Stevens Quarry Development Plan Update 2012

Prepared by:

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Stevens Quarry Development Plan 2012 Update

1.0 Introduction

A plan for the development of a quarry in the Stevens area was first prepared in 1994 in conjunction with a proposed country residential subdivision that did not proceed. The Stevens site encompasses a series of north south ridges and rolling terrain located on the north side of the Alaska Highway extending north towards the Takhini River. The site is just inside the City of Whitehorse western city limits (**see Figure 1**).

Since the initial 1994 Plan was prepared there have been a number of changes that directly affect the design, layout and management of the proposed quarry. The need for a sand and gravel source serving the north end of the city has been growing for some time. Existing sources are becoming depleted and previous studies have confirmed there are limited opportunities to develop new sites to meet industry and public needs.

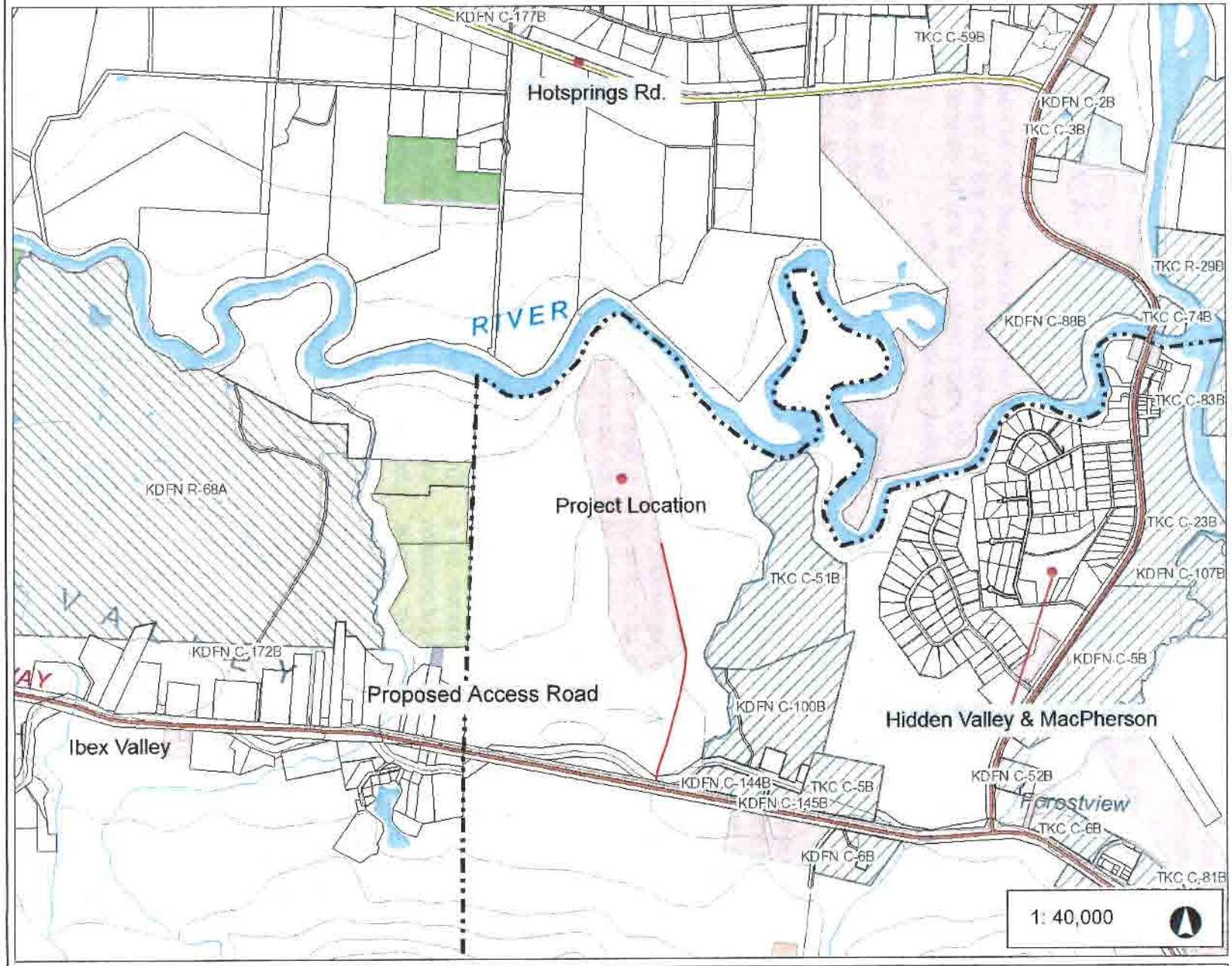
The Stevens Quarry Development Plan is being updated for the following reasons:

- The City of Whitehorse Official Community Plan (OCP) has been amended confirming the suitability of this site for quarry development;
- The Kwanlin Dün and Ta'an Kwäch'än land claims have been settled and both First Nations have interests either directly in quarry development or in land selections in the immediate vicinity;
- Additional geotechnical testing by EBA in subsequent years suggests the deposit is more complex than initially thought and unlikely to yield the volumes of material initially anticipated. This means the area affected will be smaller and the quarry lifespan shorter; and,
- The Yukon Environment & Socio-economic Assessment Act (YESAA) did not exist at the time the original Quarry Development Plan was completed.

The *Lands Act Quarry Regulations (OIC1985/205)* require the preparation of an Operation and Rehabilitation Plan before actual site development. This plan outlines how extraction can be carried out to minimize impacts on adjacent land uses. It includes both pit operation and reclamation guidelines applicable to all leases and sets the framework for the individual pit operator plans that must be submitted as part of the lease agreement.

The updated plan will become part of the project description submitted to YESAA. Once that process is complete and Management Board approves project funding, site development would begin with the target of having lease lots available in 2013. The plan also provides guidance to leaseholders on what their individual operating and reclamation responsibilities are to minimize impacts on adjacent land users. The objective is to ensure best practices are followed during the operation and reclamation phases of the quarry's lifespan. Each leaseholder is required to provide Yukon Energy, Mines & Resources Lands Branch with an operation and reclamation plan as part of the lease process and to comply with the applicable City of Whitehorse bylaws.

Figure 1. Stevens Quarry Project Area



Legend

- Municipal: Official Extents
- Surveyed Easements
- Surveyed Land Parcels

Land Dispositions

- Land Applications - Active
- Agreement for Sale
- Easement
- Lease
- Reservation
- Agricultural Applications
- Agricultural Dispositions

Surveyed Settlement Lands

- A
- B
- FN
- Contour lines (50k)

Notes

2.0 0 1.02 2.0 Kilometers

NAD_1983_Yukon_Albers
Produced from: Yukon Placer Watershed Atlas

Date Printed: 01-Mar-2012

1.1 Assumptions

Key assumptions and area land use policies have changed since 1994 and new factors have to be considered including specific land claim obligations arising from settlement of the Kwanlin Dün and Ta'an Kwäch'än land claims. Of most relevance is the obligation to KDFN to offer the First Nation government 1.18 million m^3 of materials in the Stevens Quarry, or a portion thereof to be supplemented by alternate quarry resources at other locations. Both First Nations have land selections immediately east of the proposed quarry which will be affected by development of the quarry TKC has indicated they intend to develop their C-51B land selection for country residential use.

In the subsequent 1994, 2002 and 2010 reviews of the OCP, the importance of preserving the Stevens area for quarry development was acknowledged and affirmed as a priority land use in that area of the city. The principal applicable 2010 OCP policies dealing with resource extraction are 8.2.3 which requires an approximate 300m separation distance from residential land designations and policies 8.3.2 through 8.3.8. The clauses cover haul road access, site management and operational considerations, as well as the minimum site reclamation requirements. A Quarry Development Plan must also be prepared and this is the purpose of this update.

The original 1994 quarry plan covered 139 ha and was estimated to contain a minimum of 7,000,000m^3 of extractable sands and gravels. Additional geotechnical investigations in subsequent years including 2011 where the traditional backhoe sampling method (3-4m deep) was augmented by 3 sonic drill holes (30m deep) reconfirmed the complexity of the site's surficial geology first identified by R.M. Hardy in 1978. As a result, the quarry area has been reduced by 15% from 139 to 119.5 ha and the estimated probable aggregate yield reduced by two-thirds to 2,350,000m^3. The implication of this reduction in volume means that quarry life will be shorter than originally anticipated and not all interests in obtaining aggregate leases can be accommodated at this location. This will put pressure on the Yukon and city governments to find additional locations to accommodate commercial operator site requests.

The volume of aggregate material now anticipated to be present is a conservative estimate and reflects the limitations of the present testing program. Experience with other Whitehorse quarries suggest that as individual leases are depleted and additional testing is done by individual leaseholders, the volume of extractable material may increase extending overall pit life. However, in the interim it is expected that the Stevens Quarry once developed will have a minimum active quarry life of 10-12 years. This is based on a review of historical consumption patterns from Yukon and City of Whitehorse records which show a steadily increasing demand for sand and gravel and a recognition that the lifespan of a number of the main existing pits is declining.

Contractors indicate that haulage distance and aggregate quality are the key considerations in determining which quarry site they use as the primary source for a given project. Thus it is assumed that the Stevens Quarry would serve the northern portion of the City. If the existing McLean Lake and South Access Road pits serve the southern portion of the City and annual production is split on a 50/50 basis then the Stevens Quarry would probably supply no more than 100,000m^3 of sand and gravel during any given year. This assumption has been factored into the assumed minimum pit life.

The second factor that is relevant to quarry material demand is the nature of the Yukon economy which is forecasted to grow steadily over the next 5-10 years. It is noteworthy that 80% of the growth associated with the current economic prosperity is being channelled into Whitehorse. As a result there is increased demand for new subdivisions like Whistle Bend which consume considerable volumes of material for infrastructure development.

2.0 Lot & Access Road Layout

The quarry has been reduced in size and boundaries reconfigured based on recent geotechnical test results. The best material is concentrated in the knobs and east face of the north/south rolling hills between the Alaska Highway and Takhini River. Aggregate quality declines with more sand than gravel content as extraction activity proceeds westward.

Considerations that affected quarry layout included:

- the policy direction contained in the 2010 OCP including setbacks from potential residential lands;
- Government land claim obligations to both First Nations under their settlement agreements;
- the requirement for a separate, controlled, haul road from the Alaska Highway;
- the needs of government and the private sector for access to aggregate material;
- the preference of quarry operators for larger and wider lots than longer or narrower ones for operational efficiency; and
- the desire to ensure quarry development, even as an interim land use, does not unduly restrict future options for land use development after quarry decommissioning.

Five different lot configurations were developed, reviewed, and tweaked to arrive at the present concept. These included comparing access routes along the east and west sides of the deposit along with lot layouts of various shapes and sizes. The present plan results in 4 lots, one which is a shared government pit to be used by the city and territorial governments to meet their internal needs plus a lot that is expected to produce sufficient material to meet 70% of the KDFN land claim obligation and 2 pits that would be available for commercial lease. A fifth possible pit is identified that has a higher sand content but it would require both an OCP boundary adjustment and a relaxation of the 300m setback from proposed residential lands to go ahead.

