RM AGGREGATE RESOURCE MANUAL

SARM

Saskatchewan Association of Rural Municipalities

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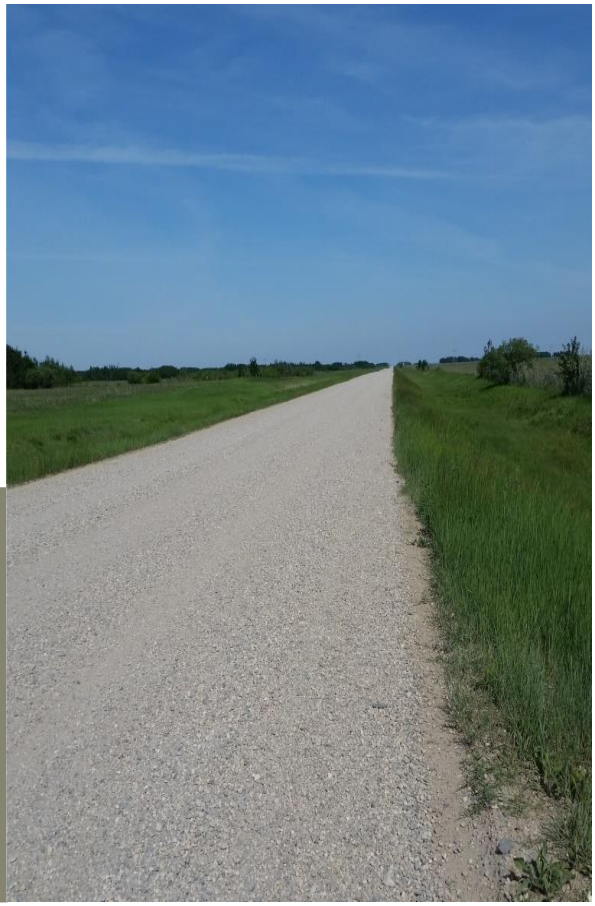
1. INTRODUCTION



The Saskatchewan Association of Rural Municipalities (SARM) is the independent association that represents the interests of rural municipal government in Saskatchewan and is the principal advocate in representing them before senior governments. The Association takes direction from its members and forms its policy accordingly. SARM proudly represents all 296 RMs and has been the voice of rural Saskatchewan since its incorporation in 1905.

Gravel is a non-renewable resource that is necessary for a variety of different initiatives, notably infrastructure construction and maintenance. It is inevitable that local supplies will eventually be exhausted thus it is important to find the means to extend the life of the fixed supply through better management of existing gravel stocks, along with new technologies, processes and practices in constructing and maintaining rural infrastructure.

SARM commissioned a report, Got Gravel, which studied the current state of aggregate resources in Saskatchewan and developed strategies for Rural Municipality sustainable gravel resource management. Additionally, historical information, legislation and some best management practices were discussed.

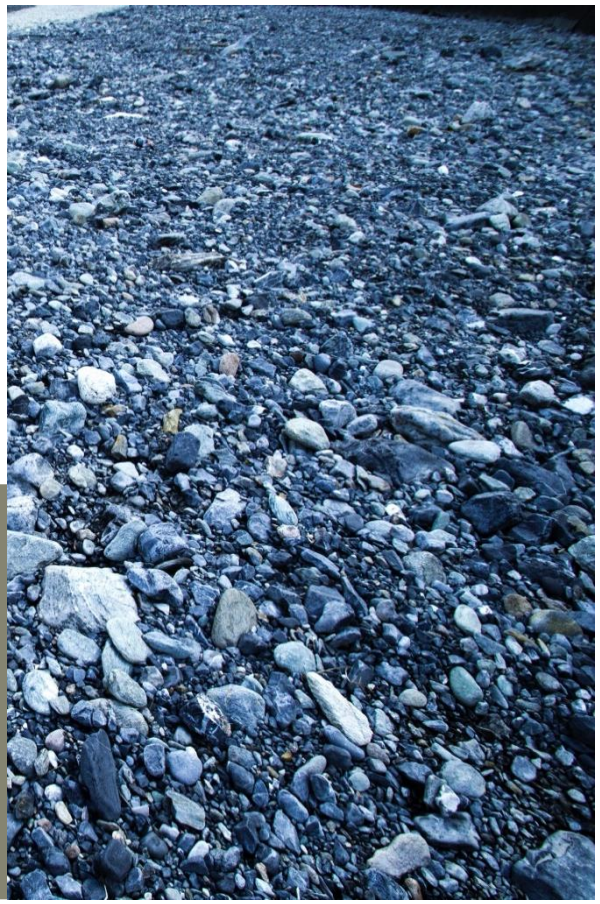
Rural roads are the backbone of the Saskatchewan economy and this Aggregate Resource Manual provides a strategic foothold in managing the long-term aggregate resource issue in the province.

MANUAL RATIONAL AND APPROACH

The manual seeks to assist the Rural Municipalities of Saskatchewan in the overall management of aggregate resource in Saskatchewan. The manual provides information on current outlook for aggregate, best practices, various elements of the aggregate management cycle and costing. Finally, the manual provides tools and templates for all elements of the Aggregate Resource Manual and the manual also includes a Cost-Benefit Analysis model that RMs can use to consider options in areas including gravel supply, innovation and service delivery.

Through a Request for Proposals process, McNair Business Development Inc. (McNair) and WSP Canada (WSP) were chosen as the successful proponents (the "project team") for the development of the manual. The approach included stakeholder engagement through consultation with municipal, provincial and landowner stakeholders and analysis of new and existing data (discussed below). In addition to the stakeholder engagement, there was primary and secondary research completed.

2. AGGREGATE IN SASKATCHEWAN



2.1 Aggregate Management Issues in Saskatchewan

The development of the Aggregate Resource Manual included a focus on engaging with Rural Municipalities throughout the project. In total, the project team engaged with nearly 100 RMs through a variety of different engagement strategies including:

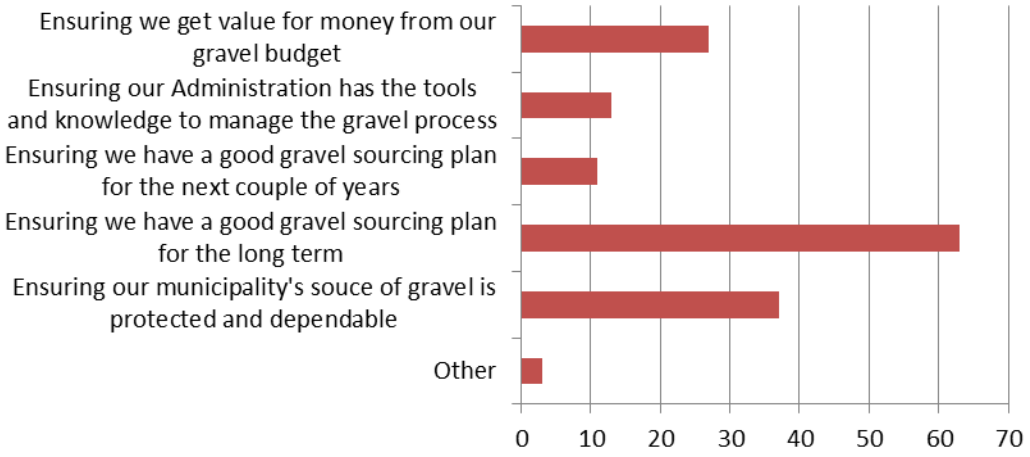
- Direct one-on-one interviews with 9 RMs from across the province discussing the changing landscape of gravel management and sourcing, partnerships, concerns of RMs with respect to gravel and discussing expectations for the manual.
- Survey responses from 93 RMs to get feedback on key aggregate management issues and allow for direct comments on the top issues facing their RM.
- A group session at the SARM Mid-Term Convention with representatives from 15 different RMs with dialogue of key issues and opportunities in aggregate management.
- A twenty minute presentation at the SARM Annual Convention in March 2018.

Based on findings from engagement, the main issue facing Saskatchewan RMs is decreasing supply of aggregate. Not only is the supply decreasing, but there is an increase in demand as well, especially around major centres and areas experiencing high levels of economic activity. For example, the Regina Bypass project drastically increased the demand for gravel in Regina and surrounding area, which depleted local supplies. Additionally, it is becoming more common for private contractors to purchase land or sign land agreements with private landowners to secure their required supply for their commercial use as they naturally look for stability and business opportunities. It was noted that often these organizations have much more financial resources and typically will outbid an RM in negotiations for these aggregate sourcing opportunities. This has led some RMs to consider innovative strategies when it comes to sourcing gravel. One RM noted that they have gone from one year tenders to multi-year tenders, while several others noted that they have had to start considering the purchase of land when in the past that had never been a consideration.

"Cost is the greatest issue, it has blown us away." ~ *Saskatchewan Rural Municipality*

A survey was deployed in the development of the Aggregate Resource Manual to get a sense of an RM's top priority related to gravel. One of the survey questions asked RMs for their 'Primary Concerns Related to Gravel' with results highlighted in the table below:

Primary Concerns Related to Gravel, as Reported by RMs



The results noted above aligned with feedback gathered during subsequent one-one-one engagements with over two-thirds (67%) of respondents to the question above noting that ensuring a good gravel source plan for the long term is a primary concern. The lack of long-term sourcing plans has led to a variety of issues for RMs with the most prevalent being the major increases in costs that are being experienced.

> "There is so little aggregate around that we cannot even tender for it."
> ~ *Saskatchewan Rural Municipality*

In addition to the focus on a long term sourcing plan, RMs highlighted the importance of a protected and dependable gravel source and the need to get value for money, with short-term concerns and administration issues being comparatively less important. The following is a quote from an RM that captures the many different streams some RMs must use to meet their demands:

> "We've purchased gravel from private contractors on a per yard crushed basis and also from private land owners. We've purchased gravel from adjacent RMs when asphalt contractors are set up in their pits rather than setting up another asphalt plant in our RM. MHI lets us know when they have crown land they've explored that has gravel potential but they won't be developing. We've also shared road construction costs with First Nation communities where we take gravel and clay instead of cash when constructing roads."
> ~ *Saskatchewan Rural Municipality*

Additional issues regarding the future for aggregate supply in Saskatchewan largely loomed around the current state and future of hauling. The dramatic increase in road traffic over the last several decades has created large issues for RMs. Increased traffic and heavier loads are creating more wear and tear on roads and increasing demand for maintenance and gravel. The increased demand for gravel due to traffic coupled with depleting aggregate supplies is leading to longer haul distances; and, gravel hauling by trucks with heavy loads puts stress on roads and actually contributes to the problem it is trying to alleviate. Road haul agreements have proved insufficient for compensating for the impacts of bulk hauling as compensation amounts are insufficient and they are difficult

to enforce. This has created an environment where RMs are stuck trying to manage cost escalation on both the supply and demand side of aggregate management.

