’ or ‘select grade’ material.
4.1.2 Granular Supply Operations

A truck hauling gravel from an active borrow source for construction purposes is a common site in the NWT, especially around municipalities (Photo 19 and Photo 20). In a granular hauling operation, the distance required to access a quarry is the most important consideration with regard to project costs.

Most NWT communities lack the capability of producing select grade materials because processing equipment is not available locally. Therefore the demands for select grade materials categorize NWT municipalities under the following production costs:

**Minimal**

Communities with all season access to the NWT Hwy system and market driven economies can normally obtain select grade material on a project-by-project basis.

**Moderate**

Communities that have seasonal access to the NWT Hwy system require the mobilization/demobilization of processing equipment over seasonal ice and winter roads and thus increased project costs.

**Highest**

Communities that are not connected to the NWT Hwy system (Sachs Harbour, Ulukhaktok, Paulatuk, Wekweti, and Lutsel K’e) have the highest gravel costs related to granular acquisition and processing.

4.1.3 Granular Acquisition – As and When

A number of communities are self sufficient in terms of granular supply and are able to obtain granular materials on an ‘as-and-when’ basis with all season/all weather access. As-and-when hauling operations are straightforward and require a permanent all-weather access to the source, however, the haul distance to the borrow source will still play a major role in terms of project costs (Appendix D – Feasibility Study).

Other NWT communities are not self-sufficient in terms of granular supply and are dependent on seasonal and/or long distance supply operations to meet their granular requirements. The NWT communities listed in Table 5 are not self-sufficient in supplying granular materials. Common factors arising in these communities are long distances and/or seasonal access is necessary to obtain gravel. In some cases, granular sources close to the community have been depleted. As a result, a significant effort is now needed to develop identified sources that are now a long distance from the community. In other cases, the lack of granular sources is a function of geographic location. The environment of deposition that surrounds the community or region, often for many
kilometres, is simply not conducive to the formation of granular materials or the provision of suitable access. Often, the land to the gravel source is rugged and dissected by rivers and lakes, and the only access is over ice and winter roads. The result in both cases is high gravel costs for a relatively small granular demand.

**Table 5: NWT Communities - Seasonal/Long Distance Access**

<table>
<thead>
<tr>
<th>Community</th>
<th>Supply Operation</th>
<th>Distance to Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuktoyaktuk</td>
<td>Seasonal and long distance</td>
<td>20 &amp; 60 km</td>
</tr>
<tr>
<td>Aklavik</td>
<td>Seasonal and long distance</td>
<td>18 km (27 km by Peel Channel)</td>
</tr>
<tr>
<td>Paulatuk</td>
<td>Seasonal</td>
<td>5 km</td>
</tr>
<tr>
<td>Tulita</td>
<td>Seasonal and long distance</td>
<td>17 km</td>
</tr>
<tr>
<td>Colville Lake</td>
<td>Seasonal</td>
<td>3.5 km</td>
</tr>
<tr>
<td>Nahanni Butte</td>
<td>Seasonal</td>
<td>9 km</td>
</tr>
<tr>
<td>Trout Lake</td>
<td>Seasonal and long distance</td>
<td>15 km</td>
</tr>
<tr>
<td>Fort Providence</td>
<td>Long distance</td>
<td>Varies 50 - 80 km</td>
</tr>
<tr>
<td>Lutsel K’e</td>
<td>Long distance</td>
<td>Varies 8 - 20 km</td>
</tr>
<tr>
<td>Wekweti</td>
<td>Seasonal</td>
<td>3 -10 km</td>
</tr>
<tr>
<td>Kakisa</td>
<td>Long distance</td>
<td>15 km</td>
</tr>
</tbody>
</table>

4.1.4 Granular Acquisition - *Permanent Access (Appendix D – Feasibility Study)*

The alternative to construct permanent year-round access roads to local gravel sources is an option available to all communities. However, the geographic location, supply and demand requirements, regulatory process, environmental impact, design considerations, economic viability, and community preference, impact the feasibility to construct a user-oriented access road. The following guidelines are recommended if construction of a permanent access to a quarry is considered:

- A permanent access to an identified gravel source must be able to be constructed in an economical and timely manner;
- The identified gravel deposit should contain a minimum of a twenty-year supply of fair to good quality material to meet the long term supply/demand requirements of the community;
- A permanent access road to a gravel source or quarry should be cost-effective or deemed economically viable if combined with other socio-economic opportunities;
- A permanent access road to a gravel source or quarry must be able to be maintained year-round; and
- Access road design, construction and route selection must be able to meet all land use, land claim, GNWT, and Federal Government regulations and legislation; community concerns and preference.
4.1.5 Granular Acquisition - Seasonal Operations

An alternative to a permanent all-weather road is the construction of seasonal access to granular sources. Typical seasonal access roads in the NWT consist of ice roads over rivers and lakes and overland snow roads.

Seasonal access roads are a challenge for a number of communities in the NWT due to the increased project cost associated with the construction and maintenance of winter access roads, which results in higher gravel prices. Ice crossing/winter road construction varies depending on length, terrain, weather and capacity and costs must include construction and maintenance. In 2015, about 235 km of winter road was constructed at an average cost of $5,200.00 per kilometre, not including maintenance.

The timing of pit operations, thickness of the ice and safety considerations are important factors for the construction of these roads. The Department of Transportation has prepared a quick reference booklet for the construction and maintenance of winter roads, ice roads, and ice bridges (DOT Web Site/ Publications/ A field Guide to Ice Construction Safety).

The “fixed” costs to construct and maintain a seasonal access road seldom decline, typically costs increase annually. As funding is normally limited to supplying gravel for the approaching construction season, “economies of scale” are not available as a cost reduction option. The results are continual high production costs, required annually, for a limited quantity of gravel hauled. The alternative is to either haul and stockpile a substantial 3 – 5 year supply, thus reducing the ‘fixed’ costs by hauling large volumes over the seasonal access road, or build a permanent year-round access that would remove the annual costs to construct and maintain seasonal access.

4.1.6 Granular Acquisition Guidelines

1. Identify borrow source
2. Determine material quantities and gradation
3. Prepare supply/demands model
4. Determine method/timing of access - all weather or seasonal ice or tundra
5. Determine project schedule (start and completion dates)
6. Determine project scope – gravel haul/stockpile, processing/stockpile, etc.
7. Determine project cost estimate
8. Verify available funding
9. Determine contract/tender – invitational, public, negotiated, sole source
10. Award Contract
11. Arrange quality control (for processing material)
12. Determine method of payment – truck box, in-place survey, etc.
4.1.7 Unit Price Contract

Most granular supply operations are conducted under a ‘unit price’ contract. It is important to ensure that all associated costs of granular supply operations are included in the unit price submitted by a contractor. This is especially important when applied to seasonal granular supply operations.