Equity and the KDFN land claim obligation were also considered in the layout options with the final lot lines drawn to balance off lot size, anticipated material quantity and quality. KDFN gets 35% of the proven/probable reserves which meets 70% of the land claim obligation for access to 1.18M m^3 of material, preferably at this location. The First Nation is now the largest private landowner in Whitehorse. They have a number of properties including site selections near the quarry where access to aggregate material will be required. KDFN also recognized that beyond their own needs, there is also a competitive business opportunity to supply others with similar needs.

The Quarry Development Plan layout is shown on the next page along with a conservative estimate of the anticipated aggregate yield based on current geotechnical information. The 119.5 ha development area is divided into 5 separate lease parcels:

- Lease Lot #1 (21.7 ha)
- Lease Lot #2 (15.2 ha)
- KDFN Pit (24.4 ha)
- YG / City Government Pit (34.4 ha)
- Potential Additional Future Lease (23.8 ha)[1]

The project also requires construction of a 2.27 km access road from the Alaska Highway. Up to 500m of the existing Old Alaska Highway will need to be realigned to maintain the current service road function, improve sight lines and intersection clearances. The location of the haul road on the east face of the deposit takes into account three key factors. First the quality of material present is best along the east face of the deposit and the east side location provides operational efficiencies to pit leaseholders. Second, after resource extraction is complete the road will become the first part of the internal road network for future development. Third, the Alaska Highway intersection location is assumed to become the main access point for development of the remaining lands from the depleted quarry to the western city boundary. The Old Alaska Highway would continue its service road function because of the large rock outcrop which separates the road and new highway. The quarry haul road will be signed on the north side of the old highway.

Material for road construction will come from the new quarry and the road will be constructed to City of Whitehorse standards. The quarry access road will be hard surfaced for durability and dust control.

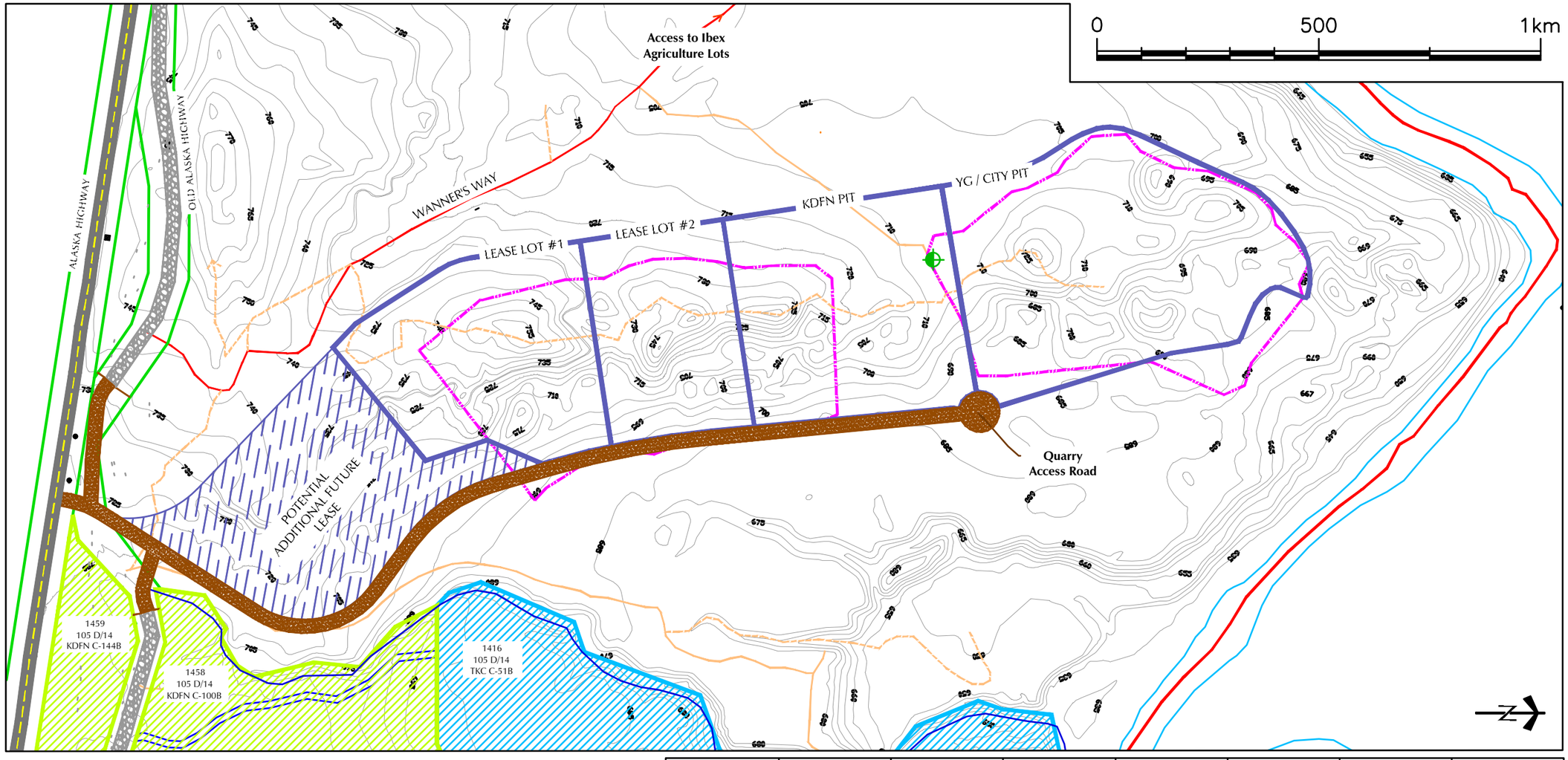
The proposed lot layout for the 2012 Stevens Quarry Development Plan is illustrated in **Figure 2**. The right-of-way can accommodate the future installation of power and telephone service but it is not required for quarry operations. Specific test pit and borehole locations in relation to lot layout which are illustrated in **Figure 3**

2.1 Phasing

The quarry will be developed in one phase. Allowance has been made for the possible addition of a fifth lot closer to the highway but that would require a OCP amendment and agreement by KDFN and TKC not to develop a portion of their adjacent land selections for residential purposes until quarry operations are complete. The 300m setback is only applicable if both first Nations choose to develop their abutting properties for residential purposes. TKC has already indicated that is their intention for their C-51B parcel and this is reflected in the 2010 OCP while KDFN has not confirmed their intentions for their C-144B or C-100B site selections at this time. In the interim, the status quo prevails as reflected in the 2010 OCP so a 300m setback has been applied from both First Nation lot boundaries.

[1] Subject to future CoW OCP amendment.

Figure 2. Stevens Quarry Development Plan



LEGEND:

- CITY OF WHITEHORSE BOUNDARY
- QUARRY LOTS
- ACCESS ROAD
- TAAN KWÄCHÄN FIRST NATION LAND
- KWANLIN DÜN FIRST NATION LAND
- ROW BOUNDARY
- EASEMENT BOUNDARY
- IQ ZONING BOUNDARY (2006)
- MAIN TRAIL
- MINOR TRAIL
- 1990 TEST WELL KLOTIN LEONOFF

NOTE:
5m CONTOUR INTERVAL

Notes:

- KDFN pit has 35% of proven / probable aggregate reserves.

- Government pit would be shared by all YG departments and City of Whitehorse.

- Total aggregate yield is a conservative estimate of based on available geotechnical data and 4 m average test pit depth

- Minimum quarry life estimated at 10-12 years based on assumed consumption of 100,000m³/yr. and available geotechnical information. Further testing could result in significant quarry life extension.

- Potential additional future lease lot would require OCP amendment

Lot Type	*Area (ha)*	*Probable Gravel Yeild (m³)*	*Probable Sand Yield (m³)*	*Total Probable Aggregate Yield (m³)*	*Min Elevation (m)*	*Max Elevation (m)*	*Distance to Alaska Hwy (m)*
Lease Lot #1	21.7	145,000 - 240,000	400,000	545,000	695	755	1070
Lease Lot #2	15.2	100,000 - 125,000	250,000	350,000	690	750	1435
KDFN Pit	24.4	425,000 - 575,000	400,000	825,000	690	745	1760
YG / City Pit	34.4	125,000 - 200,000	200,000	325,000	680	730	2265
Potential Additional Future Lease	23.8	5,000 - 10,000	300,000	305,000	690	745	245
Total	**119.5 ha**	**800,000 - 1,150,000**	**1,550,000**	**2,350,000**			

REVISIONS :

NO.	DATE	BY	DESCRIPTION
1	20/12/11	JB	Final Concept Plan
2	07/03/12	RN	Open House Concept Pan
3	28/03/12	RN	Aggregate Volume Corrections

Yukon
Community Services
Infrastructure Development Branch

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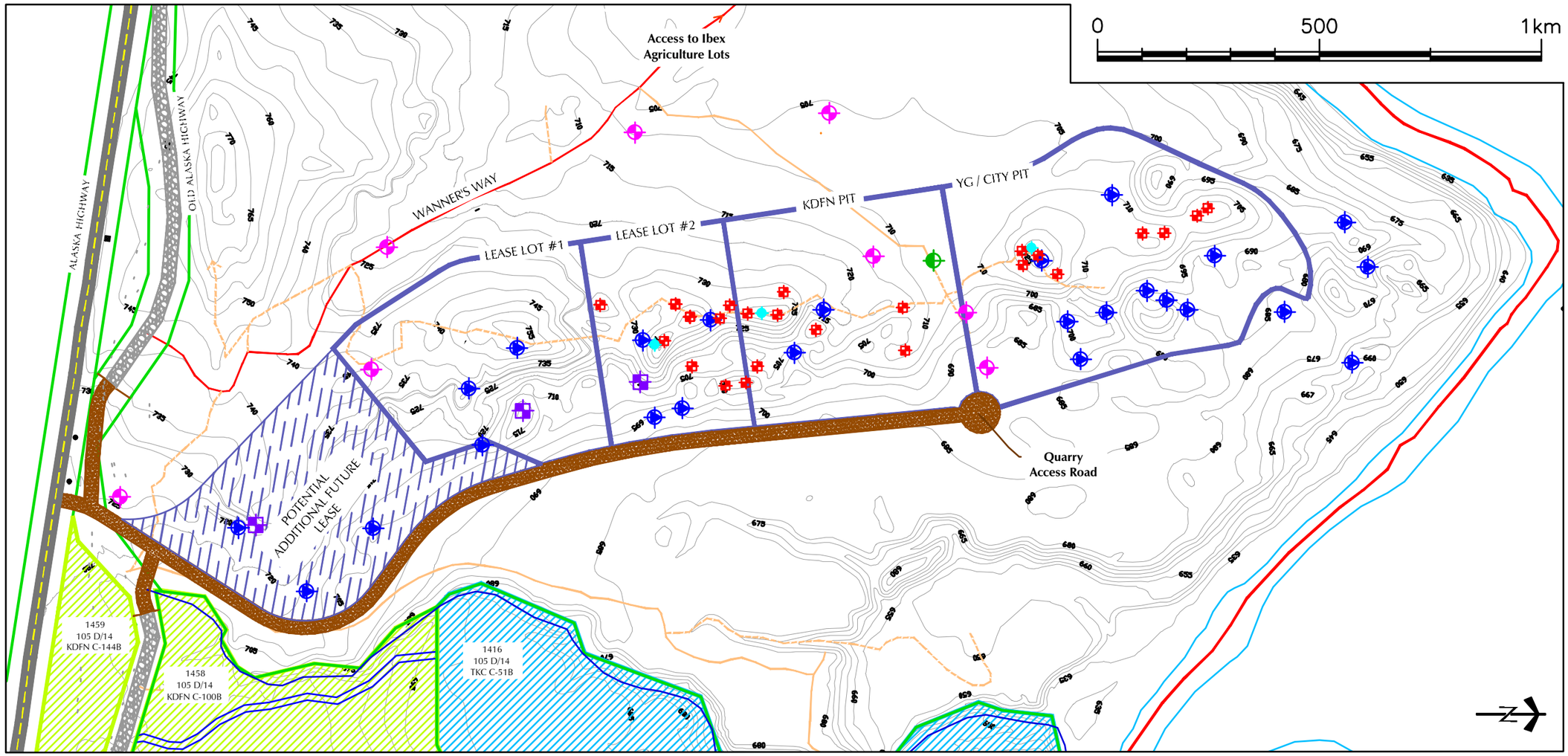
YES Yukon Engineering Services
eba A TETRA TECH COMPANY