"Gravel is the number one thing we do. Roads are our responsibility and maintenance revolves around gravel." ~ *Saskatchewan Rural Municipality*

Cooperation among RMs could provide opportunities to get better information on gravel sourcing opportunities, various costs related to aggregate management and the use of innovative materials and management techniques, but there are some barriers to cooperation. RMs often compete among themselves for aggregate sources and some RMs believe it best to keep most information related to gravel in their area confidential in order to best protect the interests of their ratepayers. Additionally, there is a natural separation of "have" and "have nots" among RMs with some having abundant supplies or gravel and others having little to no supply. RMs with abundant gravel need to establish a sound aggregate management plan, but don't face the same pressures and uncertainty in creating a long-term gravel supply plan relative to those RMs with no gravel. Despite these natural conflicts, there are some clusters of RMs that do collect, aggregate and share data to support increased knowledge among RMs in their area. Additionally, Saskatchewan RMs have a natural tendency to support neighbours and other RMs, so increased partnership and information sharing represents a strong area of opportunity.

"If another RM called to partner, we'd be there in a heartbeat, along with the other adjacent RMs"; "We would not consider (partnerships with other RMs)"
~ Two Saskatchewan RMs on their desire to work with others

2.2 Regulatory Considerations

The following federal and provincial Acts may apply to an aggregate development depending on the location, land ownership, project size and environmental sensitivities located at or immediately adjacent to the project location (Table 1-1).

Potentially Applicable Environmental Legislation

Legislation	Agency	Permit	Notes
Federal			
Canadian Environmental Assessment Act 2012	Variable, depends on landowner and type/size of project	N	*Canadian Environmental Assessment Act 2012* applies to projects described in the Regulations Designating Physical Activities and to projects designated by the Minister of the Environment.
Species at Risk Act	Variable, Depends on the Federal Agency but is also applied through Provincial regulatory permits	N	The *Species at Risk Act* (*SARA*) prohibits the killing, harming, harassment, possession, capturing or taking of a species listed as extirpated, endangered or threatened; the damage or destruction of a residence or the destruction of any part of the critical habitat of such a listed species, unless authorized by the Minister who is responsible for the species in question.

Legislation	Agency	Permit	Notes
Fisheries Act	Fisheries and Oceans Canada	Self-Assessment or formal Request for Review, or Section 35 approval.	The *Fisheries Act* requires that projects avoid causing serious harm to fish unless authorized by the Minister of Fisheries and Oceans Canada. This applies to work being conducted in or near waterbodies that support fish that are part of or that support a commercial, recreational or Aboriginal fishery.
Migratory Bird Convention Act, 1994	Environment and Climate Change Canada	N	Migratory birds, their nests, and eggs, are legally protected under the federal *Migratory Birds Convention Act, 1994*
Provincial			
Environmental Management and Protection Act, 2010	Water Security Agency	Aquatic Habitat Protection Permit and Drainage Permit	Protects the air, land and water resources of the province through regulating and controlling potentially harmful activities and substances.
Environmental Assessment Act	Ministry of Environment	N	Provides a practical means to ensure that development proceeds with adequate environmental safeguards and in a manner broadly understood by and acceptable to the public through the integrated assessment of environmental impact.
The Wildlife Habitat Protection Act	Ministry of Environment	N	Provides for the management, conservation and protection of wildlife lands and wildlife by preventing the sale and alteration of certain Crown lands.
The Heritage Property Act (1980)	Heritage Conservation Branch (HCB), Ministry of Parks, Culture and Sport	Y – Clearance Letter	*The Heritage Property Act (1980)* is the primary statue for protecting, conserving and developing heritage property in Saskatchewan.
The Wildlife Act, 1988	Ministry of Environment	N	Prohibits the willful destruction or disturbance of any bird, nest, or eggs of any species protected pursuant to *The Wildlife Act 1998*

2.2.1 HERITAGE RESOURCES

Through *The Heritage Property Act* Section 63(1), 1980, the Province of Saskatchewan mandates that any activity that may result in the damage, alteration or destruction of a heritage property may be subject to an archaeological investigation. Heritage resources are deemed Crown property and include, but are not limited to, archaeological sites, built heritage sites, structures of historical or architectural significance and palaeontological sites.

The Saskatchewan Heritage Conservation Branch (HCB) has based their screening criteria on a number of well-documented factors common to locational characteristics of heritage sites. With topography taken into consideration, parcels of native prairie are considered a primary candidate for demonstrating high archaeological potential as they have not been subject to the destruction of agricultural practices or development, allowing for the preservation of archaeological sites. This is not to say that lands demonstrating previous

disturbance do not play host to heritage property as many post-contact and pre-contact artefacts have been recorded from within these areas.

Proximity to previously recorded heritage properties is also taken into consideration with regards to direct or nearby conflict with a proposed development. Furthermore, archaeological sites frequently occur in numbers, generally based on their location or proximity to a landform. Previously recorded sites may be used as an indicator of additional cultural material to be present within an area.

Topographic features such as valleys, ridges, hills or escarpments and terrestrial features associated with watercourses are also considered to be areas of high archaeological potential as they provided protection, shelter, sustenance and security.

Ground-disturbance resulting from aggregate extraction has the potential to negatively impact heritage resources. Resource extraction activities are considered to be high impact and may involve, but are not limited to, the following actions: vegetation removal, heavy equipment traffic, aggregate mining and excavation activities, and access construction impacting undisturbed terrain.

The following steps are recommended as part of a comprehensive due-diligence program to support regulatory compliance for any aggregate development in Saskatchewan.

DESKTOP SCREENING

This screening can best be done using the Ministry of Parks, Culture and Sport Developers Online Screening Tool. This online database allows the user to access quarter sections in Saskatchewan that have been reviewed for heritage sensitivity, allowing developers to plan in advance resource projects to reduce the likelihood of a project being in conflict with a heritage resource.

FOLLOW UP HERITAGE RESOURCE FIELD EVALUATIONS

Depending on the location, size of the project and site sensitivity, a range of heritage resource mitigation measures may be required to facilitate development. Mitigation measures will be determined by the HCB through consultation with a licensed archaeologist. Avoidance of heritage resources when discovered is always the preferred mitigation measure, however the HCB can require a wide range of further mitigation measures ranging from:

- A Heritage Resource Impact Assessment (HRIA) completed by a licensed Archaeologist which may include:
  - pedestrian survey
  - shovel test pitting
  - deep test pitting with an excavator
  - or a full excavation if heritage resources are discovered (process and intensity determined through engagement with the HCB)
  - palaeontological studies
- If heritage resources are discovered additional work may be required such as:
  - in-situ artefact recording and mapping
  - cleaning and cataloguing of artefacts and submission to the Royal Saskatchewan Museum

In certain circumstances heritage resource monitoring conducted by a qualified licensed archaeologist may be required during excavation (including during the resource testing phases of the project).

All studies require specific recording and submissions to the HCB for approval and ***HCB clearance issued prior to the initiation of development.***

It should be noted that the discovery of a sensitive heritage resource during the project life may result in project shut down and long term delays while appropriate mitigation measures are developed through engagement with the HCB and implemented by a qualified licensed archaeologist. It is critical that a licensed archaeologist be employed early on in the project planning phase to reduce the risk of these potentially costly shut downs and delays. It is recommended that aggregate developers contact a licensed archaeologist early in the planning and development phase to effectively screen proposed projects for heritage resource sensitivities, conduct required archaeological studies, mitigate for heritage resources discovered on-site, and support compliance to enacted Saskatchewan legislation.

2.2.2 Environmental Considerations

Aggregate extraction, like all land disturbance projects, has the potential to have significant impacts on sensitive ecological features and species if completed without an adequate measure of due diligence and mitigation. Regulatory requirements in Saskatchewan are highly variable depending on the location of the project, land ownership, and size of the project.

The following steps are recommended as part of a due-diligence program to support regulatory compliance for any aggregate development in Saskatchewan.

Desktop Information Review by a Qualified Environmental Scientist

At a minimum the desktop review should be completed prior to the initiation of any exploration program and should be completed by an experienced Environmental Scientist. The Scientist can provide valuable context and understanding of the information pertaining to environmental sensitivities, regulatory requirements, and established and effective mitigation measures that can be used during both exploration and development. The desktop environmental review should be completed prior to exploration activities and depending on the project location, habitats and time lag (e.g. greater than 2 years), between exploration and potential resource extraction the desktop review should be completed again as part of a comprehensive environmental program.

A desktop review of existing information is an important first step in identifying potential environmental sensitivities that may be in conflict with the project. The desktop review can incorporate a wide variety of information sources which may include but are not limited to:

- A review of the project area and the surrounding areas using available databases and literature

- A review of available aerial imagery (recent and historic, wet and dry years, <0.5m resolution)
- Pre-existing environmental reports that may be available

A conservative approach is best used to reduce the risk of potentially long delays due to unanticipated environmental sensitivities.

Regulatory agencies may advise that if there are no detections in the area of rare or listed species that no further mitigation is required. This advice may put your project at risk. Developers should seek the advice of a qualified environmental consultant to aide in evaluating environmental sensitivities if your project is in or directly adjacent to or within the following habitat types and land uses:

- native prairie,
- wetlands (including the generic terms swamp, slough, dugout, lake, pond, seasonal)
- pasture (e.g. there may be high quality habitat that is being used for pasture),
- hayland, or areas considered as "modified" or "improved" prairie
- forested habitats

Available databases and literature will only identify species detections if they have been previously documented and submitted to the Saskatchewan Conservation Data Centre. This data may not be up to date or out of date. A null report does not indicate that species are not present; it only indicates they have not been detected in the area. There is still potential for species to be present that are protected under the various enacted laws and regulations.

PRE-DISTURBANCE SITE ASSESSMENTS (PDSA)

PDSAs are used to identify and evaluate potential environmental sensitivities. At a minimum it is recommended that developers complete a site visit by qualified personnel to confirm and refine the desktop information review. This would include but not be limited to:

- Landscape assessment to determine surface water flow, presence of riparian areas, and existing soil stability issues to aid in siting and determination of additional mitigation that may be required
- Soils assessment to support growth material/soil salvage planning
- Wetland boundary confirmation (if applicable)
- Plant community assessment
- Listed plant survey in suitable habitats and listed plant habitat potential evaluation completed during the plant community assessment. The need for additional survey would be dependent upon the potential listed species and their preferred habitats, project location, available suitable habitat, and connectivity to adjacent patches
- Weed survey to determine the presence of prohibited, noxious, or nuisance species regulated under the Weed Control Act completed during the plant community assessment
- Heritage Resource Impact Assessment (if required as described in the previous section)

POTENTIAL MITIGATION MEASURES

There are a wide variety of additional mitigation measures that may need to be employed during the pre-disturbance site assessments. They depend on the proposed timing of the initial clearing, the scale of the operation, location of project, land ownership and previously identified environmental sensitivities on the project or adjacent to the project location. These may include but are not limited to.