The following is a generic example of a ‘unit price’ contract for the delivery of *3,000 m$^3$ of 250 mm minus pitrun*, extracted, hauled and stockpiled to a designated site. The contractor ensures that all cost items are included within the unit price submitted. The following line items are normally considered part of any submitted 'unit price' for the acquisition and/or production and stockpiling of granular materials from a local source. Cost items include the supply of all equipment, labour, materials, supplies and incidentals necessary to complete the work including, but not limited to, the following guidelines:

- Mobilization will include the costs of, but not limited to, transportation to and from the project site of all necessary manpower, tools, equipment, supplies and operational materials required to perform the work (Mobilization and Demobilization costs are to be included within the Unit Prices and will not be paid as a separate item);
- Access road development and maintenance where required;
- Haul road construction if required, maintenance and clean-up;
- Site preparation including any clearing and grubbing of the source area and access;
- Clearing and levelling of a stockpile site if part of project, and preparation of a suitable pad if required;
- Excavate, load and haul, 3000 m$^3$ of pitrun material from the selected quarry and stockpile (or place) at the designated location(s);
- Clean up of all project sites;
- Quarry remediation/restoration;
- Payment of all accommodation and meal expenses incurred over the course of the project (or cost of camp);
- Blend source – if required;
- Payment of all fees, levies and other direct and indirect costs related to the project;
- Payment for rentals, fuel, maintenance, repairs, wages, insurance, licensing, taxes and all costs incurred in carrying out the work;
- There will be no separate payment for clearing, ripping, excavating, screening, loading, hauling, haul road construction, haul road maintenance, preparation of stockpile sites and access to the sites, or stockpiling material; and
- Measurement for payment for hauled material acceptably placed in the stockpile shall be by survey measurement and paid at the agreed per unit price.
4.1.8 Project Cost Estimate – Major Factors

1. Haul distance
2. Project scope (the quantity of granular material to be extracted)
3. Turn-around-time (the time it takes a truck to load and haul material to the project site and return to the pit)
4. Number and size of gravel trucks and related equipment (loaders, backhoes)
5. If processing is required, then the cost to mob/demob and type of equipment

4.1.9 A Granular Supply Operation - Example

A NWT community has decided to implement a granular supply operation. The community granular demand forecast has shown that:

- Approximately 6000 m$^3$ of pitrun material is needed by the community for planned infrastructure and O&M requirements over the next two years;
- About 4000 m$^3$ of pitrun is required by various GNWT departments over the same period for capital projects in this community; and
- The GNWT and the municipality agree to conduct a joint-venture, coordinated, granular supply operation to achieve ‘economies of scale’ and reduce project costs.

A granular acquisition operation is tendered to extract, haul and stockpile in two separate locations, a total of 10000 m$^3$ of pitrun material. The closest, active, developed gravel pit can only be accessed during the winter months by a ten kilometre, seasonal winter road. A local contractor was awarded the contract based on the lowest submitted ‘unit price’ per cubic metre of material, hauled and stockpiled in two locations in the community; payment is based on survey-in-place measurements. The contractor has five trucks, each with a measured 10 m$^3$ capacity and the speed on the haul road is limited to 30 km/hr. Permits have already been obtained.

The turn-around-time would be about one hour per truck – to load, haul and stockpile at the community sites and return to the pit. The contractor has five trucks. Therefore:

- in one hour, one truck can haul 10 m$^3$;
- in a twelve hour shift, one truck can haul 120 m$^3$;
- in one shift, 5 trucks can haul and stockpile 600 m$^3$ per day; and
- based on a twelve hour shift and five trucks it would take about 16.5 days to haul and stockpile the 10000 m$^3$ specified in the contract.

This is a simplified example as down time would be expected for equipment repair and maintenance, haul road maintenance, time to load the trucks, demob operations, weather days, etc. However, it does give an estimated time for project completion of 16 - 20 days, which is important information especially where seasonal, weather-sensitive haul
roads are concerned. Also, there would be the time necessary for pit clean-up and remediation before road closure.

This example also shows that a minimum of 1000 truck loads will be required, if all trucks are filled to capacity (to the fill line). In this case, usually a 15% contingency would be added to the number of truck loads required, to ensure the contractual quantities are met.

4.2 Granular Production

4.2.1 Select Grade

Processing consists of screening and/or crushing pitrun for the production of select grade materials and requires specialized equipment that is mobilized to the quarry selected for development. The following are some guideline scenarios:

- Typically the pitrun is processed at the quarry then hauled and stockpiled either within the quarry or at a designated project site. The processing equipment must be located in an easily accessible position in the pit, on well drained and solid ground.
- Processing equipment is located in the community, if seasonal winter or ice road conditions are deemed too sensitive or, there are public safety concerns, to mobilize/demob heavy equipment. This is especially a concern over winter ice roads late in the season. In this scenario, the pitrun would be hauled over the seasonal access road to the project site/community and then processed.
- During a large scale, multi-phase, granular supply operation, the pitrun would be extracted, hauled, and stockpiled in the community during the winter months where seasonal access to the active source is required, and then processed during the summer months. The pitrun would not be frozen during a summer crushing operation and would be well drained. In this scenario, processing equipment is mob/demob over seasonal roads or by barge to the community rather than the selected pit.

Either scenario, the processing of pitrun for select grade requirements does substantially increase the unit price cost and overall project budgets.

4.2.2 Processing Equipment:

- A ‘jaw crusher’ (primary) is normally used for crushing larger material up to boulder size;
- A ‘cone crusher’ (secondary) is used to crush smaller size material 250 mm or less. Cone crushers are more easily transported (less costs), as the entire plant can be mobilized by truck over winter access roads and seasonal haul roads. Knowing the average grain size of the material within the borrow source will determine the type of processing/crushing equipment that would be mobilized to the project site;
- Often a ‘crushing plant’ with primary and secondary crushers along with moving belts and blending equipment is required during large scale processing operations (Photo 24);
- A ‘grizzly screener’ is simple to construct and use for screening raw pitrun to a specific size especially where small quantities of select grade materials are required (Photo 22). Mobile and more complex screeners are available (Photo 23). Design specification for construction of a grizzly screener is available from PWS Yellowknife; and
- A ‘blend source’, usually clean sand, is sometimes added to improve the gradation of the processed product; a suitable borrow source of clean sand should be identified for use during the production supply operation. With regard to a blend source in a granular production operation, the following costs are normally considered incidental to the crushed granular production, and as part of the unit price would not be measured separately for payment:
  1. Development cost of the blend source/site
  2. Haul costs of blend material if required
  3. Cost of cleanup and remediation of the blend source/site

4.2.3 Quality Control (note Section 4.3 Basic Material Testing)

In processing operations during the production of crushed or screened material, quality control is used to ensure that the end product conforms to the required engineering specifications. Normally a Service Contract is established with an engineering testing firm. Quality control testing is normally ongoing and continuous during production operations. The most important quality control engineering tests for processed granular materials are:

- Washed Sieve Analysis (WSA) including the USC and grain size curve: The grain size analysis should fall within the grain size curves for the size of the material required using the Grading C Specifications;
- Fractured Face Count (FFC) – should be greater than 50 %; and
- Atterberg Limits – normally only used if ‘fines’ are greater than 10 %, which would be determined by a WSA test.