STEVENS QUARRY

QUARRY DEVELOPMENT PLAN

SCALE: 1:10000	DATE: 30 March 2012
PAPER SIZE: Tabloid	PROJECT: CITY 10-02
DESIGN: IR	DRAWING FILE: [illegible]
DRAWN: RN	SHEET NO.: 1 OF 2
DWG. NO.: 1	REV.: 3

Figure 3. Stevens Quarry Development Plan with Testpit Locations



LEGEND:

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- KWANLIN DÜN FIRST NATION LAND
- ROW BOUNDARY
- EASEMENT BOUNDARY
- MAIN TRAIL
- MINOR TRAIL

TEST PIT LOCATIONS

- 1978 TEST PITS R.M. HARDY AND ASSOC.
- 1988 TEST PITS KLOHN LEONOFF
- 1990 TEST WELL KLOHN LEONOFF
- 1991 TEST PITS - EBA
- 2011 TEST PITS EBA
- 2011 BOREHOLE EBA

NOTE:
5m CONTOUR INTERVAL

REVISIONS :

NO.	DATE	BY	DESCRIPTION
1	2012/03/	JB	Final Concept Plan
2	2012/03/	RN	Open House Concept Pan
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Notes:

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QUARRY DEVELOPMENT PLAN with TESTPITS

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PAPER SIZE: Tabloid	PROJECT: CITY 10-02
DESIGN: IR	DRAWING FILE:
DRAWN: RN	SHEET NO.: 2 OF 2
DWG. NO.: 2	REV.: 3

3.0 Pit Operating Guidelines

The 1994 recommended pit operating guidelines are now covered in the 2010 Natural Resource Designation Policies (OCP pages 52-53, policies 8.3.1 through 8.3.8). They are also captured in the Government of Yukon quarry lease application process and reflected in the specific Stevens Quarry Development Plan layout. The general requirements include:

- A required for a separate, hard surface haul road and dust abatement practices;
- Compliance with the City of Whitehorse Maintenance bylaw including hours of operation;
- The requirement for individual leaseholders to prepare and follow an approved Operation and Reclamation as part of their lease agreement; and
- Restore and reclaim the decommissioned pit to as natural a state as possible.

The Stevens site warrants some additional guidelines to ensure the full aggregate resource potential of the site is exploited without compromising other interests and values present. The main difference between 1994 and today is that the current resource assessment suggests that the operational life of the quarry will likely be shorter than originally envisioned. This means the quarry is truly more of an interim land use. However, as noted previously it is quite conceivable that additional drilling of the deposit over time may identify more extractable material at depth extending quarry life but complicating site reclamation.

These include:

- Each leaseholder operation and reclamation plan should outline how site development and management practices will address dust control because of the arid site conditions created by the nature of the soils present, their fast percolation rates and limited moisture storage capacity. Progressive site stripping is encouraged to reduce moisture loss. A water source for reclamation will also need to be identified to assist vegetation re-establishment for a minimum of one growing season after seeding.
- To ensure efficient extraction practices between leaseholders with adjoining boundaries, it is the responsibility of the pit operators to work out an excavation plan to maximize extraction of sands and gravels along their common boundary. No buffer is required and the extraction principle to be used is that once excavation reaches a point where a 2:1 slope remains between the two leaseholders along the common property line, no encroachment shall occur until the operators work out an agreement to share the resulting triangle of material on a 50/50 basis.
- Once extraction depths reach a common 685m base level, each leaseholder may retest their lease to determine if there is sufficient additional material to warrant continued excavation to a greater depth. Should that occur the common boundary principle would still apply and the overall site development plan for the quarry should be reviewed to determine the implications for future land use and site remediation.

The rationale for these guidelines is as follows. The thin, covering of topsoil at the Steven's site will be difficult to strip and stockpile separately from the overburden for use in future reclamation. For this reason it is imperative that areas not required for quarry operations not be disturbed until needed. Attempting to separate the thin organic topsoil layer from the strippings is not practical and in fact counter productive since the strippings actually help improve the moisture holding capacity.

Best site management practices in the case of the Steven's leases would be not to strip individual leases bare at the beginning because it will increase potential dust problems. Hand clearing of trees and surface vegetation should be done separately from grubbing with only those areas required for immediate needs grubbed completely. This would include the active pit face, the material stockpile and manoeuvring areas. Leaving the vegetated surface mat as long as possible will substantially reduce the potential for erosion, bank instability and need for active dust control.

The fast percolation rate and low moisture holding capacity of the sands and gravels already mean it will be difficult for new growth to become established when reclamation activities start. The surface strippings do not have to be clean because the intent is to restore the site as much as possible to its original condition. Stockpiling the topsoil and strippings together will retain more of the moisture holding capacity. This can be supplemented with chipping un-merchantable timber and roots to create mulch which can be combined with silts and compost for use during the reclamation process.

Maximizing the extraction potential of the Steven's site is consistent with the municipal OCP objectives. Given the complex surficial geology of the site and the results of geotechnical testing to date, the depth, width and nature of the sand and gravel seams within the deposit are anticipated to be quite variable, potentially making it difficult to develop an efficient excavation strategy. Maintaining a buffer between common lease boundaries is inefficient. Encouraging leaseholder cooperation facilitates efficient extraction of the limited volumes of sand and gravel present for all concerned. This cooperation can also be extended to site restoration once the aggregate resources are depleted.

4.0 Reclamation Guidelines

If additional testing confirms the quarry can be developed to depth, this will result in steeper slopes requiring slope stabilization measures during the quarry operation and decommissioning phases. Re-contouring pit walls to create grades conducive to revegetation is the objective.

Selective scarification and topsoil placement may help promote revegetation in these areas. The steeper slopes will also make the hilltops susceptible to slumping as excavation occurs along the face. For this reason, considerable care must be taken in cutting back the knobs to prevent damage to the backslope. Choice of equipment will be important in this regard with a "grade-all" style shovel preferred to a bulldozer.

The trees are shallow rooted and susceptible to blowdown. Encroachment into the buffers particularly along the haul road and lot boundaries will have to be prevented. Pit operators will need to be advised on how to maintain these buffers and undertake lot clearing to minimize the risk of blowdown.

Maintenance during the first two years following reclamation will be critical to site revegetation. Fertilizer rates, planting time and the choice of plant material will be important. A need for supplemental irrigation in some form may be necessary to get revegetation started on the steeper slopes.

The absence of any drainage courses and the lack of ponding in the kettle depressions mean snowmelt is critical to plant development. There are two options for supplementary irrigation source water. The first is to develop the existing drilled well within the site which is located in the northwest corner of the KDFN lot. The alternative is to truck water from the Takhini River at the nearest accessible point (e.g. Takhini River Bridge) when needed. In this case, a water license would be required should the daily volume extracted exceed 300 m^3/day; however, this threshold far exceeds the volumes which would be necessary for supplementary irrigation purposes.

4.1 Progressive Reclamation

Two strategies are prescribed. The first strategy is based on the principle of enhancing the existing buffers by preventing encroachment and strengthening the inherent vitality of the site margins. Thinning of the regenerating pines, fertilizing the periphery of the cleared areas and feathering the edges of the buffer, all help to promote a healthy "forest edge". This helps the forest to re-seed itself and encroach naturally into the quarry area. This approach is most applicable along the rear property line of each lease lot. In the case of Stevens this would affect the south and west boundary of lease lot 1, the west boundary of lease lot 2 and the KDFN lot (lot3) as well as the west, north and east edges of the government pit.

Figure 4 is a plan view illustrating how a typical lot might initially be developed.