- Avoidance of sensitive areas
- Construction monitoring during work in sensitive areas
- Construction outside of the breeding bird period for the project, or pre-construction breeding bird nest surveys
- Erosion and sediment control plan
- Other wildlife surveys as determined by the likelihood of listed wildlife at the project location and applicable legislation
- Vegetation mitigation plans
- Weed management plan to prevent the introduction or spread of prohibited, noxious, or nuisance species regulated under the Weed Control Act
- Growth material or soil salvage plan to determine the appropriate soils handling and to prevent soil degradation. Soil salvage and storage for later use during reclamation is important for successful reclamation
- Detailed reclamation planning and implementation

Following the measures above will support compliance with enacted legislation and best practices. In addition, reclamation is typically more successful if proper pre-disturbance information is collected and appropriate plans for the project location are in place.

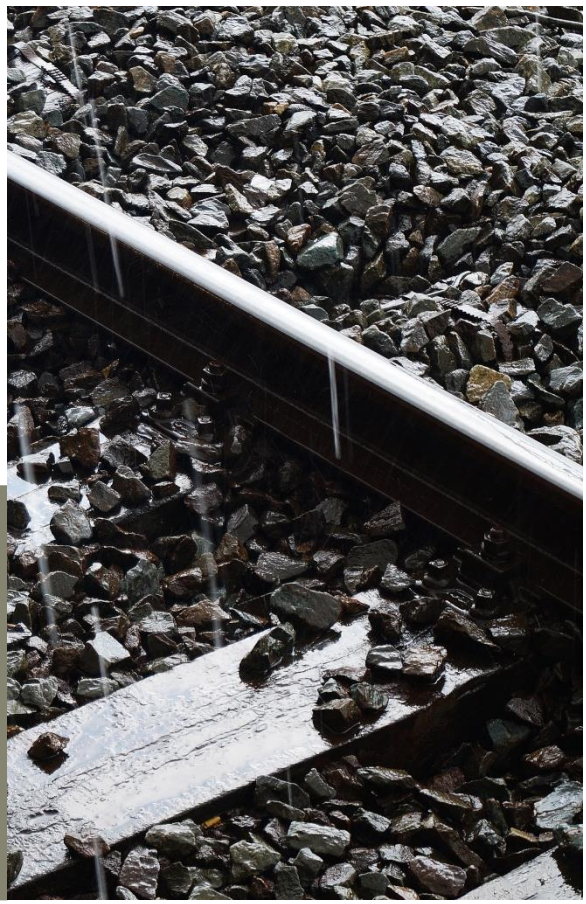
Developers must also be aware that environmental studies such as vegetation or wildlife surveys require the issuance of a Research Permit from the Ministry of Environment to complete such studies. Study methods, timing, weather conditions, and Environmental Scientist experience must meet the requirements outlined in the issued permit. There are also data submission requirements to the Ministry for any collected data.

Certain developments will require the issuance of permits such as aquatic habitat protection permits. Permitting takes time and it is recommended that developers start the planning process early to allow for necessary field studies to be completed, permit applications to be evaluated and permits issued prior to development.

CLARIFICATION ON ENVIRONMENTAL STUDIES

Please note that the desk-top environmental review and the PDSA are not the technical equivalent of a Phase I Environmental Site Assessment (ESA). These are two distinctly different products concerning different environmental considerations. A Phase I ESA is not considered part of a best management practice in this document text. For more on Phase I ESA contact your local environmental consultant to determine the appropriateness of a Phase I ESA for your property.

3. STRATEGIC GRAVEL SUPPLY BEST PRACTICES



3.1 Options for Strategic Gravel Supply

Strategic gravel supply can come from a variety of different resources. RMs have different options available to them and it is not uncommon for an RM to use multiple different sources to cover their aggregate needs. These options include:

- Tendering the entire aggregate process (or certain pieces);
- Obtaining titles to property and running their own pits;
- Obtaining agreements with property owners and running their own pits; and
- Agreements on Saskatchewan crown land.

There are many different factors that go into determining which option to choose, including:

- Availability of aggregate in the area;
- Cost of aggregate in the area;
- Competition for aggregate in the area; and
- Expertise, know-how and capabilities of the RM.

3.1.1 Tender

Tendering is the simplest approach to sourcing aggregate for an RM. It consists of releasing a tender out to private contractors for bids. The tenders outline the amount of aggregate that is required for a given year along with specifications and any other requirements specific to the RM. Although it represents the easiest option, it can often be the most expensive option as the RM is paying the private contractor for their costs plus profit. There is also administrative work required, along with ensuring that the contractor is meeting their obligations as defined in the tender response. Annual aggregate tenders make RMs susceptible to market conditions and regional gravel demand from the private sector or other public sector users will impact cost. Additionally, if there are few private pits in the region, then the RM will have a less competitive environment that reduces its ability to control costs. Conversely, if there are limited regional demands for aggregate due to reduced economic and construction activity, supported by a competitive regional environment, then RMs can get strong pricing through annual tendering.

3.1.2 Purchasing Land

Obtaining the title to a property is another strategy that could be used to secure aggregate. By purchasing the land in which there are aggregate deposits, the RM has full control over the resource and can understand the amount of aggregate available and the expected length of time the aggregate will last. There should be analysis done to ensure that the RM fully understands the amount of aggregate that is available on the land and how it fits into its long term aggregate strategy.

There are risks that may arise with this strategy as well. The first is the cost of the land. Rather than obtaining a lease or tendering, this strategy may require more upfront capital in order to secure the land. This issue can be compounded if there is a high degree of competition in the area where private organizations may have more financial wherewithal to outbid an RM. Secondly, having faulty assumptions on the quality and quantity of aggregate is another major risk. Working with a prospective land owner to conduct

exploration and testing in advance would mitigate this risk, but increased information could also drive up costs if shared with the landowner.

3.1.3 Agreements with Private Landowners

Developing quantity or yardage agreements with private landowners is an alternative option to purchasing private land outright. Quantity agreements work best if the source does not have the quantity to warrant a purchase, if the price of gravel in the area is competitive with purchase, or if the owner prefers to maintain ownership of the land. There are many private aggregate pit owners that operate commercial aggregate supply operations and most often RMs will purchase the aggregate from private sources on a cost per yardage basis. Quantity agreements are generally negotiated on a seasonal or project specific basis in RMs.

There are certain situations whereby a damage agreement is the most viable option for aggregate acquisition. This option is viable when there is going to be a one-time-only removal and the aggregate source does not warrant purchase due to minimal quantity existing at the site. With this scenario a lump sum damage agreement can potentially be negotiated providing the landowner agrees to this strategy and providing the price does not exceed that which would be recognized in a standard quantity agreement.

Annual, or even multi-year agreements, with private landowners provide short-term comfort on gravel supply and allow RMs to have good information about their aggregate source. However, they do not provide any long-term assurances and require formalized legal agreements to provide added assurances to RMs. Additionally, multi-year agreements may run into issues when land is sold to other private parties, even if proper agreements are in place. If market conditions change drastically in a region, a landowner may seek to alter negotiated prices if they are under market rates, so there remains exposure to regional market conditions.

3.1.4 Agreements on Crown Land

RMs can also obtain aggregate through surface control by lease or permit. There are several controllers of crown land including the Ministry of Agriculture, the Ministry of Environment, Ministry of Economy and the Prairie Farm Rehabilitation Administration (PFRA).

In order to obtain a lease for land through the Saskatchewan Ministries, the RM must complete and submit an application to the Ministry. These applications differ depending on the Ministry but allow for surface control and can last anywhere between one and 21 years. Each application requires information on the land area, the expected aggregate to be excavated and remediation plans. Please consult with the agencies directly in order to ensure all requirements have been met.

OWN VS. LEASE VS. TENDER – KEY CONSIDERATIONS

There is no right or wrong answer for a RM in determining its approach to developing an aggregate supply strategy based on purchasing land with a strong aggregate resource, entering into agreements with private landowners, securing a lease on crown land or tendering out gravel supply on an annual basis. The optimal solution for a particular RM will depend on gravel availability within the RM and in the region as a whole, forecasted economic activity that will impact gravel demand, financial priorities of a municipality and level of competition for gravel supply in the area. However, from a risk mitigation perspective, securing a long-term strategic supply of gravel through ownership or a long-term lease would reduce access concerns, reduce volatility due to economic activity and provide more predictability in RM cost planning. Consider the following strategic questions:

- Would the RM be willing to pay a small cost premium if it protected against major price shocks due to economic expansion? Consider that some RMs experienced up to 200% price escalation over a short period of time following the major economic boom time.
- Would going through the exploration process, securing a gravel supply and developing and managing a gravel pit provide useful information and know-how for the RM that would further contribute to efficient and effective gravel management long-term?

In areas with abundant gravel and/or abundant Crown lease opportunities, all options will likely provide good value but the cost of land may be prohibitive. However, in areas of current or impending gravel shortages, or areas that could experience considerable economic and traffic expansion, it is prudent to fully consider options that could support a more secure long-term source of gravel, including purchasing land.

Refer to Section 5.1.3 Cost-Benefit Analysis to see an example of how an RM can use a Cost-Benefit Analysis to predict which option may be the most financially beneficial.

3.2 Leading Approaches to Aggregate Supply Development

3.2.1 Identification & Sourcing

A. Strategic Identification

There are several aspects which could be considered when identifying strategic locations for the identification of gravel.

Economic Advantages

One key aspect of location analysis is considering economic advantages. There are many different considerations, including ensuring that there are short hauls (in order to reduce costs) and whether or not the pit is accessible to high traffic roadways. Alternatively, these benefits must be considered against the negative externalities (dust, sound and aesthetics) that come along with the development of an aggregate pit.

Another consideration that could help the economics of aggregate would be the use of rail transportation for the movement of aggregate to areas of high need. Additionally the development of a provincial strategy for SARM members would provide significant benefits.

Continuous Search Programs

A tool that can be used to help ensure continuous supply of aggregate is the development of a continuous aggregate search program as a proactive approach to aggregate best practices; aggregate search, opportunities and preservation opportunities should be an ongoing process. The programs can also be developed along with partnerships with other RMs, MHI or other stakeholders.

B. Partnerships

Investigate potential partnership opportunities with others (RMs, MHI and First Nations) for acquisition of aggregate sources. Refer to Section 3.4 Partnership Models for Aggregate Supply Development.

C. Railing Aggregate

Another alternative in sourcing aggregate mentioned by multiple stakeholders was the potential for railing aggregate:

> Railing aggregate becomes more feasible when you have economies of scale. If RMs all need certain tonnage, they can get together to organize supply through a rail line. The more (aggregate), the more feasible it gets. That type of thing becomes more technically and economically feasible. As surpluses begin to be depleted and hauls get longer, those types of things become more feasible. *~ Stakeholder*

Research from Ontario through the Ontario Stone, Sand & Gravel Association (OSSGA) provided data of the best transportation mode for gravel, both in terms of cost and environmental impact, which were closely related. The report found that although close

to market transport is the best option in terms of cost and GHG emissions, long-haul rail transport was the next best alternative.