There are two main engineering specifications for road surfacing in the NWT, as noted in Appendix D:

1. 16 mm Chip Seal
2. 20 mm Gravel Surfacing

If the processed product does not meet spec it can be refused by the project engineer.
4.2.4 Stockpile Management Practices

If the stockpile of blasted rock, processed material or pitrun is to provide granular material for community capital projects and/or maintenance requirements over a period of time or sold to users as a business venture, then stockpile management needs to be addressed. There will be the continual settlement of the material over time along with base compaction. This is the reason why a stockpile pad should be constructed to better support the weight of the stockpile. Also, the stockpile needs to be monitored to avoid unauthorized removal, so security at the site location needs to be a consideration.

Stockpiling of material should:

- Minimize the inclusion of snow or ice;
- Be oriented in such a manner to avoid snow drifting over access roads and communication lines;
- Not accept any method of construction, which allows snow or ice to build-up; and
- The stockpile should be shaped with slopes not steeper than 1.5:1

Furthermore, the foundation of the site is also important, especially if the stockpile has a long life expectancy (longer than two years). Stockpiles should not be placed directly on permafrost or poorly drained ground. To minimize base consolidation and embankment loss, the stockpiled material should be placed on solid ground with a minimum 300 mm pad (Photo 25) or on bedrock (Photo 26). The GNWT/PWS has prepared two documents with regard to stockpile management.

1. Stockpile Inventory Loss Assessment, Asset Management Division, Department of Public Works and Services, GNWT
2. Guidelines and Procedures for Volume Surveys of Stockpiles, Asset Management Division, Department of Public Works and Services, GNWT

4.2.5 Measurement for Payment

1. Truck Box Measurement

Truck box measurement is a common method to determine the quantity of material extracted and hauled (either pitrun or processed) during a granular supply operation. A ‘truck box’ has a length, width, and height (Photo 27), thus each truck used can haul a calculated volume of material (L x W x H). This method is recommended in granular supply operations where the hauled product is to be placed and compacted on site. Although contractors prefer the ‘truck box’ method when stockpiling material, there is often up to a 30% discrepancy in the actual amount hauled and stockpiled due to:

- Trucks are not filled to capacity at point of loading;
- Poor unloading and/or stockpiling practices;
- No quality control;
- Truck load limit reductions on ice and winter roads; and
• Inclusion of organics, snow/ice, and oversize material during loading.

The ‘truck box’ method requires quality control by means of a ‘checker’ to inspect the trucks to ensure they are full to capacity without the inclusion of not just snow, ice, organics, etc. but also oversized material that does not meet the contract specifications. Each truck load hauled would be recorded on a truck ticket, which is to indicate the date and time of delivery and be signed by the authorized checker and the truck driver. Only those loads recorded and signed by the checker and truck driver would be included for payment.

2. Survey-In-Place

The ‘survey-in-place’ method is recommended when a large quantity of extracted or processed material is to be hauled and stockpiled, whereby the payment is based on a surveyed measurement of the delivered product for the agreed unit price per cubic metre.

A total station stockpile survey would be carried out using a base line that was set during the pre-engineering survey of the base surface of the stockpile site and would be tied to geodetic survey control (Photo 28). However, other survey procedures are available if the stockpile is already in place.

Survey-in-place will add to the cost of a project but ensures that payment is based only on what is delivered by the contractor.

3. By Measured Weight

The ‘measured weight’ method is the most accurate method of payment as weight scales are used to measure the true quantity of material removed from a quarry. Payment is based on weight rather than volume. The true quantity is the difference between the weights of the truck loaded/full minus the weight of the truck empty, which has already been recorded. In the NWT, this method is mostly used during highway operations related to the territorial-wide construction of the NWT highway system, or large-scale granular supply operations where a substantial quantity of material is to be stockpiled for maintenance purposes. The measurement is usually calculated in metric ‘tonnes’ of material to supply and stockpile on site.

Where one tonne: = 1000 kilograms = 2204.62 lbs
4.3 Basic Granular Testing

4.3.1 Coarse Grained Materials

The purpose of the sieve analysis is to determine the gradation of pitrun material. Granular samples are obtained from designated locations within the quarry from test pits or bore holes. A sample is passed through a variety of sieves with gradually smaller aperture sizes. This provides a graphical representation of the particle-size distribution called a gradation curve. The gradation curve provides a useful means to describe the material. The following figure depicts five different gradation curves described below.

- **Curve A SAND**: poorly-graded, medium grained: poorly graded because the curve is steep (narrow range of sizes), and medium sand because the majority of the soil (approx. 65%) lies within medium sand sub range.

- **Curve B GRAVEL and SAND**: well graded: well graded because it’s containing a wide range of particle sizes and classified as gravel and sand because half of the soil is gravel and half is sand.

- **Curve C SAND**: silt, well graded: contains large range of particles predominantly throughout the sand faction and has a significant silt faction.

- **Curve D SILT**: sandy, some clay, well graded: well graded throughout predominant silt faction.

- **Curve E CLAY**: clay material some silt.
4.3.2 Fine Grained Materials

The gradation of soils finer than 75 mm is determined from a Hydrometer Test (ASTM D422). In addition to gradation, plasticity of fine soils has an important effect on engineering properties such as load-bearing strength and compaction, therefore plastic consistency is used as a basis of their classification. Atterberg Limit testing (ASTM D4318) is used to determine the plasticity of a soil.

The change in volume of a saturated cohesive soil is approximately proportional to a change in water content. A total of four consistency states can be defined for fine grained soils and are shown in the following figure.

![Diagram showing the relationship between water content and volume](image)

Where:
- \( w_l \): the liquid limit, the water content at which the soil ceases to be a liquid and becomes plastic
- \( w_p \): the plastic limit, the water content at which the soil ceases to be plastic and becomes a semi-plastic solid
- \( w_s \): the shrinkage limit, the water content at which drying-shrinkage at constant stress ceases

The two most important of these states are the liquid and plastic limits, which represent respectively the upper and lower bounds of the plastic state. The range of the plastic state is given by their difference and is termed the plasticity index \( I_p = w_l - w_p \).