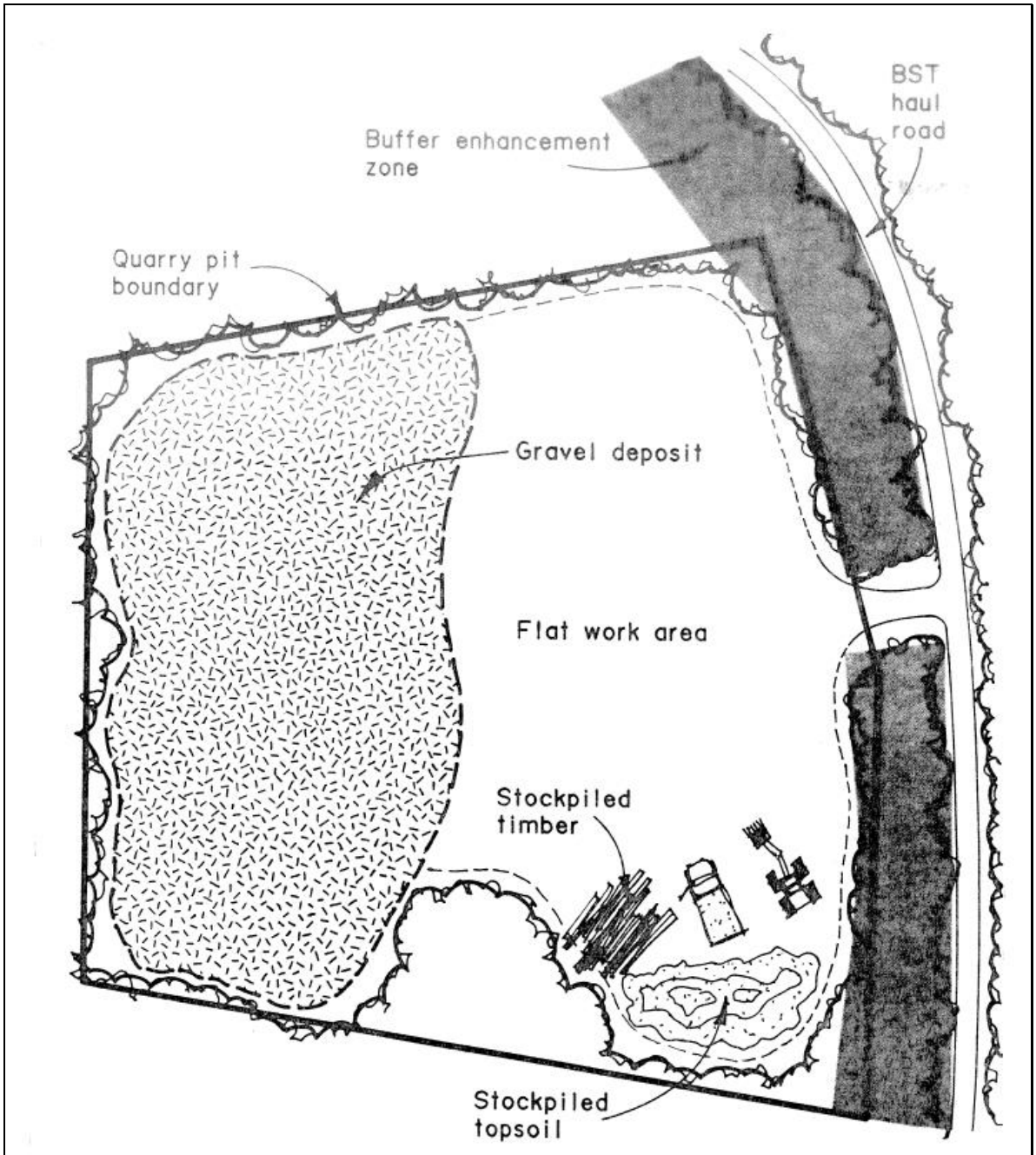


Figure 4 – Plan View of Typical Lot

As noted earlier, the objective in the case of Stevens is not to strip, separate out the topsoil and grub the entire lease area as a first step in site development. The site may be cleared but the vegetative mat should be retained as long as possible in non-active areas to control erosion, retain soil moisture and minimize the need for dust control intervention. The stockpiled strippings should be spread to an optimum depth of 200mm in the fall overlying a minimum of 500mm of overburden. The strippings can be enhanced by mixing in wood chip mulch from initial tree clearing, as well as silt lenses encountered during aggregate extraction.

Spring seeding is usually preferred, but fall seeding is recommended here to take advantage of the snowmelt moisture in the spring. It is necessary to increase seeding rates from 25-30% if fall seeding is used. Hydro-seeding or cyclone seeding techniques should be used, Fertilize immediately and follow-up each spring for two years to promote the best growth. For the initial seeding to take, moisture is critical during the first 10 days. For this reason, given local weather and soil conditions, some form of mulch will be needed to help retain moisture. Given local soil conditions, getting new vegetation re-established will be a challenge and the need for supplementary irrigation should be anticipated. With fall seeding the need for some over-seeding may also be expected, particularly on steeper, exposed slopes where snow melts first.

Where natural regeneration begins to occur, additional seeding and fertilizer will help to strengthen the existing plant material and provide a "host" environment favourable to further regeneration. Other more labour intensive methods include transplanting grass clumps from areas about to be excavated or using shrub and tree cuttings.

The rates of nutrient application differ according to site conditions. Suggested application rates for the backslopes, quarry front slopes and lower terrace in **Appendix 1** are based on the 1994 Norwest Labs Soil Samples Analysis described in **Appendix 2**. Each leaseholder as a condition of the lease shall provide a soil analysis from the stripping pile prior to beginning site reclamation along with an update of the approach to be used and a description of how seed, fertilizer and other soil amendment rates have been adjusted to reflect the results of the soil analysis.

Until sufficient quantities of native Yukon plant seed species are available, agronomic selections are the preferred choice for revegetation. Seed type availability will vary from year to year. Suggested selections are described in **Appendix 1**.

In recent year's concerns with invasive plant species is becoming a concern. Many invasive species have migrated into the Yukon along the main highway corridors. Invasive plants often quickly out compete native species in disturbed landscapes with white and yellow sweetclover (*Melilotus officinalis*) the species of most serious concern. It already exists along the Alaska Highway in this section of road and will invade the new haul road if it is not quickly revegetated after construction. This species may also adapt quickly to disturbed quarry leases. Other invasive species that are relatively common in and around Whitehorse that leaseholders should be aware of include foxtail barley (*Hordeum jubatum*), common tansy (Tanacetum vulgare) and perennial sow-thistle (*Sonchus avensis*).

4.2 Implementation Strategy

The implementation priorities focus first on retention of the existing vegetation around the perimeter of the quarry lots because of their buffer function. It is important to protect and improve the vitality of these areas. These buffers screen quarry operations, encourage natural regeneration, manage runoff and assist erosion control while helping to reduce dust and noise transmission, which are key public concerns.

The second priority is to manage the haul road construction and lease preparation processes. It is important to salvage all strippings for use in reclamation. Since the organic soil layer is so thin, it is not necessary to try and screen out the topsoil but rather it is more beneficial to keep the strippings intact to assist with moisture retention. Once the quarry road has been constructed the right-of-way needs to be revegetated as soon as possible to discourage invasive species, manage run-off, and assist with dust control.

Leaseholders are encouraged not to clear and grub their entire lease areas as part of the initial site preparation process but rather to retain the surface vegetative mat as long as possible so site preparation proceeds in tandem with extraction and production. The advantage of this approach is that it helps retain moisture, reduce erosion and manage dust transmission. Strippings should be stockpiled in one location so they can be drawn upon as needed for progressive reclamation. A soil test of the strippings will provide the leaseholder with direction on what they can do to enhance the productivity of the strippings for use in reclamation. The soil test will also provide an indication of what fertilizers should be used as well as appropriate fertilizer and seeding rates to promote plant growth.

The third priority reflects the needs of the three different pit frontages. The western **backslopes** are extremely sensitive to disturbance. There is little understory below the regenerating pines. Thinning and the application of fertilizers will help promote growth (**Figure 5**). Since the quarry is designed to allow all pit operators to start from the each face of the ridge and move westward excavating into the ridge, this will be the last area disturbed.

The **frontslopes** of the quarry include the east and southeast faces of the hills where extraction will start (**Figure 6**). Stabilizing slopes greater than 15% is always labour intensive. Again, maintaining the vegetative mat as long as possible on steeper slopes is the best management practice for site management, safety and future reclamation reasons. During reclamation activities along the haul road and within the leases where slopes are less than 15% the ground can be ridged by walking a bulldozer across the slope. The cat tracks scarify the surface to a depth of 30-50mm creating moisture and seed traps for windblown seedlings. These slopes can be seeded with summer drought resistant species. A successful mixture for dry sites has included (Vaartnou 1992):

- 30% Smooth brome *(Bromus inermis)*
- 30% Sheep fescue *(Festuca ovina)*
- 30% Violet & Slender wheatgrass *(Agrpyron violaceum & Agropyron trachycaulum)*
- 10% Bentgrass *(Agrostis spp.)*