Transportation Cost per Tonne, based on Transportation Mode[i]

Transport Mode	Cost Per Tonne
Marine Transport	$52.00
Long-Haul Truck Transport	$44.31
Long-Haul Rail Transport	$17.66
Close to Market Transport	$9.46

Note: The cost per tonne is based on specific examples for cost to transport aggregate to the Greater Toronto Area using different methods. Both the long-haul truck and long-haul rail costs are based on the same tonnage and origin, thus it can be reasonably be deduced that long-haul trucking can cost up to twice as much as long haul rail.

Additionally, the report found that over similar distances, long-haul truck transport produced 66% more greenhouse gas emissions than long-haul rail.[ii]

Other statistics also support the idea that railing aggregate is becoming more and more popular in North America. For example, in the United States, statistics by the American Association of Railroads has noted a substantial increase in the annual rail traffic data within the last decade. Since 2009 the amount of "crushed stone, sand and gravel" that has traveled by rail has increased over 60% to 130 million tonnes (143.3 million US tons) in 2016 from 80 million tonnes (88.2 million US tons) in 2009.[iii]

Despite its growing trend, the benefits still pale in comparison to close to market transport, but compared to long-haul trucking or marine transportation (with marine much less applicable in Saskatchewan), rail seems to be the most beneficial option. An additional Saskatchewan consideration is rail capacity constraints and increased Saskatchewan rail activity, driven by growing agricultural use and other sectors, which would alter the economics.

The report from OSSGA concluded its discussion on rail with by saying:

> "The results of this assessment should not be taken as a conclusion that some long distance transport by rail or ship is not feasible, appropriate, cost-effective or environmentally inappropriate. Smaller quantities and/or using rail from closer sources may prove to be viable and are currently occurring or are under consideration. However, it is reasonable to conclude that there are strong economic, environmental and social reasons why the alternatives will not replace using close to market sources of aggregate that is transported over short distances."[iv]

D. Additional Strategies

- Evaluating aggregate potential in the areas of highest requirement. This can be done through desktop studies; field testing and paper crush to determine quantity and quality.
- Working with consultants on "paper crush" strategies to better assess aggregate sources prior to extraction or crushing options.
- Working with consultants who have access to laboratory crushers which can do model scale crushing to help assess quantities and quality of existing or new sources.

3.2.2 Pit Longevity

The objective of pit longevity is to undertake the efficient use of materials within a pit for the purpose for which they are "Best Suited". The efficient working of a deposit results in the maximum use of the quality and quantity of material present. This is possible only through proper discussion and dialogue between the landowner, contractor and any other stakeholders involved.

A. Proper Planning

Pit utilization and longevity includes the planned and systematic usage of an aggregate deposit including stripping of pits, placement of stripping, working of areas both above and below the water table, dewatering, working of the pit to minimize reject materials, placement of reject materials and other factors that affect the production of a pit. It can also include such things as identification of oversize and usage and disposal of oversize to ensure minimization of waste from aggregate production. This also ties in to whether to use a primary crusher (crush of oversize) or storage of oversize to be crushed at a later date.

B. Selection of Materials

The selection of materials within a pit area for the purpose for which they are best suited is also very important from a pit longevity perspective. The use of poorer areas of a pit for the production of subbase and traffic gravel is important so that higher quality aggregate locations of a pit can be utilized for the production of base course aggregate. This requires the working of a gravel source such that maximum use of the quality and quantity of aggregate is properly achieved. Proper pit plans should suggest the areas to be worked, the direction the material is to be worked in and the placement of stripping piles. If the quality of aggregate differs from one area of a pit to another then the plan should note this fact and as such different areas should be assigned to produce different products from a particular pit. In most if not all cases the pit should be worked right down to the bottom of a deposit or as deep as is feasible. This is possible only through proper discussion and dialogue between the landowner, contractor and any other stakeholders involved.

C. Surveying

Part of pit longevity includes a detailed and proper survey of the existing or proposed pit site. The survey is required to produce a plan for a new location or to update the plan of an existing location. Survey should include gravel boundaries, test holes (existing or new sites), excavated areas, stripped areas, stripping piles, oversize rock piles, stockpiles,

bush and fence lines, trails and roadways, waterways, topographic land features, utilities and structures located on site. GPS and data dictionaries are recommended for pit surveys however there are many options for undertaking a pit survey. Surveys should include locations of control points, test hole locations, haul route description, stockpiles checked (new stockpiles surveyed and if stockpiles are gone note it), survey new stripping piles and note stripping piles no longer in place. They should also include a survey of the entire worked area not just the open face, note any new fence lines, stripping piles, open water dugouts and adjacent creeks not already on the existing plan, note steep hills, gates and overhead lines that may be a problem during extraction and production, and provide enough survey detail to facilitate the definition of gravel pit volume analysis and proper pit development.

D. Reporting

Another aspect of pit longevity is the systematic reporting of materials removed from a pit and the resulting change to the pit. This will ensure that the pit status is current and up to date. Doing so will help the planning for future projects to help developers be efficient and ensure remaining aggregate quantities are known so there are now surprises when planning for future extraction from the pit. This also provides valuable information as to how much aggregate remains in a certain location so new aggregate searches/acquisition can be planned and undertaken as soon as possible. As soon as possible after aggregate removal is complete a revised pit plan should be completed containing the new open pit area, clearing, stripping and oversize disposal areas, stockpiles and the quantities/types located within the pit boundary and update of estimated quantity remaining. Accurate pit records are paramount in terms of pit longevity and pit utilization and these records should contain information such as pit number, registered owner, location, existing agreements, quantities of sand and/or gravel, price of gravel, acres and price of stripping, conditions etc.

E. Recycled Aggregates

Another part of pit longevity includes the use of recycled aggregates wherever possible and feasible. Some pit owners (RMs, MHI or private) may stockpile concrete rubble and recycled asphalt pavement at existing pit sites. This material may then be included in future crushing contracts to produce aggregate minimizing the amount of aggregate required from the pit. Stockpiling of concrete rubble and RAP at existing aggregate pits should be implemented as part of standard (BMP) where economically feasible to do so.

From an overall perspective some things can be done to improve the recycling of aggregate in Saskatchewan such as:

- Develop specifications for recycled products (RAP and concrete),
- Establish a technical group from all stakeholders (local governments, contractors, engineers, agencies) to improve the options for reusing recycled aggregates,
- Develop and implement tender policies and construction techniques that encourage recycling, and
- Public education.

3.2.3 ROADWAY DESIGN & LIFE CYCLE MAINTENANCE

The best roadway design for the specific conditions should be the goal in all cases. The best design may not necessarily be a "standard" design depending on the conditions existing in the field. Safety should never be sacrificed for cheaper designs. Designers should always be seeking improvement and innovation in all design and life cycle maintenance activities. Owners should be constantly looking for ways to improve on maintenance activities and construction techniques as a means of stretching budget dollars and conserving non-renewable resources such as aggregate. Promoting innovation roadway design and life cycle maintenance as a means of achieving savings is paramount.

A. CHEMICAL TREATMENTS

The use of chemical treatments is a relatively new tool being used across the world, with prevalence in Australia, New Zealand and South Africa. The cost can vary wildly between the different products and different suppliers, which creates uncertainty for RMs in considering implementing innovative solutions. The best time to use chemical treatments to ensure success and cost-savings is to incorporate during the construction or major re-working of a road. Often, if chemical treatments are added after the fact, they end up costing a lot more and with poorer results. Chemical treatments can help extend the life of good roads, but they do not fix bad roads.

There are issues with chemical treatments. The biggest is that there are no professional or industry associations that release any standards or specifications that must be followed. There are suppliers who have proprietary chemicals, which significantly add risk due to uncertainty of what is being applied to roads. David Jones, PhD, has released some specifications for the different chemical classes shown below. These should be used to evaluate potential chemicals.

"A New Procedure for Selecting Chemical Treatments for Unpaved Roads"
David Jones, PhD and Roger Surdahl, P.E. have completed work on the understanding of Chemical Treatments and how to determine which Chemical Treatment is ideal for each municipality or organization. The following section is derived from their work, "A New Procedure for Selecting Chemical Treatments for Unpaved Roads" which can be found here: http://docs.trb.org/prp/14-3437.pdf.

There are seven categories of chemical treatments that are used on unpaved roads (although there are different combinations of chemicals from different categories). They are:

1. Water and Water with Surfactants
2. Water Absorbing (including: calcium chloride, magnesium chloride and sodium chloride brines)
3. Organic Non-Petroleum (including: plant derived additives including glycerin based products, lignosulfonates, molasses- and sugar-based products, plant oils and tall oil pitch resins)
4. Organic Petroleum and Synthetic Fluids (including: petroleum refining based products including diluted asphalt emulsions, base and mineral oils, petroleum resins and synthetic fluids)

5. Synthetic Polymer Emulsions (including: acrylates (homopolymers and co-polymers), acetates (homopolymers and co-polymers) and styrene butadiene co-polymer emulsions, either neat or in combination)
6. Concentrated Liquid Stabilizers (including: electrochemical additives, sulfonated oils, sulfonated petroleum products (SPPs), ionic stabilizers and enzymes)
7. Clay Additives (bentonite is the most commonly used clay additives; however, other clay sources are also appropriate)[v]

Jones and Surdahl outline three steps in order to determine which may work best. They are:

1. Collecting Relevant Information about the Road,
2. Understanding Material Properties, and
3. Selecting an Appropriate Chemical Treatment.

An example of a success can be found in the example below, "Case Study – Montana".

Case Study – Montana

In 1998 the United State Forest Service re-graveled a road in Northern Montana that led access to a hiking trail, a lake for fishing and a camp site. The road is heavily used in the late spring throughout summer when it can carry up to 300 vehicles a day. When re-graveling, they incorporated a magnesium chloride product, compacted and shaped it, and then did nothing to it for the rest of the season. The winter conditions were poor, as the road does not get plowed during the winter. In the spring they did a reshape and added about one quarter to one third the amount of the magnesium chloride product that was initially added. Since then, the US Forestry Service has not had to add any gravel onto the road, a road that has very rough conditions and that, under typical circumstances might need to be re-graveled every three to four years.

This case example provides a real-world example of some savings that can be realized when looking towards the long-term investment in treatments to extend the life-cycle of an unpaved road.

Based on discussions with MHI, and their use of multiple products, they have found the highest-value of money product is Calcium Chloride, which is often one of the least expensive products while being one of the most effective.