The relationship between the plasticity index and liquid limit is used in the Unified Soil Classification shown below to establish the sub-group of fine grained soils. The line A provides an arbitrary division between silts and clays (Note Appendix C – Unified Soil Classification System).
### UNIFIED SOIL CLASSIFICATION†

<table>
<thead>
<tr>
<th>MAJOR DIVISIONS</th>
<th>GROUP SYMBOLS</th>
<th>TYPICAL NAMES</th>
<th>CLASSIFICATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse-Grained Soils</strong></td>
<td>GW</td>
<td>Well-graded gravels and gravel-sand mixtures, little or no fines</td>
<td>$C_u = \frac{D_{50}}{D_{10}}$ Greater than 4</td>
</tr>
<tr>
<td></td>
<td>GP</td>
<td>Poorly-graded gravels and gravel-sand mixtures, little or no fines</td>
<td>Not meeting either criterion for GW</td>
</tr>
<tr>
<td></td>
<td>GM</td>
<td>Silty gravels, gravel-sand-silt mixtures</td>
<td>Atterberg limits plot below &quot;A&quot; line or plasticity index less than 4</td>
</tr>
<tr>
<td></td>
<td>GC</td>
<td>Clayey gravels, gravel-sand-clay mixtures</td>
<td>Atterberg limits plot above &quot;A&quot; line and plasticity index greater than 7</td>
</tr>
<tr>
<td></td>
<td>SW</td>
<td>Well-graded sands and gravelly sands, little or no fines</td>
<td>$C_u = \frac{D_{50}}{D_{10}}$ Greater than 6</td>
</tr>
<tr>
<td></td>
<td>SP</td>
<td>Poorly-graded sands and gravelly sands, little or no fines</td>
<td>Not meeting either criterion for SW</td>
</tr>
<tr>
<td></td>
<td>SM</td>
<td>Silty sands, sand-silt mixtures</td>
<td>Atterberg limits plot below &quot;A&quot; line or plasticity index less than 4</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>Clayey sands, silt-clay mixtures</td>
<td>Atterberg limits plot above &quot;A&quot; line and plasticity index greater than 7</td>
</tr>
</tbody>
</table>

**Fine-Grained Soils**

<table>
<thead>
<tr>
<th>GROUP SYMBOLS</th>
<th>TYPICAL NAMES</th>
<th>CLASSIFICATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML</td>
<td>Inorganic silts, very fine sands, rock flour, silty or clayey fine sands</td>
<td>Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols</td>
</tr>
<tr>
<td>CL</td>
<td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays</td>
<td>Equation of &quot;A&quot; line: PL = 0.73(ILL - 20)</td>
</tr>
<tr>
<td>OL</td>
<td>Organic silts and organic silty clays of low plasticity</td>
<td></td>
</tr>
<tr>
<td>MH</td>
<td>Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts</td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>Inorganic clay of high plasticity, lat clays</td>
<td></td>
</tr>
<tr>
<td>OH</td>
<td>Organic clays of medium to high plasticity</td>
<td></td>
</tr>
</tbody>
</table>

**Highly Organic Soils**

<table>
<thead>
<tr>
<th>GROUP SYMBOLS</th>
<th>TYPICAL NAMES</th>
<th>CLASSIFICATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td>Peat, muck and other highly organic soils</td>
<td>&quot;Based on the material passing the 3 in. (75 mm) sieve. IASTM Designation D 2487, for identification procedure see D 2488&quot;</td>
</tr>
</tbody>
</table>
4.3.3 Material Compaction

Compaction is the process of increasing the density of the soil by decreasing the air voids within the soil by mechanical means, such as: rolling, tamping or vibrating the soil. There are 3 main objectives in the compaction of soil, namely:

1. To reduce the void ratio and thus the permeability of the soil
2. To increase the shear strength and therefore the bearing capacity of the soil
3. To make the soil less susceptible to subsequent volume changes (settlement)

The effectiveness of the compaction process is dependent on the following factors:

1. The nature and type of soil
2. The water content of the soil during placement
3. The maximum possible state of compaction attainable for the soil
4. The maximum amount of compaction attainable under field conditions
5. Type of compaction equipment used

The state of compaction of a soil is measured by the *Maximum Dry Density* which can be determined from a laboratory Standard Proctor test (*ASTM D698*).

As water is added to dry soil, films of absorbed water form around the particles. As the absorbed water films increase in thickness the particles become lubricated and are able to pack more closely together thus density increases. At a certain point however, the porewater pressure in the absorbed films tends to push the particles apart and so, with further increases in water content, the density decreases. The maximum dry density therefore occurs at optimum water content as shown in the following figure.
4.3.4 Additional Testing

LA Abrasion testing (ASTM C131)

The Los Angeles Abrasion test is a measure of degradation of mineral aggregates of standard grading resulting from a combination of actions including abrasion or attrition, impact, and grinding in a rotating steel drum containing a specified number of steel spheres. The L.A. Abrasion test is widely used as an indicator of the relative quality or competence of mineral aggregates.
Fractured Face Count (ASTM D5821)

Some specifications contain requirements relating to percentage of fractured particles in coarse aggregates. One purpose of such requirements is to maximize shear strength by increasing inter-particle friction in either bound or unbound aggregate mixtures. Another purpose is to provide stability for surface treatment aggregates and to provide increased friction and texture for aggregates used in pavement surface courses. This test method provides a standard procedure for determining the acceptability of coarse aggregate with respect to such requirements.

Water Soluble Sulphate (CSA A23-3B)

Assess sulphate exposure of concrete placed in direct contact with soil, i.e. for structural foundation walls and slabs. Also helps determine type of cement to use in the concrete mix.

Lab Crush

There is no standard procedure for this test, however most geotechnical laboratories can accommodate this testing. The test is typically completed on 75 mm minus samples. The sample is mechanically crushed in the laboratory to determine if the material can achieve a certain specification prior to contractor setting up a large crushing operation.