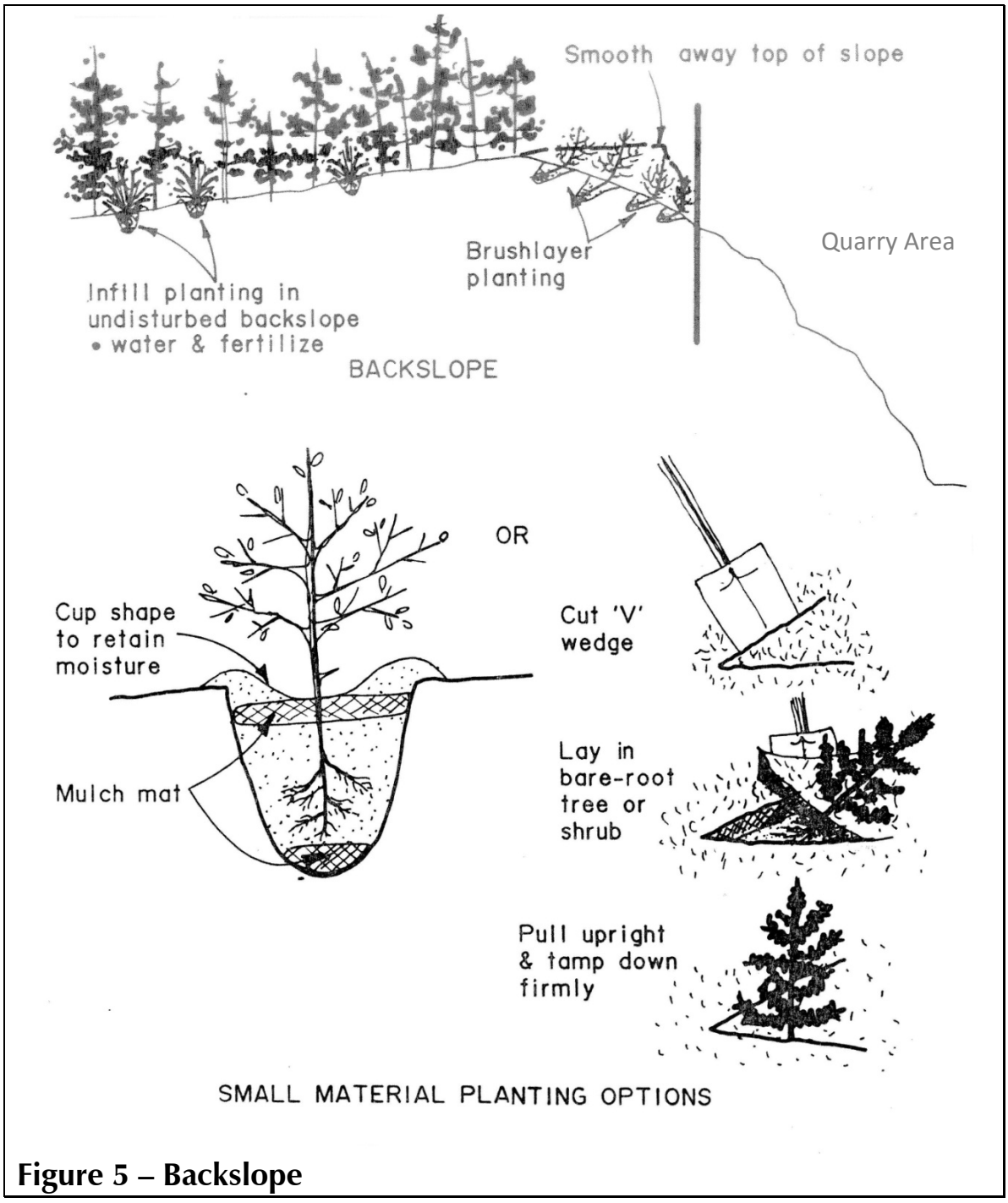


Figure 5 – Backslope

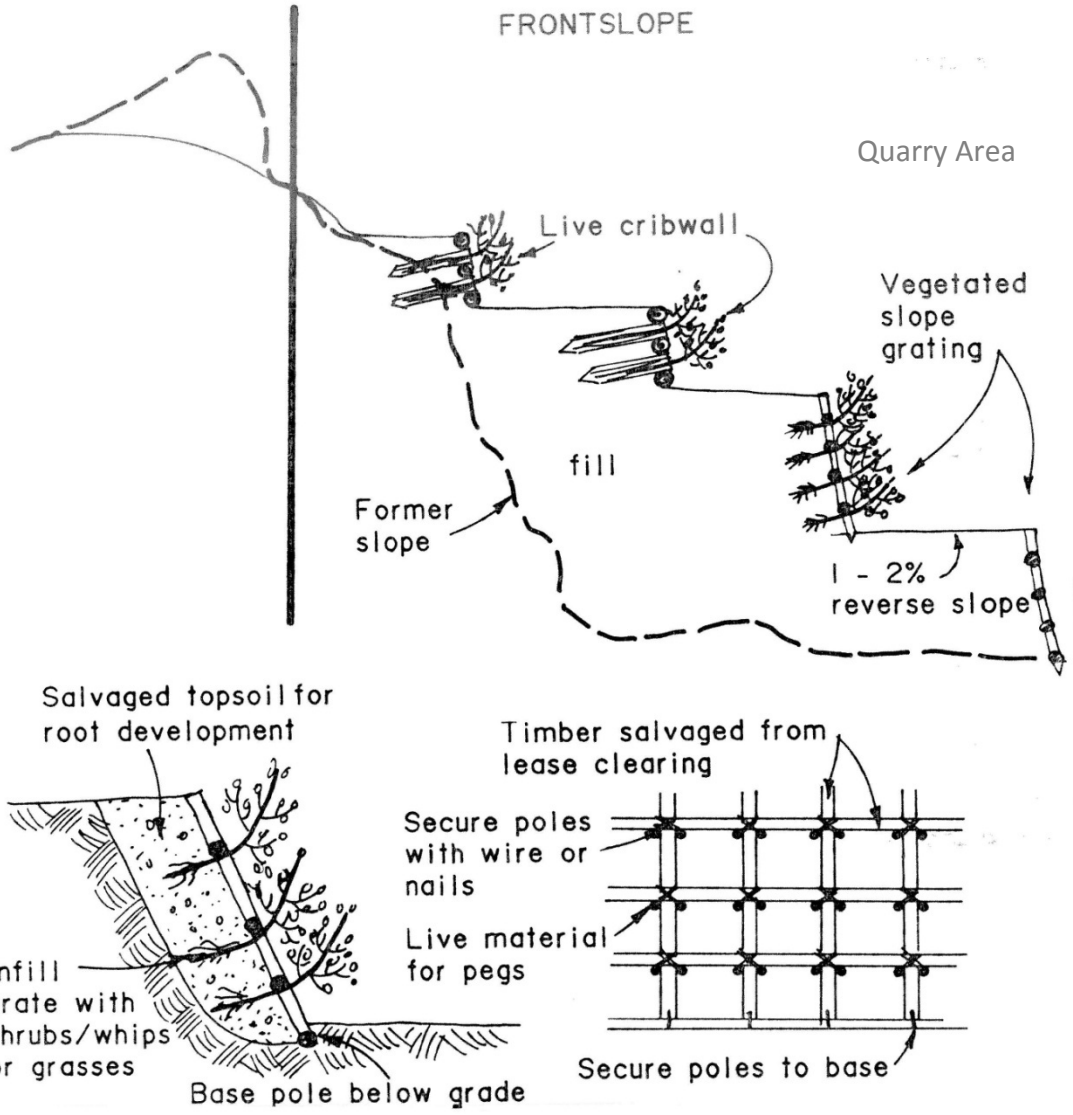


Figure 6 – Frontslope

Where slopes exceed 15%, previous test site experience by Highways & Public Works suggest terracing is often the most effective process in encouraging plant regrowth and managing erosion. Given the dry silty-sand site conditions, moisture retention is the main challenge (**Figure 7**).

The terraces should be spaced at no more than 3 m intervals and include a 1-2% reverse to trap moisture. The terraces can be scarified with a mechanical drag or bulldozer as the tracks will trap seed, fertilizer and moisture. As quarry activity eats into the face of the slope drawing material down to grade for pick-up and processing with front end loaders, the terraces required for site reclamation will have to be built from the ground up. Overburden should be replaced at the toe of the slope to a width consistent with the natural angle of repose.

The placement of strippings on these steeper slopes is crucial. Without a minimum 200mm cover, and terracing, revegetation success rates are generally low. The steeper slopes will have to be hand-seeded and are labour intensive. Planting shrub whips into side-slope trenches has been shown to be particularly effective. Once the whips take hold they tend to act as "host" plants creating a complementary growing environment for other species. **Figure 8** illustrates how slopes of less than 10% can be handled.

The **flat work areas** will be heavily compacted and require scarification **(Figure 9)**. Again the surface area should be kept rough to promote moisture retention. If major rocks are removed the area can be re-seeded with a mechanical seed drill. Seed drill methods are more efficient producing higher germination rates while requiring less seed and fertilizer. The areas can also be hydro-seeded with a mulch base, cyclone seeded with a rotary seeder or hand scattered. Seed the area first then apply the fertilizer in separate applications.

Seeding should occur as soon as possible after pit abandonment to keep out noxious weeds and other invasive plants. Fall seeding is acceptable for dry sites such as the south and east facing slopes as the seed takes advantage of snowmelt to promote spring germination. Avoid summer seeding unless repairing small areas.

The shared government pit area could provide an opportunity for the Yukon government to develop a series of reclamation test plots to explore the use of different progressive rehabilitation techniques. Since this pit will be shared by various Yukon departments and the City of Whitehorse it will be important that the agencies work out a common pit operation and management protocol procedures with one agency assigned responsibility for coordination and management of pit operations through site reclamation.

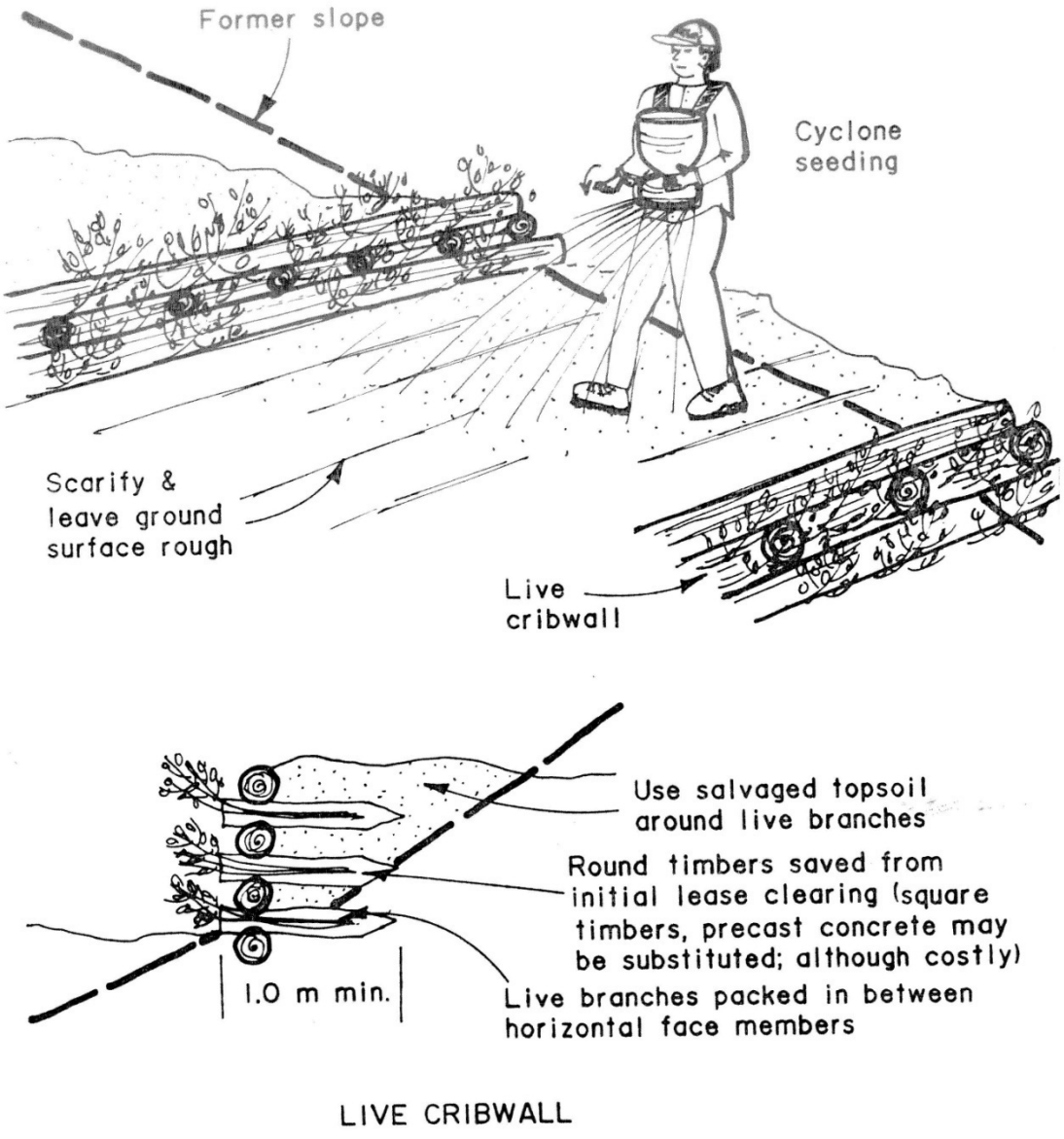
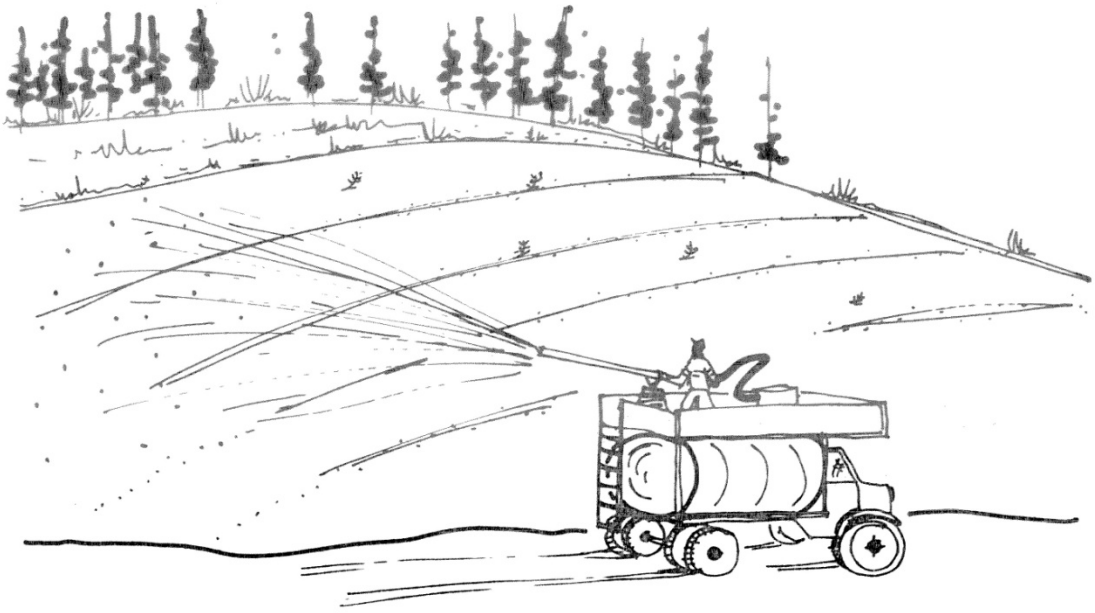
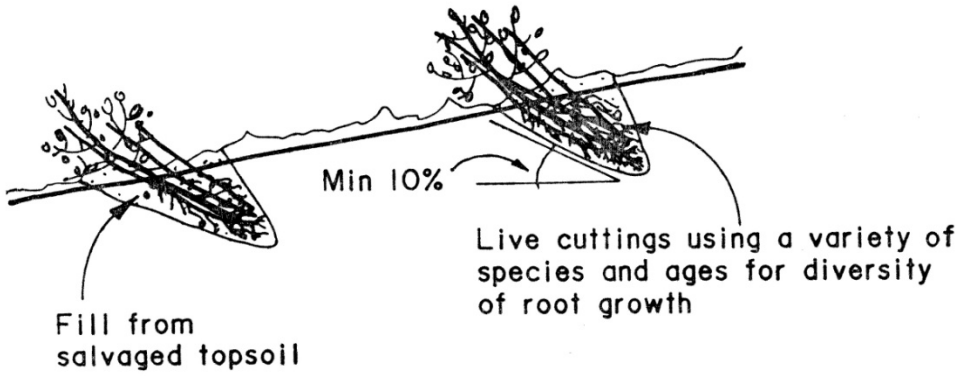