B. Clay Capping

Clay capping is another method in which road maintenance can be reduced on a particular gravel road. Clay capping includes placing a layer of clay material on an existing road to stabilize the grade and improve the general ride quality of the road. Several RMs in Saskatchewan are using this innovation and one noted that it has reduced their need for gravel by a third. Working with an engineer in the planning and implementation of clay capping will support successful results for clay capping. The step-by-step approach is outlined in the table below:

- **Step 1:** Placing a layer of clay on a prepared subgrade with the proper width so as to be able to incorporate the clay cap onto the existing subgrade (based on design plans or as designated by the engineer).
- **Step 2:** The sampling and testing of the clay source.
- **Step 3:** Samples of proposed sources should be collected and taken to a lab to determine the Plasticity Index (PI) of the clay. The material should have a PI greater than 8 and less than 30 for proper clay cap construction.
- **Step 4:** Borrow sources for clay capping should be designated by the RM and should be located as close to the road as possible to reduce haul costs. Landscape or dugout borrow sources are acceptable for construction.
- **Step 5:** Ensure that all topsoil and unsuitable materials are removed from borrow sources.
- **Step 6:** Scarify the existing road surface to a minimum depth of 100 mm. All rocks must be removed from the surface.
- **Step 7:** All soft, wet or areas with organic materials should be sub cut to a minimum of 300 mm below existing surface and replaced with a competent fill as directed by the engineer.
- **Step 8:** The subgrade should be bladed to a smooth surface conforming to the design cross section of the road.
- **Step 9:** Add 300 mm of clay to the existing surface, placed in layers no greater than 150 mm spread evenly by means of a motor grader. The material should be compacted to a minimum of 95 percent of Standard Proctor Maximum Dry Density (SPMDD), dried to at least the optimum moisture content. The crown of the clay surface should be constructed with a 4 percent cross slope.
- **Step 10:** If ***incorporation*** is to take place subsequent to clay capping, it is recommended that a MHI Type 103 Traffic Gravel be used. For surface traffic gravel, a MHI Type 106 Traffic Gravel is recommended. Gravel incorporation should result in gravel being uniformly mixed with the existing (clay capped) subgrade in the top 75 mm of the finished road top. The mixture shall be packed to produce a smooth surface that will support normal traffic. The amount to be blended into the subgrade may vary as directed by the engineer based on traffic and environmental factors but generally between 190 and 380 cubic metres per kilometre (400 to 800 cubic yards per mile). The width and depth of the material loosened up for incorporation may vary, however, the width will normally be two metres less than the finished road top and the depth will be between 50 mm to 100 mm. Water can be added to the mixture as required if there is insufficient moisture to produce a stable driving surface.
- **Step 11:** Remove and dispose of all surplus rock (greater than 80 mm) from the surface. Subsequent to incorporation, traffic gravel Type 106 should be applied at a rate of 100 to 150 cubic metres per kilometre (200 to 300 cubic yards per mile) depending on the surface width. If no incorporation took place, then traffic gravel (Type 106) should be applied at a rate of 150 to 200 cubic metres per kilometre (300 to 400 cubic yards per mile) depending on the surface width.

C. GEOSYNTHETICS, GEOTEXTILES & GEOCELLS

Geosynthetics are products that help to stabilize ground and are used in a variety of different construction activities, including roadways and gravel roads. They act as a layer between the subgrade and the aggregate on top and can lead to improved strength of a

road, can reduce the amount of aggregate required on the roads and extend a road's overall life. The technology has been around for several decades now and has been growing in popularity. The use of geotextiles in failure repair minimize the amount of aggregate required in repairs and provide a much higher probability of success in terms of long term performance of the repaired section of roadway. Price is often a deterrent along with lack of understanding and knowledge about their effectiveness. Geocells, or as they are more formally known as, cellular confinement systems, are honeycomb like structures that are often made from geosynthetics. They can be laid out and filled with other materials, such as sand, to form a road.

D. Gravel Blading

The introduction of blading of graveled surfaces can help to extend the life of roads. This work includes:

- Removing potholes, rutting and ponding areas to create a proper crown at the centre to promote proper drainage of the surface.
- Spreading existing gravel evenly across the surface of the road to ensure optimal gravel usage.
- Blading areas that are rough or pitted when dry. Major reshaping can be done only after a rain when the surface is soft and can be cut easily.
- Preparing gravel surfaces for winter by removing any excess material off the road top and onto the side-slopes of the subgrade; the material stored on the side-slope can be re-used in the spring by pulling it back onto the road surface.
- For summer maintenance, it may be advisable from an economic standpoint to gravel complete links at one time; also the application rate in each link should be carefully determined depending on the amount of gravel already in place and the nature of the soil.
- In the fall, re-shaping of the shoulders should be done to recover lost gravel and to return the surface width to that of the original construction.

E. Road & Soil Stabilization

Road and soil stabilization is an increasingly popular remediation technique in Saskatchewan. As roads become pushed out, this can be used to bring them back into their desired width. In general, it is completed by stripping the shoulders that have extended outwards, bringing it all up and mixing in with different materials. This can include clay, additional aggregate and other products such as SoilMax. It offers a longer-term "band-aid" fix to roads that have widened. Depending on the skill level of the organization completing the work, it can add another 10+ years of life to the road. Costs can vary but in general can be between $48,000 and $80,000 per kilometer ($30,000 and $50,000 per mile).

F. RECYCLING

RMs can promote the use of recycled aggregate (such as concrete and RAP) without compromising safety or durability of the infrastructure. This can be achieved in a few simple steps:

1. Setting targets for recycling aggregate.
2. Investigating the potential of a landfill tax to reduce the amount of useable recycled materials that could act as a substitute for virgin aggregate.
3. Investigate strategies to reduce, reuse and recycle aggregates in partnership(s) with MHI, other RMs and urban municipalities.

Another way to recycle material is to pull material from the shoulder. This should only be done on very low traffic roads, such as access roads where RMs can pull material up from the shoulder and reshape. This can be followed up by spreading mulched material followed by a layer of sand/gravel.

G. SPRING GRAVELING

Spring graveling can be a good alternative to putting gravel on in the fall and risk having it bladed off during the fall/winter period. If an RM has a road that it knows will be troublesome, it is often best to fix it in the spring. Additionally, RMs can run into issues in the spring following a fall graveling since often the gravel must be removed so that it can be dried out. This issue can be mitigated with spring graveling.

H. OTHER CONSIDERATIONS

- Other products that could be added to existing roads in order to extend their life include asphalt and shredded tires.
- Other strategies include incorporating engineered solutions into your maintenance strategies, such as; incorporating some sampling, testing and design into your maintenance and repair strategies to ensure that the proper products and procedures are being utilized as part of the asset management of the system.
- Ensure that proper specifications are being met during production, proper tonnages are being produced during crushing and proper (design) application rates are being adhered to as a means of aggregate conservation and best practices.
- Road management systems can be integral tools. Whenever an RM does any sort of maintenance or innovation, they should be taken down on record. Having access to this information can help when looking to find additional money for innovative practices.
- Phone based applications are a newer innovation where a phone based application can come up with an IRI number. It is not as specific as a laser based system but can give consistent and reasonable data.
- Drones have also begun to play a role in the maintenance of roads. They have been used to do inspections of roads and drainage systems. The software is often inexpensive and useful.

Comparison of Innovations

	Chemical Treatments	Clay Capping	Geosynthetics, Geotextiles & Geocells	Gravel Blading	Road & Soil Stabilization	Recycling	Spring Graveling
Capital or Maintenance Application	Either	Either	Capital	Maintenance	Either	Either	Maintenance
Cost	$$$	$$	$$$	$	$$	$$	$
Optimal Timing	Beginning	Beginning	Beginning	N/A	N/A	N/A	N/A
Vendor	Supplier	Contractor	Supplier	Contractor	Contractor	Contractor	Contractor
Required Resources	Equipment Chemicals Expertise	Equipment Clay Expertise	Equipment Supplier Expertise	Equipment Expertise	Equipment Expertise	Equipment Recycled Aggregate Expertise	Equipment Expertise
Regional Advantage	No	Near clay resources	No	No	No	Near recycled reserves	No
Complexity	High	Medium	High	Low	Med	Med	Low
Experience	Little	Some	Little	A lot	A lot	Little	Some

Practical Guide to Innovations

There are a variety of aggregate and roadway innovations highlighted in this section and they require varying levels of technical expertise and have different risks, which creates a challenge for RM administration and leadership in trying to find solutions that might bring value to their ratepayers. Having a practical system for considering and implementing innovations will support putting structure around the concept, and the following guide provides step-by-step recommendations on considering innovations.

1. Hold informal discussions with staff, Council members and knowledgeable ratepayers about the various innovation concepts highlighted in the Aggregate Management Manual to determine anything that has been tried in the past, appetite for implementation, any local expertise that might exist and any thoughts on specific regional conditions that may provide guidance on innovation selection.
2. Hold informal discussions with neighbouring RMs to see if they have any insight into innovation ideas and to understand whether or not they are also interested in exploring concepts, which could create an opportunity for collaboration.
3. Narrow the list of potential innovations to a manageable number for analysis, which could include:

   - Capacity and/or appetite of leadership in considering solutions with high capable costs
   - Local material advantages that could support efficient implementation
   - Insights from local experts on opportunities
   - Referral from local contacts to other experts that could include vendors or other municipal leaders with experience with a particular innovation.

4. Engage service providers or vendors to get an overview of the proposed innovation that would include a description of the product or service, examples of where it has been used before, financial implications, initial thoughts on suitability for the region, benefits of the innovation and required steps to evaluate and implement and references for other municipal customers.
5. As required, engage third parties as required to validate information that could include references in other municipalities, SARM, or technical resources like consulting engineers.
6. Develop high-level profiles of the products or services and highlight preliminary thoughts and opportunity and suitability for the RM. Present information to RM administration and/or RM Council with a recommendation on whether or not to proceed to further analysis.
7. If the RM wishes to proceed to further due diligence, ask the vendor for a formal proposal on the proposed solution.
8. Conduct a cost-benefit analysis for the opportunity highlighting benefits and risks. Engage technical experts as required to validate assumptions and provide formal recommendations depending on the complexity and cost of the innovation.
9. Developing a recommendation for Council based on the cost-benefit analysis that highlights key components including:

   - Description of the product
   - Description of product benefits
   - Existing customers and user profiles
   - Resource requirements (e.g. engineering/construction resources)
   - Financial Implications
   - Risk Analysis
   - Technical Evaluation

- Recommendation

10. If a recommendation is made to proceed with an opportunity, then highlight an implementation plan that includes how the innovation will be worked into existing aggregate management practices.
11. If approval to proceed is received, engage engineering and construction support resources if required.
12. Finalize contracts with vendor.
13. Manage implementation process and ensure that proposed deliverable are being met.
14. Measure forecasted results against actual results as part of ongoing aggregate management reporting.