4.3.5 Samples of Test Results

The following figure depicts a gradation curve from a typical sieve analysis test. The chart insert on the right side describes the GNWT specification for a 20 mm minus crush. The blue lines of the graph bounding the shaded area are the graphical representation of the upper and lower specification band (indicated in the chart). The green line indicates a sample that is within specification therefore acceptable. The red line indicates a typical out of specification result; in this case, the sample is out of spec on the 5 mm sieve indicating the sample has a high sand content.
Additionally, the chart insert on the lower right shows the GNWT specification for percent fractured faces (60% +) and LA Abrasion loss (50%) in red. These results are recorded on the sieve sheets and are either pass/fail. For surfacing aggregate used in chip seal or asphalt, typical maximum LA Abrasion loss is 30% because a more durable aggregate is required in these applications.
The following excerpt from a borehole log presents a typical location to find a water soluble sulphate test result:

The borehole log indicates that a soluble sulphate test was completed on a sample taken at approximately 1.8 m below grade and yielded a result of 0.04%. This result is considered ‘low’. The subsequent report would have a paragraph typically indicating the type of cement to use in order to resist the level of sulphate in the soil:

*The potential degree of sulphate attack on concrete may be considered to be ‘low’. Accordingly, the use of Type GU (formerly known as Type 10) Portland cement may be used. A maximum water/cementing material ratio by mass of 0.55 and a minimum specified 28-day compressive strength of 25 MPa is recommended. Stricter recommendations may be required due to structural considerations, or for de-icing chemicals.*

Typically, the sample chosen for testing is taken from the zone where the concrete structure will be located. In this case the sample was taken from 1.8 m below grade since the footing was expected to be constructed and buried at this level due to adequate bearing pressure.
4.3.6 Concrete Mix Design

Most geotechnical laboratories will complete a number of tests to determine if the material is suitable to use as concrete aggregate. Testing consists of sieve analysis of the coarse and fine factions, mix design (amounts of coarse aggregate, fine aggregate, cement ratio, water content, etc), and organic content, etc.

The following excerpts are from a typical concrete mix design report. The laboratory will separate a sample of pitrun into coarse and fine factions to test the physical properties of the aggregate as summarized in the following table.

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Coarse Aggregate (20-5 mm)</th>
<th>Fine Aggregate (14-0 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coarse Faction (14-5 mm)</td>
<td>Fine Faction (5-0 mm)</td>
</tr>
<tr>
<td>Bulk Specific Gravity (SSD)</td>
<td>2.70</td>
<td>2.62</td>
</tr>
<tr>
<td>Absorption (%)</td>
<td>0.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Fineness Modulus</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Color Plate #</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A sieve analysis is completed for both coarse and fine factions. In addition the amount of organic impurities will be tested within the fine faction using a test method called a color plate test. Typically a color plate number of 1-3 is good. Any result higher than 4 require extra means in the field to reduce the organics increasing the cost of processing.

Once the above testing is completed a theoretical concrete mix design can be completed, as presented in the excerpt below:
Upon completion of the theoretical mix design trial batches should be completed based on the contractors’ method of placement. For example, if the concrete is pumped it will need to have a high slump therefore the water to cement ratio may need to be changed. Typically, three trail batches are completed to achieve the desired workability and 28-day strength.
5.0 GRANULAR RESOURCE MANAGEMENT

5.1 Sustainable Development

5.1.1 Granular Resource Management

The Government of the Northwest Territories (GNWT) is committed to the conservation, sustainability and effective management of granular resources for the benefit of future generations of northerners. The GNWT considers granular material as a valued resource and under the government’s Sustainable Development Policy, and has clear objectives regarding the development of natural resources in the NWT. Since Devolution took place on April 1, 2014 the GNWT has a regulatory responsibility for the effective use and management of granular resources on both Territorial lands and Commissioner’s land. The Department of Lands administrates land use activities on both these lands.

The management of granular resources is the responsibility of the land owners or public land managers. Land owners and public land managers issue quarry permits for the purpose of extracting sand, gravel, stone, loam, and other types of granular material. The Mackenzie Valley Land and Water Board issues LUPs on both public and private lands in the Mackenzie Valley. The GNWT issues LUPs on public lands in the Inuvialuit Settlement Region. The Inuvialuit are the only land owners that issue LUPs on their own lands.

Within the Inuvialuit Settlement Region (ISR), the Gwich’in Settlement Region (GSR), the Sahtu Settlement Region (SSR), the Wek’eezhii area (Tlicho) and on lands administered by the Federal and Territorial governments, granular resource management frameworks already exist.

Land management and regulatory boards have been established by the land claim/self government agreements in these regions to allow for the development of an orderly approach to granular resource management. As noted in the Website Directory, a number of websites are available that provides further information related to granular resource administration and management on private, Federal, Territorial and Commissioner’s lands in the NWT.

5.1.2 Sustainability Principles

There is a projected drawdown of 950,000 m$^3$ over the next three years from existing territorial granular reserves for GNWT and municipal capital project and municipal O&M requirements, and this does not include GNWT territorial-wide O&M granular needs.

The GNWT encourages communities to develop a sustainability plan for local granular resources prior to development that will address the current and future needs of municipalities and the GNWT. Each plan would be community specific and consolidate
and update information as part of a regional granular database. The sustainable use of NWT granular resources is based on the following sustainability-based management principles (*Appendix E – Paper to the Joint Review Panel*):

1. Optimum and best use of each granular borrow source selected
2. Conserve quality sources/materials
3. Determine exact extraction quantities for usage
4. Use the most appropriate source for grade require

5.1.3 Material Construction Guidelines – Optimum Use

The sustainability of granular resources is dependent on the **optimum** and **best use** of the material. The following are material construction guidelines when developing a granular borrow source:

**General Fill:**

If the source material is to be used as general fill, the pitrun should be well graded, clean gravel and sands or low plastic clay material and able to be compacted to a minimum of 98 percent of maximum density.

**Structural Fill:**

Structural fill is usually designed for load bearing capacity such as roads and building pads. The source material should only be comprised of clean, well graded sands and gravel with minimum ‘fines’ and able to be compacted to not less than 100 percent of maximum density.

**Coarse Gravel:**

Consists of material where 70 – 90 percent of the material is greater than 10 mm in size to a maximum of 50 mm with minimum ‘fines’.

**Coarse Sand:**

Consists of material where 95 – 100 % of the material is less than 5 mm in size with a maximum of 10 % less than .160 mm.

**Gradation:**

The optimum pitrun material used for either structural or back fill should conform to the following specification.

- 50 % gravel sizes of 75 mm minus material
- 25 - 50 % sand sizes
- 3 – 8 % ‘fines’
- No oversize
- Free of clay and organics

Processed:

If the source material is to be processed, the raw pitrun needs to clean, well graded, hard, free of organics and any material containing clay, and should conform to the gradation specification required normally in accordance with ASTM C136. Gradation specification for 20 mm, 25 mm, and 50 mm crushed material are available in Appendix C – Washed Sieve Grain Size Analysis – Examples.