Figure 7 – Hillside Treatment Slopes >15%



Hydroseeding with seed/fertilizer/mulch/water mixture



BRUSHLAYER PLANTING

Figure 8 – Hillside Treatment Slopes <15%

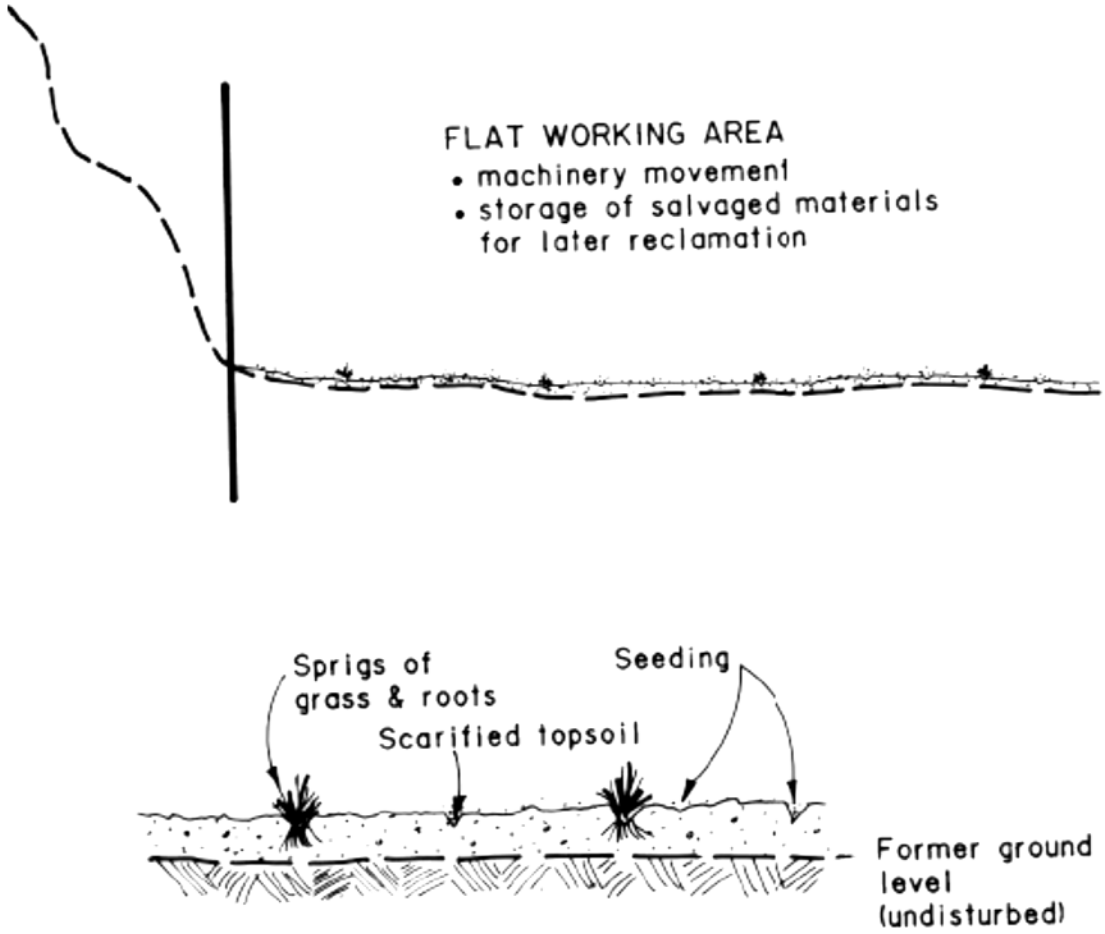


Figure 9 – Flat Work Area

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List of Appendices

APPENDIX 1 – Seed Mixture & Fertilizer Application Rates

APPENDIX 2 – Norwest Soils Sample Reports

Appendix 1 Seed Mixture and Fertilizer Application Rates

Suggested seed mixtures for reclamation are recommended in the manual " *Guidelines for Reclamation /Revegetation in the Yukon*", prepared by Yukon Renewable Resources.

For dry sandy soils in this region:

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	7	Crested wheatgrass *Agropyron cristatum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum*	3
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	3
Canada bluegrass *Poa compressa*	CANON	4	Northern brome *Bromus Pumpellianus*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Alkaligrass *Puccinellia* sp.	COMMON	4	Alkaligrass *Puccinellia* sp.	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yukon lupine *Lupinus Kuschei* Yellow locoweed *Oxytropis campestris*	2 2
Total		32		21

Due to the lack of moisture in this area it is recommended to increase seeding rates of the mixture to at least 50 kg/ha.

It is recommended that bromegrass (Carlton) *Bromus inermis* and Creeping Red Fescue *Festuca rubra* be included in the seeding mixture for this site at an approximate rate of 10-20 %. It is also recommended that Peace alfalfa *Medicaco sp.* be substituted for Rangelander.

Each year the Department of Highways selects a new mix for seeding along the highways, according to availability of seed. The 1994 Seed List for Highway Reseeding in the southeast Yukon - Rancheria-Watson Lake is the following:

Seed Type #1

15 % Timothy	Engmo
10% Smooth brome	Carlton
15 % Sheep Fescue	Common
25 % Creeping Red Fescue	Boreal
10 % Slender Wheatgrass	Revenue
15 % Canada bluegrass	Common
5 % Alfalfa	Rangelander
5 % Alsike Clover	Common

Seed Type #2

20% Slender wheatgrass	Revenue
10 % Timothy	Engmo
15 % Sheep Fescue	Common
25 % Creeping Red Fescue	Boreal
10 % Fowl Bluegrass	Common
8 % Canada bluegrgass	Common
6 % Alfalfa	Rangelander
6 % Alsike Clover	Common

Grasses found to be most successful on drier sites in the Yukon include

- Violet Wheatgrass	*Agropyron vilaceum*
- Glaucous Bluegrass	*Poa glauca*
- Slender Wheatgrass	*Agropyron pauciflorum*
- Brome grass	*Bromus inermis*
- Creeping Red Fescue	*Festuca rubra*
- Crested Wheatgrass	*Agropyron cristatum*

Fertilizers

For fertilizers it is recommeded that separate fertilizers are used for the Nitrogen(N), Phosphorous(P),Potassium (K) and Sulphur (S) requirements. Suggested application rates by fertilizer type are:

Nitrogen (0-0-34)	110-134 lbs/acre
Phoshprous (12-55-0)	18- 49 lbs/acre
Potassium (0-0-60)	18-72 lbs/acre
Sulphur (21-0-0-21)	11-20 lbs/acre

The recommendations for fertilizer for each of the four soil samples are indicated in the soil test analysis. The average to excellent rate for yields should be used. Fertilizers should be well blended before application to ensure the best nutrient availability.

Seeding and Fertilizing

The following guidelines are suggested:

- Reseeding should be done at the earliest opportunity in a progressive rehabilitation program
- Delayed seeding allows for invasion of noxious weeds
- Optimum results are obtained by using a seed drill in level areas.
- Broadcast seeding with a hydroseeder, or cyclone spreader is suitable for rougher terrain. Hand broadcasting is necessary on rough terrain.
- Avoid summer seeding except if absolutely necessary. Areas seeded in the summer usually need a follow up seeding the next spring.
- For optimum results the area should be covered twice, first with fertilizer, then with seed.
- If fertilizer and seed are added together ensure that they are mixed thoroughly to facilitate proper placement.

Mulch

A hay/straw mulch can be applied with a straw blower after seed and fertilizer are applied. This can be done at a rate of 3000 kg/ha. Mulch is often held in place by organic tackifiers (Terra Tack II) Apply mulch to all slopes exceeding 27 degrees (2.1 slope).