Concept of Provincial Implementation

Pursuing innovation techniques is a high risk area for individual RMs that have limited financial resources and limited technical resources to fully understand potentially complex solutions. A possible strategic implementation could be through engagement with public and private sector organizations creating value from existing research, systems for knowledge transfer and application and commercialization of private sector Research and Development (R and D). Canada as a whole is seen as lagging behind in mobilizing knowledge from universities and government to the marketplace. This may be a good opportunity for RMs to benefit from existing R and D or to engage the U of S or U of R in innovation opportunities. Universities are an option for in-kind funding with access to students for data acquisition and testing. Universities are also a source of expertise in the engineering aspects of potential pilot projects.

Ideally implementation should be as soon as the necessary funding and in-kind support is in place and the RM(s) are set up and ready to undertake the project. Test sections should be conducted initially as the first step in the innovation process. A pilot project that would include complete dissemination of project results to all RMs and other stakeholders would be of considerable value and could attract funding as a strategic step toward innovative infrastructure management. Federal or provincial government innovation programs could be pursued as benefits could be far-reaching if a single pilot informed opportunities in hundreds of RMs. Funding would enable adequate professional service resources to be involved to ensure proper planning, testing, implementation and reporting in order to support a pilot that could be more widely deployed if successful. The absence of these types of projects and programs in other jurisdictions could also be an economic development focus for Saskatchewan as it could provide the private sector with a leg-up in pursuing innovative infrastructure solutions.

RMs that support and promote innovation through their own existing practices are ideal candidates for innovative ideas and methods. RMs that continually upgrade equipment with new types of attachments and continually look at new products that change the properties of soils and aggregates are very good options for innovations in roadway management and design.

RMs in a better financial position would be more suited to a pilot project due to the availability of equipment, manpower, budget, etc., but any RM could be a candidate if they have the particular conditions for select innovations and if leadership and administration is keen. For example test sections should be properly planned out and situated for optimal exposure and in locations that minimize the variables to ensure success of the project. Prior to any pilot project the road selection should be based on soil conditions (from testing) and road condition rating. The RM should have ample access to aggregate sources in order to easily and readily be able to utilize for test sections. The ability to properly document all aspects of the test sections is paramount to the overall success of the research.

3.3 Gravel Procurement

3.3.1 Tendering & Contracting

RMs could use several tendering and contracting engagements in the execution of their gravel management program that could include procuring consultants to support exploration and testing or tendering for crushing or hauling. Traditionally, tendering processes have focused on low cost and most outsourced activities related to gravel are straight-forward enough to lend themselves to heavy emphasis on cost in evaluation and award. However, over the last several years a variety of issues have come up with low-bid procurement that failed to properly account for experience, past contractor performance, local knowledge or ability to meet timelines. These issues led to a Government of Saskatchewan push toward best value procurement that is best highlighted in the creation of the Best Value in Procurement Act that amended The Highways and Transportation Act, 1997 and The Public Works and Services Act with the following key components:

> *Subject to subsection (4), the minister shall:*
> *(a) obtain competitive prices for the construction or alteration of all public works through the public tender process mentioned in subsection (1); and*
> *(b) award the contract to the bidder whose bid, in the opinion of the minister, offers the best value taking into consideration all or any of the factors described in the tender documents.*
> *"(4) The minister is not required to accept any tender".*

For RMs, integrating considerations for best value into procurement mechanisms can be undertaken to protect against issues stemming from having contractor with poor past performance win bids and to ensure that consultants and contracts have adequate experience and knowledge to execute on bid submissions. Invitation to Tender documents related to gravel supply or crushing will still be cost-driven decisions, but structuring procurement documents to include experience, local knowledge and past contractor performance provide options for RMs. RMs can also include a clause that allows the RM to cancel the tender if needed or if circumstances warrant it.

For more comprehensive information on best value procurement in Saskatchewan, please reference the Priority Saskatchewan Procurement Guide:
http://www.saskbuilds.ca/PrioritySK/Files/Priority_SK_Procurement_Guide.pdf

In addition to contemplating best value procurement, another strategic opportunity in procurement is using multi-year tendering. Multi-year tendering, generally reflected in two year contracts in gravel crushing or supply, can provide value in that it provides predictable multi-year pricing for RMs while also providing the security of multi-year work for outsourced resources. Contractors that can look up multi-year agreements have more security to invest in proper people and equipment and this enhanced security can be reflected in better pricing for RMs. Some RMs note success with early implementation of two year agreements and it is a strategic opportunity that should be considered in contemplating supply agreements.

3.3.2 COMMON GRAVEL SPECIFICATIONS

The most common specifications for most RMs are the MHI specifications for sub-base, base and traffic gravel.

A. SUB-BASE SPECIFICATIONS

Sub-base course shall comply with the following requirements:

Sieve Designation	Percent by Weight Passing Canadian Metric Sieve Series TYPE		
	6	8	10
50.0 mm	100.0	100.0	100.0
2.0 mm	0 – 80.0	0 – 90.0	
400 µm	0 – 45.0	0 – 60.0	
160 µm	0 – 20.0	0 – 25.0	
71 µm	0 – 6.0	0 – 15.0	0 – 20.0
Plasticity Index (all types)	0 – 6.0		

This specification also allows a tolerance of 3% in the percent by weight passing the maximum size sieve providing 100% of the oversize passes the 63.0 mm sieve.

B. BASE SPECIFICATIONS

Base course shall comply with the following requirements:

Sieve Designation	Percent by Weight Passing Canadian Metric Sieve Series Type		
	31	33	35
31.5 mm	100.0		
18.0 mm	75.0 – 90.0	100.0	100.0
12.5 mm	65.0 – 83.0	75.0 – 100.0	81.00 – 100
5.0 mm	40.0 – 69.0	50.0 – 75.0	50.0 – 85.0
2.0 mm	26.0 – 47.0	32.0 – 52.0	32.0 – 65.0
900 µm	17.0 – 32.0	20.0 – 35.0	20 – 43.0
400 µm	12.0 – 22.0	15.0 – 25.0	15.0 – 30.0
160 µm	7.0 – 14.0	8.0 – 15.0	8.0 – 18.0
71 µm	6.0 – 11.0	6.0 – 11.0	7.0 – 12.0
Plasticity Index	0 – 7.0	0 – 6.0	0 – 5.0
Fractured Face %	50.0 Minimum		
Light Weight Pieces %	5.0 Maximum		

This specification also allows a tolerance of 3% in the percent by passing the maximum size sieve providing 100% of the oversize passes the 40.0 mm sieve for Type 31 and the 22.4 mm sieve for Types 33 and 35.

C. TRAFFIC GRAVEL SPECIFICATIONS

Traffic gravel shall comply with the following requirements:

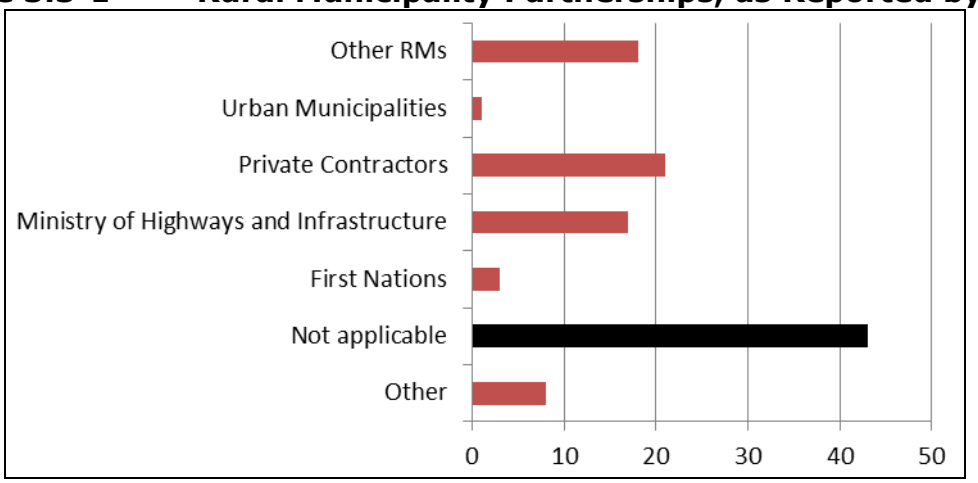
Sieve Designation	Percent by Weight Passing Canadian Metric Sieve Series Type							
	101	**102**	**103**	**104**	**105**	**106**	**108**	**109**
75.0 mm	100							
50.0 mm	55 – 85	100						
40.0 mm		63 – 92						
31.5 mm			100	100				
22.4 mm			63 – 92	63 – 92	100	100	100	
18.0 mm					63 – 92	63 – 92	63 – 92	100
5.0 mm	0 – 40	0 – 40	0 – 40	40 – 70	0 – 40	0 – 60	40 – 70	45 – 80
2.0 mm	0 – 25	0 – 25	0 – 25	20 – 45	0 – 25	0 – 45	20 – 45	25 – 60
400 µm				0 – 20			0 – 20	0 – 30
Fractured Face %	50.0 Minimum							

This specification also allows a tolerance of 3% in the percent by passing the maximum size sieve providing 100% of the oversize passes the next highest sieve. For type 101, the next highest sieve shall be 100.0 mm.

3.4 Partnership Models for Aggregate Supply Development

In a survey conducted of RMs as part of the study, close to half (46%) of all RMs stated that they did not have any partnerships at all related to aggregate. Generally, of those who did have partnerships, the next three most popular partnerships came between RMs and private contractors, multiple RMs working together and RMs and the Ministry of Highways and Infrastructure.

Figure 3.3-1 Rural Municipality Partnerships, as Reported by RMs



Although many do not have any partnerships, the reasons varied. Some RMs stated they simply have not explored these options, while others have attempted to make contact with other RMs but did not find willing partners. Conversely, many RMs that have control over a local long-term aggregate source do not prioritize partnerships as they aren't required.

The following section outlines some potential areas for collaboration between RMs and other stakeholders.

3.4.1 PARTNERSHIPS WITH GOVERNMENT

A. Municipal

One of the most popular partnerships for RMs has been with other municipalities, primarily other RMs. In total, 18 respondents (or 19%) noted they had agreements with other RMs, where one respondent indicated they had an agreement with an urban municipality. Many of these partnerships varied in scale (number of RMs involved) and scope (activities and costs split by each RM) with identified partnerships having up to four RMs involved. Some examples of partnerships are noted in the list below:

- Sharing a gravel pit lease with another RM.
- Purchasing a gravel pit jointly with another RM.
- Allowing other RMs to use the pits of a more aggregate-rich RM.

- Purchasing trucks, trailers and loaders together to provide for more timely application and cost controlling.
- Removing gravel in partnership with another RM from crown land within one of the RMs.
- Developing gravel haul roads so that other RMs can transport aggregate from other areas to their RM.