Two important sieve specifications are located in Appendix D – 16 mm and 20 mm specifications, and are excellent guidelines for use as quality control for road surfacing and maintenance purposes.

- **Grain size for a granular base coarse aggregate for roads 20 mm (DOT)**
- **Grain size for chip/seal coat aggregate for roads 16 mm (DOT)**

### 5.2 Environmental

#### 5.2.1 Criteria – New Pits/Quarries

The development of a new gravel pit/quarry should only be considered if there are no alternate sources of granular materials available (Appendix B – Northern Land Use Guidelines). Selection of a new granular source for proposed development should take into consideration the following guidelines:

- Minimum 30 metre form bodies of water;
- Avoidance of wildlife habitat;
- Avoidance of existing recreation areas;
- Avoidance of traditional areas;
- Avoidance of archaeological sites;
- Avoidance of steep slopes;
- Avoidance of potential drainage and erosion problems;
- Stability of slopes;
- Existing and/or prevalence of permafrost; and
- Access requirements

A new pit/quarry should be evaluated for material quantity and quality, location, access and land tenure and developed as part of an overall granular management plan based on Quarrying Regulations and regional Land and Water Boards regulatory requirements.
5.2.2 Granular Management Plans / New Pits

As granular sources are limited in occurrences and are essentially non-renewable, the management and sustainability of this resource is important. The increasing demands of growing industrial development and transportation infrastructure impacts on the available supply of granular resources near communities; the development of any new granular source reduces local reserves.

Only develop a new pit/quarry if existing sources cannot supply the required materials. The competition for granular materials from a new source will require effective management to ensure an adequate future supply for all users.

A granular resource management plan should:

- Allow for the systematic and orderly development of granular resources at the local and regional levels;
- Focus development on areas where granular shortages exist or significant future needs are identified;
- Minimize granular supply and demand conflicts;
- Ensure the sustainability of local reserves; and
- Ensure the adequacy, accuracy, and availability of granular resource information from granular inventories, demand forecasts, development guidelines, monitoring, and restoration.

At the site-specific level, a management plan would include the following ‘sustainability based guidelines’ to ensure sustainable development:

- Optimum best use of each granular borrow source selected;
- Conserve quality sources/materials;
- Determine exact extraction quantities for usage; and
- Use the most appropriate source/material for grade required.

Territorial, regional, and municipal granular management plans need to incorporate the objectives and goals of the GNWT’s sustainability policies to reinforce and ensure a viable granular supply for all northern users in future years.

5.2.3 Pit Operations / Restoration Guidelines

Once a pit has been depleted of recoverable materials, it is abandoned as another source is identified for development. Even with proper design and planning, large multi-use pit operations often change in direction and scope over time, avoid:

- Larger areas of land are cleared and developed outside of the original staked boundaries in a random manner (pit layout/design is not followed);
• Pit operations have progressed with little or no supervision or regulatory control; and
• Pit development has occurred in stages with some areas of the pit worked and reworked while other areas left abandoned.

Wherever a pit is located and regardless of size, it must be restored in some way (Photo 30). Pit restoration is always a condition of the land use permit and often a remediation plan is required by the regulators prior to commencing pit operations. Quarry permits issued on Territorial Lands require the submission of a Quarry Operations Plan. This plan must include details for development, use, seasonal and final restoration. Also, as hydrocarbon spills are a major source of contamination, spill prevention and response planning should be a high priority to avoid costly restoration.

The degree of restoration is dependent on:

• If the active pit is being abandoned permanently or only temporarily because it still contains useable material; and
• Possible future use of the completely abandoned borrow site such as staging area, picnic/camp site, viewpoint, community waste disposal site, landscaped, etc.

The main steps to be taken in pit restoration in the NWT are:

• Clean-up pit area especially where pit activities have been concentrated; this would include the removal of any contaminated ground;
• Re-contouring and slope stability to prevent slumping;
• Positive drainage and erosion control;
• Overburden/topsoil removal or use for landscaping;
• Security and safety; and
• Landscaping - the final shape, if the pit is to be abandoned, should blend into the natural contours of the surrounding terrain.

Other steps are oversize rock disposal and tree/brush disposal.

5.2.4 Restoration in Permafrost

An active pit located within a permafrost zone requires special attention during pit operations due to the difficult mitigation requirements during restoration. It is the amount of moisture within the frozen ground that causes most of the drainage problems along with the timing of pit operations.

Improper operating techniques during pit operations in a permafrost environment can result in (Photo 29):

1. Thermokarsting
2. Flooding
3. Slumping
4. Rutting

Even a small access trail or haul road over the seasonal active layer will result in damage to the land areas adjacent to the pit or quarry (Appendix B – Access Roads and Trails). To avoid irreversible environmental damages during pit operations within a permafrost environment:

- Allow for positive drainage away from the pit as the permafrost thaws;
- Preserve the insulating layer over the non-disturbed areas of the source;
- Complete pit operations before spring break-up so heavy equipment can be demobilized;
- Remove any exposed, large ice wedges along pit walls;
- Prevent repeated use of heavy equipment over the same track or trail to avoid rutting; and
- The practice of cutting and filling where material is excavated from one area, and used as fill in an adjacent area, should be avoided as it exposes frozen ground at the cut area to warm air, and may lead to subsidence/solifluction.

5.2.5 Winter Access

When constructing a winter access to a pit or quarry (other than an ice road) the following permafrost terrain should be avoided:

1. Patterned ground – permafrost terrain characterized by symmetrical features such as stone circles, polygons, steps and stripes over permanently frozen ground.
2. Palsa Bog – ice cored peat hummocks separated by depressed areas.
3. Hummocky terrain and steep slopes.
4. Areas where thermokarsting is already occurring - irregular subsidence of the ground surface due to differential melting of formerly frozen ground.
5. Solifluction activity – the slow down-slope flow under gravity of saturated material, also referred to as ‘slumping’.
6. Areas of high snow accumulation.
7. In areas of discontinuous permafrost black spruce trees and muskeg should be avoided as they indicate poor drainage and ground water saturation and are probably underlain by permafrost.
8. Areas that have recently experienced a forest fire are prone to erosion, whereas sites with older, unburned trees may be more stable.

The Department of Lands, Northern Land Use Guidelines - Access Roads and Trails, (Appendix B) contain detailed information on the development of roads and trails on Crown land in the NWT, especially as it relates to accessing pit and quarries. Winter access over permafrost terrain is also discussed.
5.3 Monitoring

5.3.1 Monitoring – General Guidelines

A vital concept to ensure sustainable granular reserves and an important part of updating a granular GIS and/or databases is the ability to monitor all pit operations:

- To ensure the extraction of recoverable volumes are in compliance with local regulations and land use-permits;
- To ensure information is forwarded in a timely manner to regulators and GIS personnel for review and data entry; and
- To ensure safety of pit operations and performance measurement of current pit design and material extraction.