APPENDIX 2 – Norwest Soils Sample Reports

9938-67 Avenue
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NORWEST LABS

(403)438-5522
(403)438-0396fax

W.O. NUMBER: 4 79848
PAGE: 1 of 4
LAB NUMBER: 166787

IAN ROBERTSON
INUKSHUK PLANNING & DEV.
28 KETZA ROAD
WHITEHORSE, YK
Y1A 3V8

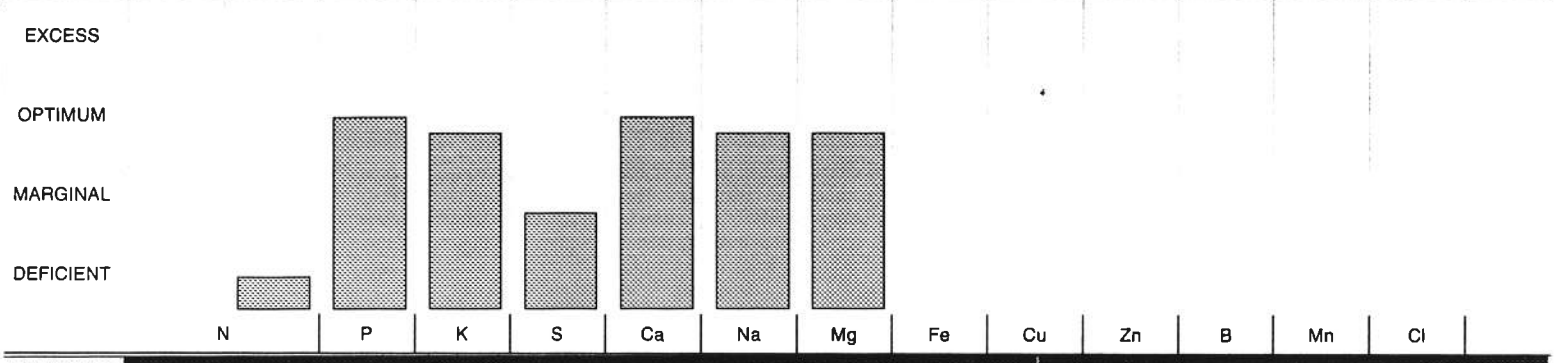
IAN ROBERTSON
SAMPLE: GP#1

SAMPLE RECEIVED: 12 MAY 94
ANALYSIS COMPLETED: 16 MAY 94 13:16
SAMPLE RETAINED UNTIL: 16 JUN 94
FOR INFORMATION CALL: Doug Keyes
AT: 1-800-661-7645
or 403-438-5522

client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		<1	35	134	3	1120	6	75						
TOTAL LBS./ACRE		<2	70	268	5									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**71**	**268**	**10**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)		E.C.(SALINITY)		ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.1	(Normal)	0.2	(O.K.)	1.5				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.8	132	24	24	15
Average	2.8	112	18	18	13
Low	2.0	92	15	15	10

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 94.4 %
(Ca: 85.0% Mg: 9.39% Na: 0.37% K: 5.21%)
Buffer pH: 7.0
On high K soils, crops may respond to 0-0-60 due to chloride or to decreased root disease.
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

These recommendations are given as a management tool based on general research consensus. They should not replace prudent and responsible judgment.

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IAN ROBERTSON
SAMPLE: GP#2

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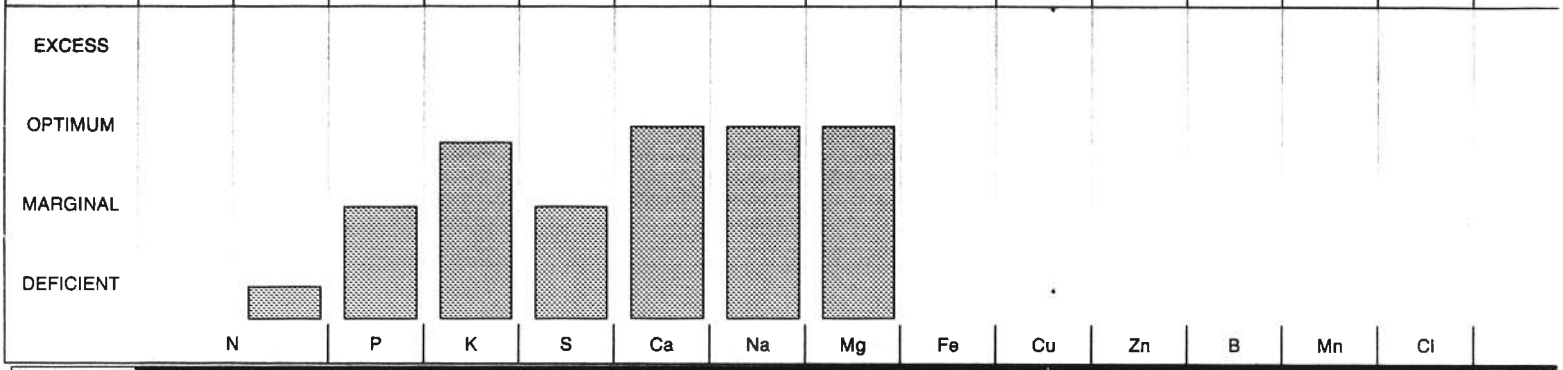
client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		2	14	142	3	1950	9	189						
TOTAL LBS./ACRE		4	27	284	6									
ESTIMATED AVAILABLE LBS./ACRE		**8**	**27**	**284**	**12**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.3 (Normal)	0.2 (O.K.)	3.9				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.7	130	49	24	14
Average	2.8	110	41	18	11
Low	2.0	90	34	15	10

These fertilizer rates are for broadcast application.

COMMENTS

- This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 96.5 %
(Ca: 83.2% Mg: 13.3% Na: 0.35% K: 3.10%)
Buffer pH: 7.0
On high K soils, crops may respond to 0-0-60 due to chloride or to decreased root disease.
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

- These recommendations are given as a management tool based on general research consensus. They should not replace prudent and responsible judgment.

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IAN ROBERTSON
SAMPLE: GP#3

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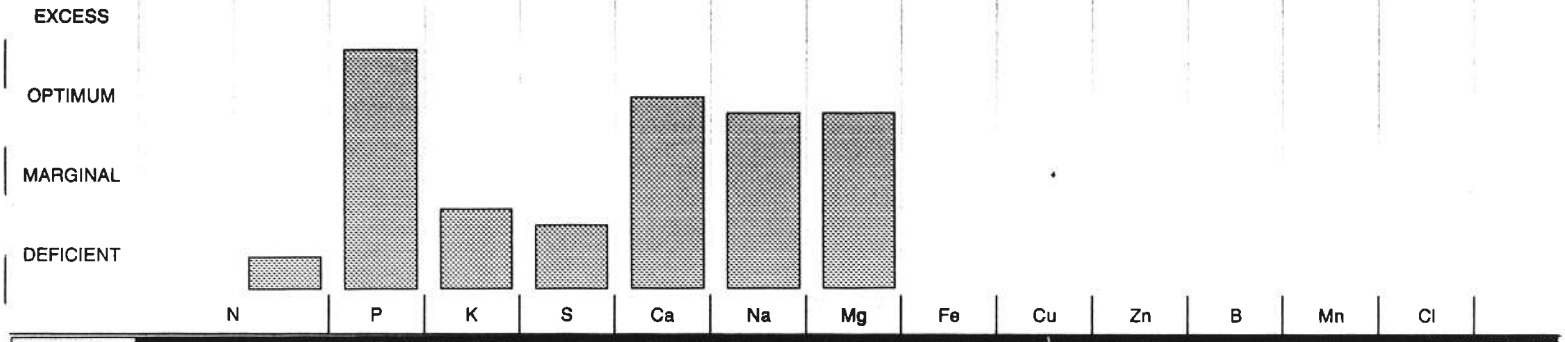
or 403-438-5522

client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		<1	56	71	1	1050	6	108						
TOTAL LBS./ACRE		<2	111	141	2									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**111**	**141**	**4**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.2 (Normal)	0.1 (O.K.)	<1.0				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.8	134	0	72	20
Average	2.9	114	0	64	16
Low	2.0	90	0	56	13

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 96.8 %
(Ca: 82.8% Mg: 13.9% Na: 0.40% K: 2.85%)
Buffer pH: 7.0
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

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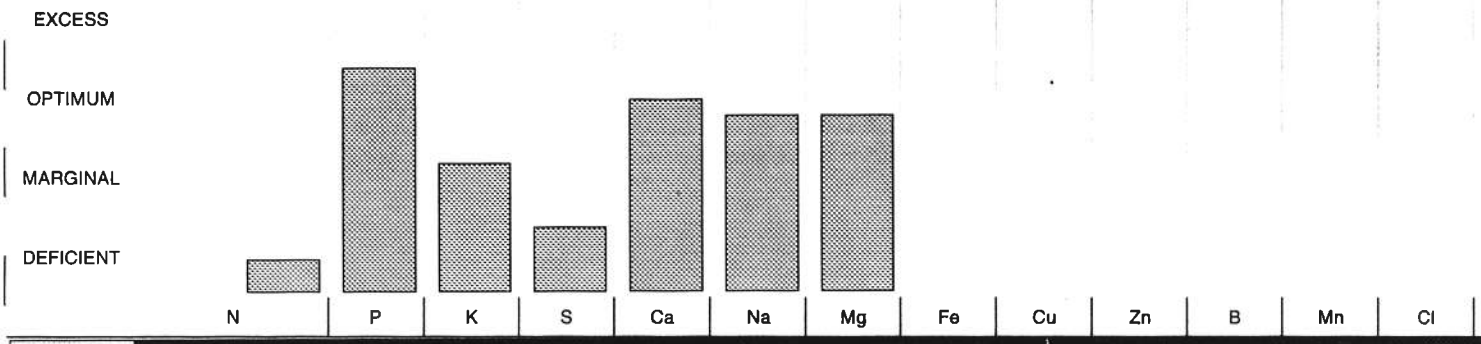
client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0- 6"		<1	50	104	<1	899	5	103						
TOTAL LBS./ACRE		<2	99	208	<2									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**99**	**208**	**4**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0- 6"	7.4 (Normal)	0.1 (O.K.)	<1.0				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.7	130	24	46	19
Average	2.8	112	18	38	16
Low	2.0	90	15	30	13

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 94.9 %
(Ca: 79.8% Mg: 15.1% Na: 0.36% K: 4.73%)
Buffer pH: 7.0
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

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IAN ROBERTSON
SAMPLE: GP#1

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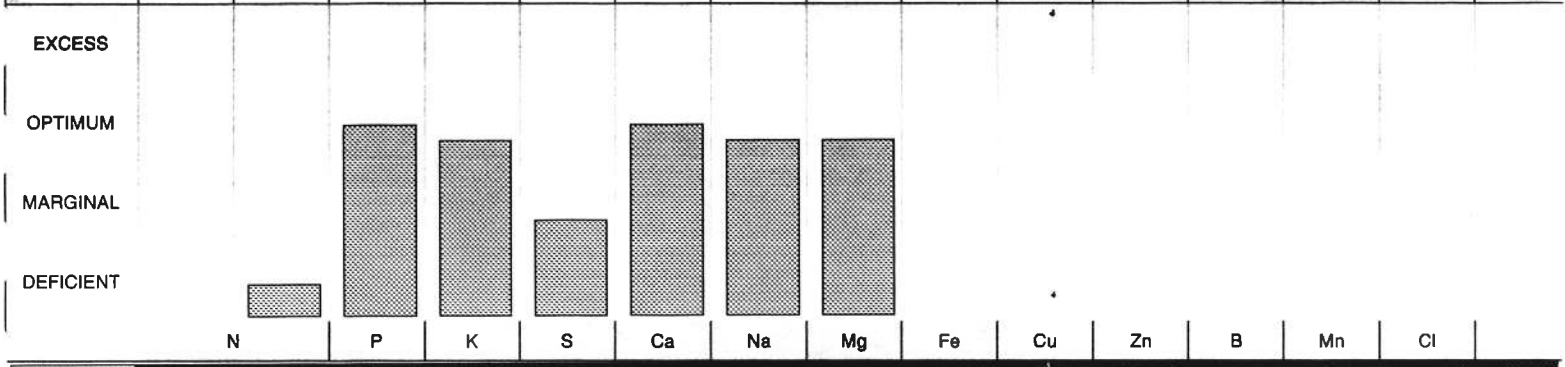
NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		<1	35	134	3	1120	6	75						
TOTAL LBS./ACRE		<2	70	268	5									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**71**	**268**	**10**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.1 (Normal)	0.2 (O.K.)	1.5				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.8	132	24	24	15
Average	2.8	112	18	18	13
Low	2.0	92	15	15	10