"We have a gravel pit with three other RMs and we share the cost of crushing and stripping, as well as lease fees." ~ *Saskatchewan Rural Municipality*

B. Provincial (Ministry of Highways & Infrastructure)

In general, there are differing opinions from RMs on their engagement with MHI. Many provided positive comments about their ability to work together. In some instances MHI informs RMs of crown land that might have gravel potential that MHI is not pursuing. In other cases RMs are able to purchase sand and gravel from depleted MHI pits. In other instances, RMs are unhappy with MHI as they exert their authority of some lands.

Overall, as the Ministry responsible for the highways and infrastructure in Saskatchewan, MHI presents an obvious opportunity for partnership. In the past, MHI has been open to the idea of partnering with RMs. These partnerships have been developed for various different outcomes but are typically dealt with on a case-by-case basis. MHI is often in the same situation as many RMs where there is limited access to aggregate and MHI needs to manage long-term risk in establishing secure supplies to have cost-effective materials for the preservation of the national and provincial highway network. That being said, there may be opportunities on partnering on the exploration of crown land. MHI is mostly concerned with finding asphalt and base aggregate, so other materials for traffic gravel could be split with the RM and costs split on a proportion basis. These types of partnerships are already underway in the southeast area of the province. Other opportunities to partner with MHI include:

- Potentially partnering on decommissioned lands which have been stripped with minimal aggregate left over.
- The exploration of crown lands.
- The combined purchasing of materials from private sources.

3.4.2 Partnership Models with First Nations

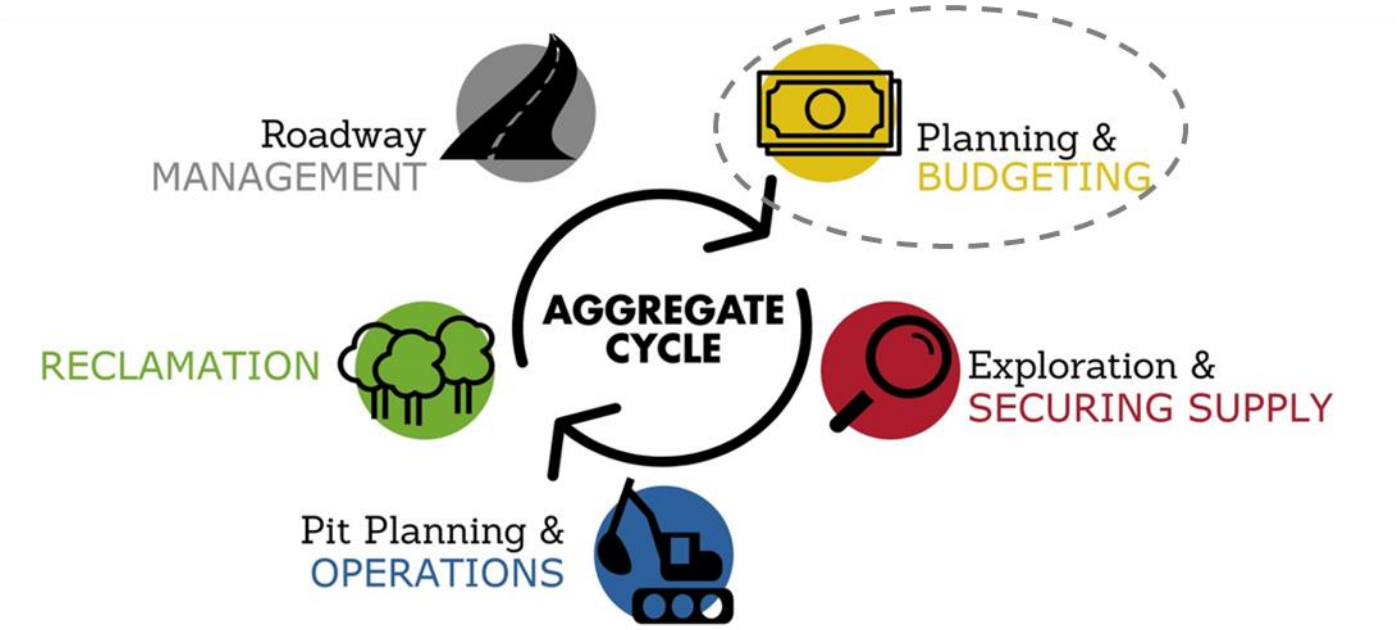
Only three of 93 respondents mentioned that they had partnerships with First Nations, making it the least popular partnership model. The few stakeholders that have been engaged with First Nations have spoken favorably of their engagement. First Nations have access and rights to a substantial amount of land in Saskatchewan and some First Nations are building the capacity and ability to provide valuable services and products to the gravel marketplace. In dealing with First Nations for the purchase of gravel there are two main options for partnership. The first would be similar to dealing with private land owners where RMs can sign an agreement to be able to extract the gravel from the land. Another is purchasing the manufactured aggregate from the First Nation itself. There are several First Nations who now have the capabilities to excavate and crush aggregate on reserve and sell directly to RMs. This practice is growing in popularity while being a great source of employment and economic activity for the community. This list includes

Poundmaker Cree Nation and Asiniy Gravel Crushing Limited Partnership, owned in part by the Ochapowace First Nation. Saskatchewan First Nations face many of the same challenges and opportunities as RMs related to gravel supply development and roadways management, so engagement and partnership development could lead to long-term mutually beneficial arrangements. Some general guidance for engagement with First Nations would include:

- Reaching out to Chief and Council of First Nations in and around your RM to arrange a meeting to discuss your knowledge of aggregate supply in the area and your RMs plans for exploration and long-term strategic supply development.
- Proposing the sharing of existing information both parties have related to supply in the area and consider undertaking a joint search program. Seek to have an agreement in principle between political leadership if there is an appetite for partnership on both search and supply should aggregate sources be identified.
- Developing relationships between RM Administration and Lands and Administration staff at the First Nation to execute any partnership initiatives.
- Proposing the sharing of information on crushing and hauling contracts including historical information and experience with various contractors.
- Relationship-building and information sharing could spur enhanced exploration on First Nation lands that could represent an untapped resource in some areas of the province.
- Some First Nations could have resources to explore and develop aggregate resources if it is made an economic priority, while others could be interested in low-cost partnerships. Past examples of low-cost partnerships have included RMs and/or contractors getting free or low cost supply if they cover costs of exploration or pit development, or if they provide gravel for First Nation roads. If a First Nation is able to invest sufficient resources to develop resources and establish more common commercial agreements, RMs can still get value of opening up new local resources through the relationship-building and information-sharing process.

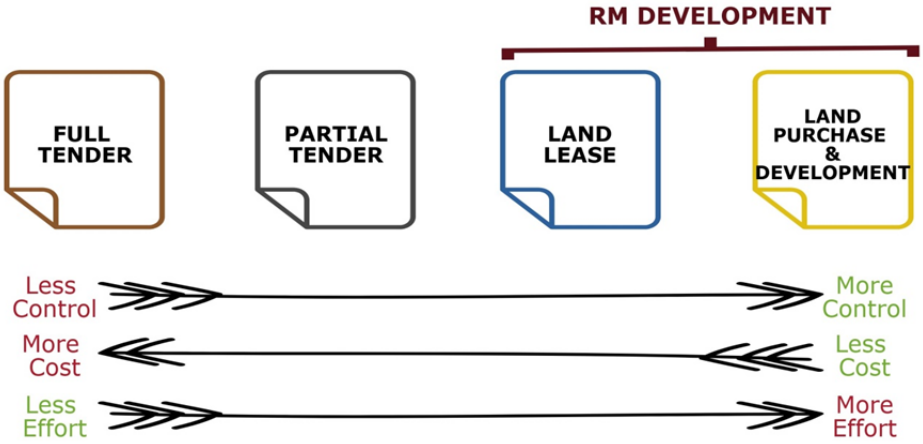
4. AGGREGATE MANAGEMENT CYCLE

4.1 PLANNING & BUDGETING



Before beginning exploration, discussions surrounding planning and budgeting need to be undertaken by RM staff in order to present a comprehensive aggregate strategy to its RM Council. On a short-term and project-level basis, these discussions should revolve around the various strategies for the roads that need to be addressed from an asset management perspective in terms of maintenance, repair, re-construction or development. Through these discussions, an asset management plan for the roadway system can be developed for the upcoming year. These discussions will all work within the framework of an overall plan which includes the budget for road maintenance for the year. Depending on the situation of the RM, there may be pre-existing agreements in place that may make these discussions fairly simple, while in other RMs where aggregate is scarce, they may require more attention.

Depending on available resources and capacity, budget and required aggregate for the year, there are several strategies that could be utilized in order to meet the needs of the RM. The figure below intends to show the spectrum of which RMs can operate their aggregate sourcing. There are many options between the two ends of the spectrum.



- **FULL TENDER:** A full tender is the simplest option as it is as easy releasing a request for proposal for the delivery of aggregate. The RM has no control over where the aggregate comes from and less control over the delivery of the product (although it will be a part of the negotiation).

- **PARTIAL TENDER:** This type of sourcing comes through the RM doing a portion of the work and contracting out another piece of it. In practice, this typically occurs with the tendering out of crushing. This can occur on leased or purchased land.

- **LAND LEASE:** RMs can go into an agreement with a Crown or a private land owner to lease lands and develop their own pits and crushing.

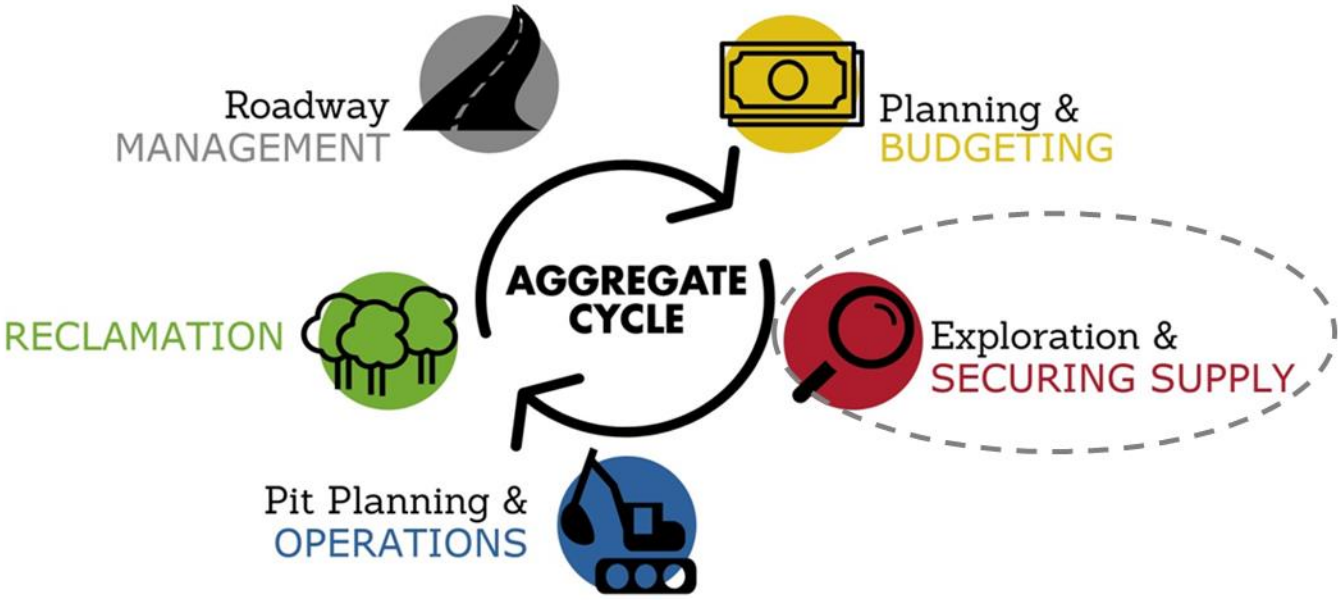
- **LAND PURCHASE & DEVELOPMENT:** The option that is likely the lowest cost, while maintaining the most control is to purchase land and complete the development completely by the RM. In this case, the RM has full control of the land and does not run the risk of losing the lease.