Furthermore, site monitoring may be required for several years to assess if remediation objectives have been met.
Granular Resource Directory

Photo Directory
Photo Directory for Chapter 2

PHOTO 1

PHOTO 2

PHOTO 3

PHOTO 4
Indexed Photos for Chapter 2

Photo 1: Active gravel/borrow pit under development.

Photo 2: This rock quarry has only been abandoned and the site area cleaned with minor remediation completed. Quarry is available for further development.

Photo 3: Well graded pitrun or common grade material.

Photo 4: Common grade pitrun, a well graded, clean, 150-mm minus granular material.

Photo 5: Select or processed material. The raw pitrun has been crushed (processed) to 19 mm minus material for road surfacing.

Photo 6: Granular material is being extracted from the ground that will eventually form an active borrow pit as noted in Photo 1.
Photo Directory for Chapter 3

PHOTO 7

PHOTO 8

PHOTO 9

PHOTO 10
Indexed Photos for Chapter 3

Photo 7: Terrain analysis – view of an esker. Various landforms are identified through aerial photos that are considered excellent sources of granular materials.

Photo 8: Air Photo imagery of an active pit from a topographical map used to determine size and extent of an active borrow sources and possible environmental constraints on pit development. Gravel-bearing landforms are also identified in this way.

Photo 9: Flagging and staking are the first steps in determining the boundaries of a potential deposit for a ground truth reconnaissance and the lateral extent and overall evaluation of the source.

Photo 10: Ground-truth reconnaissance of an identified source is necessary to determine material quantity, quality and development options.

Photo 11: Visual of stratigraphic fine and coarse gravel layers within a test pit.
Photo 12: A Test Pitting/Sampling program is conducted over the site area to visually examine the material ‘in-situ’ and obtain representative samples of the source material, which is often highly variable throughout the deposit area and with depth.

Photo 13: Engineering test are conducted on the samples to determine material properties and ultimately the end use of the borrow source material. In this photo, the sampled material is being prepared for a wash sieve analysis.

Photo 14: Example of a grain size curve prepared from a wash sieve analysis that gives the percentages of gravel, sand and ‘fines’ of the source material.

Photo 15: View of a pit layout final design with test pits and sampling completed, ready for pit operations to commence.
Photo Directory for Chapter 4

PHOTO 16

PHOTO 17

PHOTO 18

PHOTO 19

PHOTO 20

PHOTO 21
PHOTO 27

PHOTO 28
Indexed Photos for Chapter 4

**Photo 16**: Source clearance/grubbing of the flagged area ensures that only the minimum area necessary for pit operations is cleared and that pit boundaries are clearly defined.

**Photo 17**: Pit operations and material extraction are conducted in an orderly and efficient manner according to the pit design/layout. All work including access, stockpiling, and restoration must take place within the pit boundaries.

**Photo 18**: A pit design/lay-out is required before pit operations commence. The operator must decide on the shape and depth of the pit based on ground reconnaissance and material quality and quantity information.

**Photo 19**: Summer pit operations are dependent on all-weather access and normally involves less costs on an ’as-and-when’ basis requiring minimal forward planning.

**Photo 20**: Pit operations in winter often require seasonal access, higher costs and a great deal more forward planning.

**Photo 21**: The photo show the physical act of transporting granular materials by trucks, normally from the borrow source to the project site.

**Photo 22**: A Grizzly Screener is the simplest way to process raw pitrun material to a specific size and is common in northern communities. Normally used when only a small amount of processing is required to obtain coarse gravel sizes. The equipment is usually located within the active pit and consists of a coarse screen or a series of parallel rods (or both) used for rough sizing of gravel.

**Photo 23**: A portable power screener is often used by contractors to screen pitrun on site where larger volumes of select grade materials are required. Several screens of different mesh sizes are usually available.

**Photo 24**: Crushing plants for the processing and stockpiling of large volumes of select grade materials involves the mobilization and demobilization of large equipment – a primary crusher, secondary crusher, belt conveyor, belts, etc.

**Photo 25**: A crushed stockpile located on a pad

**Photo 26**: A stockpile of pitrun without a pad but located on solid bedrock.

**Photo 27**: Truck box method. A common method of measurement for payment, the length, width and height of the truck box is measured giving a know volume quantity per truck load – when loaded to the fill line.

**Photo 28**: Base line setup for an in-place granular stockpile survey to obtain an accurate volume quantity for payment in cubic metres, using a total station instrument.
**Photo Directory for Chapter 5**

**PHOTO 29**

**PHOTO 30**

**Indexed Photos for Chapter 5**

**Photo 29:** View of an active borrow pit in permafrost terrain during pit operations; permafrost is thawing, water is ponding and rutting has occurred; adequate positive drainage is required.

**Photo 30:** A panorama view of the same borrow source after restoration. Correct restoration procedures have been applied.
Regulatory Web Index

www.inuvialuit.com - Inuvialuit Land Administration (ILA) - Tuktoyaktuk

ILA is responsible for managing and administering Inuvialuit owned lands in the Inuvialuit Settlement Region (ISR). Contact for Land Use Application and permitting information related to granular resource development.

www.mvlwb.com - Mackenzie Valley Water and Land Board (MVLWB) - Yellowknife

The MVLWB regulates the use of crown land by issuing Land Use Permits (LUP) in the unsettled land claims area of the Mackenzie Valley. All granular resource development of Territorial and crown lands requires a LUP. The MVLWB also maintains a public registry that contains all existing LUP and/or applications received by the Board and all support documentation relating to these applications – this is a valuable information tool to check for any LUP for existing or potential borrow sources under consideration for development.

www.glwb.com - Gwich’in Land and Water Board (GLWB) - Inuvik

The GWLB is the regulatory authority for land management in the Gwich’in Settlement Area (GSA). Contact for Land Use Application and permitting information related to granular resource development.
**www.slwb.com** - Sahtu Land and Water Board (SLWB) – Fort Good Hope

The SLWB is the regulatory authority for land management in the Sahtu Settlement Area (SSA). Contact for Land Use Application and permitting information related to granular resource development.

**www.wlwb.ca** - Wek’eezhii Land and Water Board (WLWB)

The WLWB is the regulatory authority for land management in the Wek’eezhii area. Contact for Land Use Application and permitting information related to granular resource development.