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 94.4 %
(Ca: 85.0% Mg: 9.39% Na: 0.37% K: 5.21%)
Buffer pH: 7.0
On high K soils, crops may respond to 0-0-60 due to chloride or to decreased root disease.
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

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PAGE: 2 of 4
LAB NUMBER: 166788

IAN ROBERTSON
INUKSHUK PLANNING & DEV.
28 KETZA ROAD
WHITEHORSE, YK
Y1A 3V8

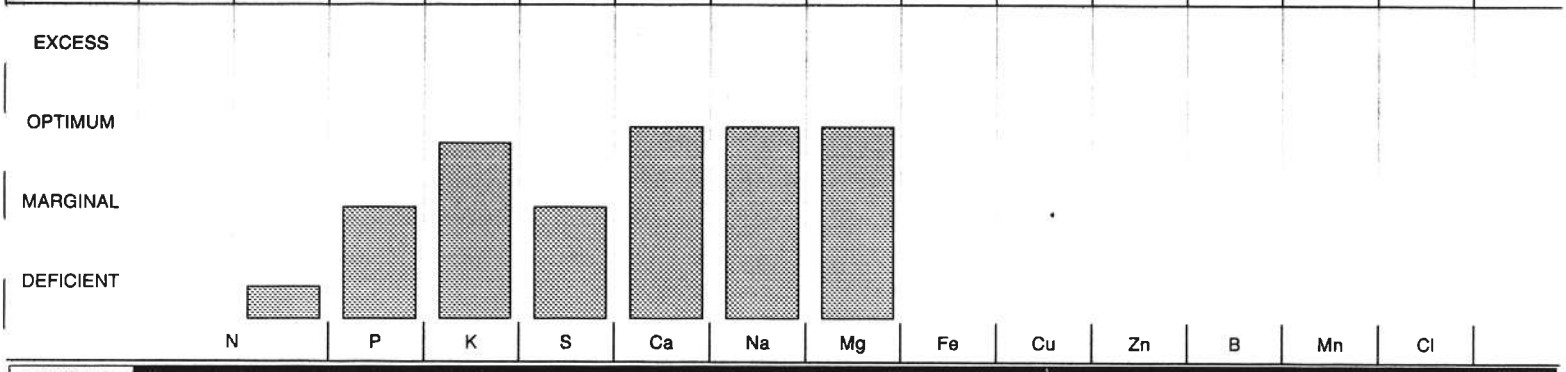
IAN ROBERTSON
SAMPLE: GP#2

SAMPLE RECEIVED: 12 MAY 94
ANALYSIS COMPLETED: 16 MAY 94 13:16
SAMPLE RETAINED UNTIL: 16 JUN 94
FOR INFORMATION CALL: Doug Keyes
AT: 1-800-661-7645
or 403-438-5522

client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		2	14	142	3	1950	9	189						
TOTAL LBS./ACRE		4	27	284	6									
ESTIMATED AVAILABLE LBS./ACRE		**8**	**27**	**284**	**12**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.3 (Normal)	0.2 (O.K.)	3.9				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N lbs/ac	P_2O_5 lbs/ac	K_2O lbs/ac	S lbs/ac
Excellent	3.7	130	49	24	14
Average	2.8	110	41	18	11
Low	2.0	90	34	15	10

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 96.5 %
(Ca: 83.2% Mg: 13.3% Na: 0.35% K: 3.10%)
Buffer pH: 7.0
On high K soils, crops may respond to 0-0-60 due to chloride or to decreased root disease.
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

These recommendations are given as a management tool based on general research consensus. They should not replace prudent and responsible judgment.

9938-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST LABS
(403)438-5522
(403)438-0396fax

W.O. NUMBER: 4 79848
PAGE: 3 of 4
LAB NUMBER: 166789

IAN ROBERTSON
INUKSHUK PLANNING & DEV.
28 KETZA ROAD
WHITEHORSE, YK
Y1A 3V8

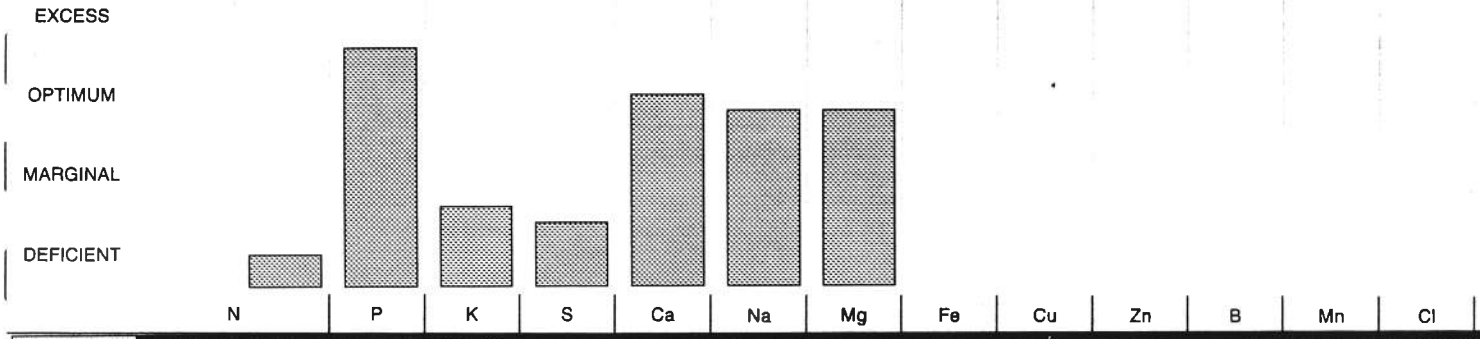
IAN ROBERTSON
SAMPLE: GP#3

SAMPLE RECEIVED: 12 MAY 94
ANALYSIS COMPLETED: 16 MAY 94 13:16
SAMPLE RETAINED UNTIL: 16 JUN 94
FOR INFORMATION CALL: Doug Keyes
AT: 1-800-661-7645
or 403-438-5522

client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		<1	56	71	1	1050	6	108						
TOTAL LBS./ACRE		<2	111	141	2									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**111**	**141**	**4**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.2 (Normal)	0.1 (O.K.)	<1.0				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.8	134	0	72	20
Average	2.9	114	0	64	16
Low	2.0	90	0	56	13

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 96.8 %
(Ca: 82.8% Mg: 13.9% Na: 0.40% K: 2.85%)
Buffer pH: 7.0
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

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Edmonton,AB
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NORWEST LABS

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W.O. NUMBER: 4 79848
PAGE: 4 of 4
LAB NUMBER: 166790

IAN ROBERTSON
INUKSHUK PLANNING & DEV.
28 KETZA ROAD
WHITEHORSE, YK
Y1A 3V8

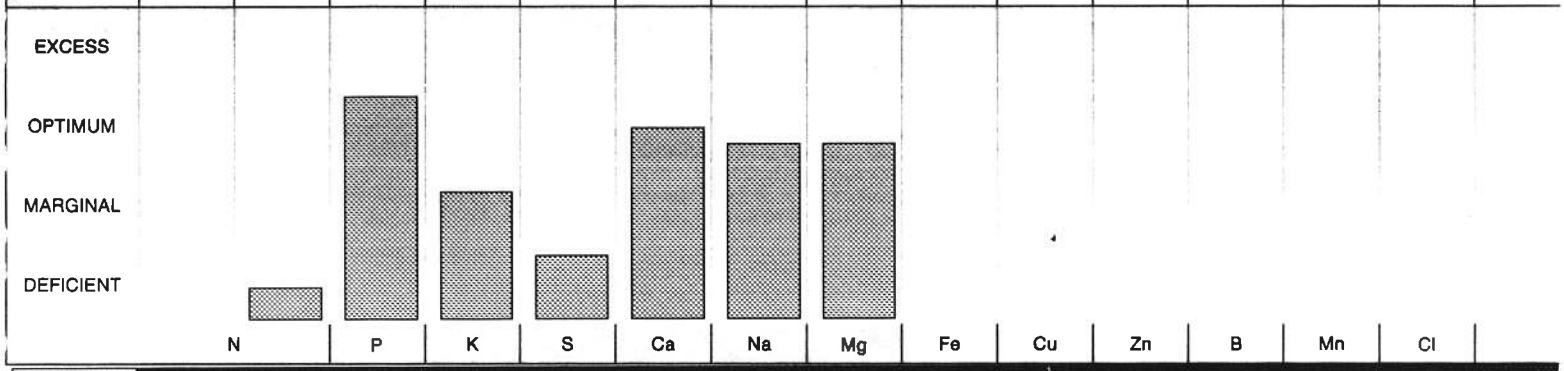
IAN ROBERTSON
SAMPLE: GP#4

SAMPLE RECEIVED: 12 MAY 94
ANALYSIS COMPLETED: 16 MAY 94 13:16
SAMPLE RETAINED UNTIL: 16 JUN 94
FOR INFORMATION CALL: Doug Keyes
AT: 1-800-661-7645
or 403-438-5522

client number: 5774 fax:FAX4036674759 phone:

NUTRIENT ANALYSIS (P.P.M.)

SAMPLE DEPTH	AMMONIUM-N	NITRATE-N	PHOSPHATE	POTASSIUM	SULPHATE-S	CALCIUM	SODIUM	MAGNESIUM	IRON	COPPER	ZINC	BORON	MANGANESE	CHLORIDE
0-6"		<1	50	104	<1	899	5	103						
TOTAL LBS./ACRE		<2	99	208	<2									
ESTIMATED AVAILABLE LBS./ACRE		**4**	**99**	**208**	**4**									



SOIL QUALITY

SAMPLE DEPTH	pH (ACIDITY)	E.C.(SALINITY)	ORGANIC MATTER %	Sand %	Silt %	Clay %	TEXTURE
0-6"	7.4 (Normal)	0.1 (O.K.)	<1.0				

MICRONUTRIENTS

No micronutrient analysis requested.

RECOMMENDATIONS

HAY-GRASS

GROWING CONDITION	YIELD (T(DM))	N	P_2O_5	K_2O	S
		----lbs/ac----			
Excellent	3.7	130	24	46	19
Average	2.8	112	18	38	16
Low	2.0	90	15	30	13

These fertilizer rates are for broadcast application.

COMMENTS

This recommendation is made for soil: Peace
The previous crop was UNKNOWN
Estimated Base Saturation: 94.9 %
(Ca: 79.8% Mg: 15.1% Na: 0.36% K: 4.73%)
Buffer pH: 7.0
Recommended application rates are based on seed placed or banded fertilizer efficiencies unless otherwise indicated.
The method of application, however, is left to your discretion. The total amount can not necessarily be placed with the seed!

These recommendations are given as a management tool based on general research consensus. They should not replace prudent and responsible judgment.