**www.dehcholands.org** - Deh Cho Land Use Planning Committee

The Dehcho Interim Measures Agreement established the Land Use Planning Committee and guidelines to develop a land use plan for the Dehcho Territory. The planning process will eventually involve administrating land use with respect to the development of natural resources, including granular borrow sources. Until such time as a Dehcho Final Agreement is reached, any LUP’s related to gravel acquisition should be directed to the MVLWB.

**http://www.lands.gov.nt.ca/** – Department of Lands Website (GNWT)

Quick links will provide access to GNWT land administration and regulatory control and also, links to PWS website and granular information.

http://www.aadnc-aandc.gc.ca/eng/1100100010002/1100100010021 – Aboriginal Affairs and Northern Affairs Canada (Federal)

The AANDC website provides numerous links to granular resource management and regulations on Federal lands.

**General - Granular Resource Information Web Index**

**www.eggerocks.com/rules.html** – Rules of thumb for gravel quantity calculations

Use formulas provided to calculate granular quantity needs

**www.aina.ucalgary.ca/astis** – Arctic Science and Technology Information System (ASTIS)
A database that contains over 63,000 records describing publications and research projects in northern Canada. Numerous directories on this server but one, the Northern Granular Resources Publications, is a browseable, web-based, northern granular resource database containing numerous granular resource publications specific to the NWT.

www.aina.ucalgary.ca/gran/61055.pdf – ASTIS Publication Database

A subset database of ASTIS, provides a review and summary of all the granular resource studies undertaken by Engineering Consultants Ltd (EBA) in the Northwest Territories.


This site is especially pertinent if considering investing in a GIS system related to the development and management of granular resources. The website provides different geotechnical file and GIS mapping formats to ensure geotechnical data standards. A summary of relevant geosciences formats can be accessed.


Here you will find volume calculators for estimating the granular resource needs for a variety of projects – pads, roads, runways. Series of sub-menus available under My Projects.

www.ersfunds.org – Environmental Studies Research Funds Management Board

Decides northern research priorities and considers research and funding that addresses issues under these priorities.

www.pws.gov.nt.ca – Department of Public Works and Services Website (GNWT)

Use the Publication’s quicklinks to access the most updated versions of the GNWT Territorial Granular Resource Forecast, Granular Resource Directory, Good Building Practices, and Communication Protocols – Granular Strategy.

http://www.lands.gov.nt.ca – Department of Lands Website (GNWT)

Quick links will provide access to GNWT land administration and territorial government information; also, provides links to granular information on the PWS website.

http://www.aadnc-aandc.gc.ca/eng/1100100010002/1100100010021 – Aboriginal Affairs and Northern Development Canada (Federal)

The AANDC website provides numerous links to granular resource databases in the NWT. Recommend access to the Northern Affairs Program (NAP) and the NWT Operations links for land administration, geoscience and sustainability information.
www.mveirb.nt.ca  –  Mackenzie Valley Environmental Impact Review Board

The Mackenzie Valley Environmental Impact Review Board’s conducts quality environmental impact assessments that protect the environment and the social, economic and cultural well being of the residents of the Mackenzie Valley. Also, includes a registry on the status of on-going environmental assessments.

www.tiny.com/33m3q5  –  Various Granular Inventory Reports directly related to Tuktoyaktuk and Aklavik – Mackenzie Delta Region

The Kiggiak-EBA report on the Evaluation of Six granular Borrow Prospects in The Mackenzie Delta Area is especially informative - Ya Ya Lakes, Site 467, Source 177, etc. – full geotechnical summaries.

www.dot.gov.nt.ca  –  Department of Transportation Website (GNWT)

Go to the Publications link, which contains various reports that mention the granular material requirements for planned and proposed transportation infrastructure projects (Highway Strategy Summary Report, 1999 / The Mackenzie Highway Extension, etc.)

www.nwta.ca  –  Northwest Territories Construction Association Home page

Go to the Bulletin link that contains construction projects and tenders related to the acquisition and processing of granular materials in the NWT.

www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0006229 SUBReadings  –  Excellent permafrost website

This site provides general information on permafrost in the north with quick links to related bibliographies and references.

www.enr.gov.nt.ca/eps/pdf/spills  –  The NWT guidelines for spill contingency planning are available.

A spill contingency and response plan is required to be submitted with any land-use permit application.

GIS and Monitoring Web Index

www.mackenziegasproject.com  –  The Mackenzie Gas Project Website

Land use application for the pit and quarries identified for development of the MGP are on this website – follow links Re: the Project/regulatory Process/application Submission/
www.mapguide.com – Reviews the next generation of web mapping technology.

Allows users to directly publish MapGuide geospatial maps and layers to Google Earth mapping service. Also discusses the physical layout of the files that provide the content of the site.
Bibliography and Reference Directory

The following granular resource reports, studies and documents are on file and can be obtained from the PW&S Library, 3rd floor, Stuart M. Hodgson Building, Yellowknife (867) 920-6451 (PWS Library) or (867) 920-6923 (Technical Support Services).

Stockpile Inventory Loss Assessment, Asset Management Division, Department of Public Works and Services, GNWT

Guidelines and Procedures for Volume Surveys of Stockpiles, Asset Management Division, Department of Public Works and Services, GNWT

The NWT Granular Users Forum, Asset Management Division, Department of Public Works and Services, GNWT

Construction of Permanent Access to Granular Sources and Gravel Pits, Asset Management Division, Department of Public Works and Services, GNWT

Northern Land Use Guidelines: Pits and Quarries, Department of Lands


An Internet Based Information Mapping and Exchange System For Granular Resource Management in the Inuvialuit Settlement Region, March 2006, Ward E. Kirby, Cal Data Ltd1990 (prepared for INAC, Ottawa, Canada)


Terrain Analysis, 1991, N.W.Rutter, Westland Consultants Ltd., Yellowknife, Binder


Territorial Granular Resource Forecast, PWS Hardcopy, Oct. 2008 Update, Yellowknife
Sustainable NWT Granular Supply – Cumulative Effects of the Mackenzie Gas Project’s Granular Requirements, March 2006, a presentation to the Mackenzie Gas Project Joint review panel, Inuvik

MGP Environmental Impact Statement, Volumes 1 and 2, Imperial Oil Resources Ventures Limited, August 2004, Submitted to the National Energy Board and the Joint Review Panel

Community Granular Revolving Fund, 1991 - 1999, Asset Management Division, Department of Public Works and Services, GNWT (reference document)

A Field Guide To Ice Construction Safety, 2007, Department of Transportation, GNWT, Yellowknife

Alternate Reference Sources

Air Photo Interpretation for Terrain Analysis (1982), E. Karl Sauer, University of Saskatchewan, Saskatoon


Cold Climate Utilities Manual (1986), Canadian Society for Civil Engineering, Beauregard Press Limited