Fully tendering for aggregate is the easiest of the options. With this option, the RM will not be required to follow the principles and guide discussed in the remainder of this section, although it will still provide valuable information.

Note on Tendering: More often than not, the most responsible choice by the RM is to choose the lowest bid in the case of a full tender or for a portion of the work (such as crushing). A best practice is to ensure that you ask for the list of equipment that they own and that they are renting (if applicable). Along with that, the RM should ask which other jobs they are committed to. If it seems as though there are not enough resources for the jobs they have committed to, there is a chance that the lowest bid may not be the best. Since the contract will be paid by the ratepayers, the RM needs a good reason not to take the lowest bid.

Determining total aggregate needs is an essential part of planning for any Rural Municipality. On an ongoing basis analyses should be completed to understand an RM's current inventory, aggregate requirements and potential for exploration. This helps to ensure that the RM secures the aggregate supply that meets their needs.

4.2 Exploration & Securing Supply



4.2.1 Overview

Exploration and searches should be continuous utilizing all potential avenues such as well drillers and industrial exploration. Searches around existing aggregate sources are also common practice. Making use of improved technology such as air photo interpretation, satellite imagery and resistivity meters can also be extremely beneficial in locating new (or expanding existing) aggregate sources.

Potential aggregate sources should be tested to determine if, in fact, the site contains aggregate. This can be completed using backhoes, drill rigs or any type of equipment that can extract samples from the proposed location. Once a site is confirmed to contain aggregate further testing is required to determine the size and extent of the source.

Numerous techniques are available to assist with aggregate exploration and as the aggregate sources become scarce in various areas of the province new technologies may be required to assist with aggregate searches. The use of these new technologies for aggregate searches need to be compared to one another and to the potential for obtaining aggregate from other locations and by other means to ensure the most economically viable solution can be implemented for aggregate searches.

Securing aggregate supply can be undertaken through several methods including obtaining title to the property, damage agreements with the registered owner of the property, surface control by lease or permit or by obtaining title to the property. The methodology will depend on various factors such as the quality of material in the pit, the quantity of material in the pit, who holds title to the property, the competition in the area and the willingness of the landowner to enter into an agreement. Prior to purchasing an aggregate source an analysis should be made on the available supply of material in the

source to ensure there is several years of availability in the source unless the aggregate supply in a specific area is very scarce.

4.2.2 Required Actions

A. Aggregate Searches

The first step in finding aggregate is looking for it, and there are several different strategies that could be utilized in order to strategically choose a point for testing that may have a high likelihood of containing aggregate. There are three glacial methods that formed aggregate in Saskatchewan and understanding these methods will help understand where aggregate may be located:

Depositional Landforms	Glaciofluvial Deposits	Glaciolacustrine Deposits
•Deposits formed when a glacier drops or pushes material to form a deposit	•Deposits formed by glacial meltwater streams	•Sediments that accumulated at the margins and bottoms of glacial lakes and ponds

Depositional Landforms:

- Moraine is an accumulation of rock debris (till) carried and then deposited by a glacier. The material can range in size from boulders to sand and clay. When the glacier drops the till, it is un-stratified and shows no sorting or bedding.
- Flutes are the depositional equivalent of erosion knob-and-tail structures. Some glaciers accumulate so much debris beneath them that they actually glide on a bed of pressurized muddy till. As basal ice flows around a pronounced bedrock knob or a boulder lodged in the substrate, a cavity often forms in the ice on the lee side of the obstacle because of the high viscosity of the ice. Any pressurized muddy paste present under the glacier may then be injected into this cavity and deposited as an elongate tail of till or flute. Flutes are a common feature found in areas covered by ground moraine.
- Drumlins are streamlined, elongated mounds of sediment. The long axis of individual drumlins is usually aligned parallel to the direction of regional ice flow. In long profile, the leading edge of a drumlin is steeper than the lee side. Some drumlins consist entirely of till, while others have bedrock cores draped with till.

Glaciofluvial Deposits:

Glaciofluvial deposits are deposits of sand and gravel carried by running water exiting from the melting ice of a glacier. Meltwater streams are generally laden to transporting capacity with debris. Once the meltwater exits the glacier, it spreads out and loses some of its velocity and deposits some of its load. As a result, various deposits are formed:

- Outwashes: are deposits of sand and gravel carried by running water from the melting ice of a glacier and laid down in stratified deposits. An outwash may attain a thickness of 100 m at the edge of a glacier, although the thickness is usually much less. It may also extend many kilometres in length. Flat-topped remnants of the older plain may be left along the valley sides, these are called terraces.
- River Terraces: are benches or steps that extend along the side of a valley and represent a former level of the valley floor. A terrace results from any hydrological or climatic shift that causes renewed down cutting. It generally has a flat top made up of sedimentary deposits and a steep fore edge and it may be the remains of an old floodplain, cut through by the river and left standing above the present floodplain level.
- Kames: are mound like hills of poorly sorted drift, mostly sand and gravel, deposited at or near the terminus of a glacier. A kame may be produced either as a delta of a meltwater stream or as an accumulation of debris let down onto the ground surface by the melting glacier. A kame terrace is produced when a meltwater stream deposits it's sediment between the ice mass and a valley wall.
- Eskers: are a long narrow winding ridge composed of stratified sand and gravel deposited by a subglacial or englacial meltwater stream. Eskers may range from 5 to 50 m in height, from 500 to 1600 m in width and a few hundred metres to tens of kilometres in length. They may occur unbroken or as detached segments. The sediment is sorted according to grain size, and cross-laminations that show only one flow direction commonly occur. Thus eskers are considered to be channel deposits (left by streams that flowed through tunnels in and below the ice) that were let down onto the ground surface as the glacier retreated. Esker formation takes place after a glacier stagnates. Because of ease of access, esker deposits often are excavated for their sand and gravel for construction purposes.
- Kettles: potholes, or ice pits are steep-sided depressions typical of many glacial and glaciofluvial deposits. Kettles or kettle holes are depressions in a glacial outwash drift made by the melting of a detached mass of glacial ice that became wholly or partly buried. The occurrence of these stranded ice masses is thought to be the result of gradual accumulation of outwash atop the irregular glacier terminus. Kettles may range in size from 5 m to 13 km in diameter and up to 45 m in depth. When filled with water they are called kettle lakes. Most kettles are circular in shape because melting blocks of ice tend to become rounded.

Glaciolacustrine Deposits:

When a stream enters a standing body of water it is forced to deposit its bed-load. The coarser gravel and sand are laid down directly at the mouth of the stream as successive, steeply inclined fore-set beds. The finer suspended silt and clay can drift a bit further into the lake where they are deposited as almost flat-lying bottom-set

beds. As the sediment builds out farther into the lake (or ocean) the river deposits a thin veneer of sub-horizontal gravely top-set beds over the fore-set units. Because the fore-set-top-set complex often has the shape of a triangle with the mouth of the stream at one apex such a body of sediment is called a delta. Many sand and gravel pits are located in deltas of former glacial lakes.

It is also integral to stay connected with community members and different contacts in industry to help with 'leads' as to where there may be aggregate located. Aerial photos are also extremely useful. Other technologies can be found in Appendix 4: Aggregate Exploration Tools.

B. Acquire Excavation Permits

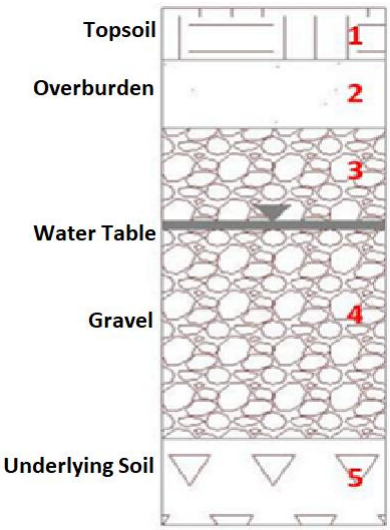
In order to perform any testing, any entity, including RMs, must apply for exploration permits. These applications ask for certain pieces of information and require certain fees. RMs must provide a legal description of the land, the scope of the operation and a reclamation plan. If the land is owned by a private land owner, consent and conditions of entry are required. These permits expire after a year and the associated costs include:

- $40 exploration permit fee
- $0.50 per acre non-refundable land use fee
- $5 backhoe test holes
- $10 per dragline test holes
- $5 auger holes

A copy of the policy can be found in Appendix 5: Sand and Gravel Lease Policy and should be reviewed before making an application.

C. Testing

Aggregate testing involves the digging of test holes to understand the potential quality and quantity of aggregate available in a certain area. The image to the right provides a visual of the typical test hole. Typically, there are five layers:



1. Topsoil
2. Overburden
3. Granular Material, above the water table (Gravel)
4. Granular Material, below the water table (Gravel)
5. Underlying Soil

Topsoil: Should be removed but does not need to be tested. In order to be thorough, the depth and condition of the soil should be taken and added to the notes for the test hole.

Overburden: The following layer will be the overburden, which may be a variety of different materials that separate the topsoil from the granular material below. Some potential content includes sand, till and clay. There is a significant amount of clay in Saskatchewan and will be one of the more prevalent overburdens found. If the overburden is silt, it should be sampled as silt can often act

as a binder. If the silt is wet, it should still be tested since it can be dried and still potentially used as a binder. Till is not typically tested unless it is very fine and dry in which case it could be used as a binder.

Granular Material: All granular material should be sampled unless a layer is less than 0.2 m. In this case, it is a "seam" and not significant for extraction. Samples should be taken at minimum each 2 m. Information that should be noted includes the depth, the depth of the water table, the largest rocks found and the presence of any other materials.

Tip: Although it is preferable to have the granular materials scientifically tested, for smaller pits they can be reviewed by a local expert (if one is available) to determine the aggregate's quality.

D. Pit Selection

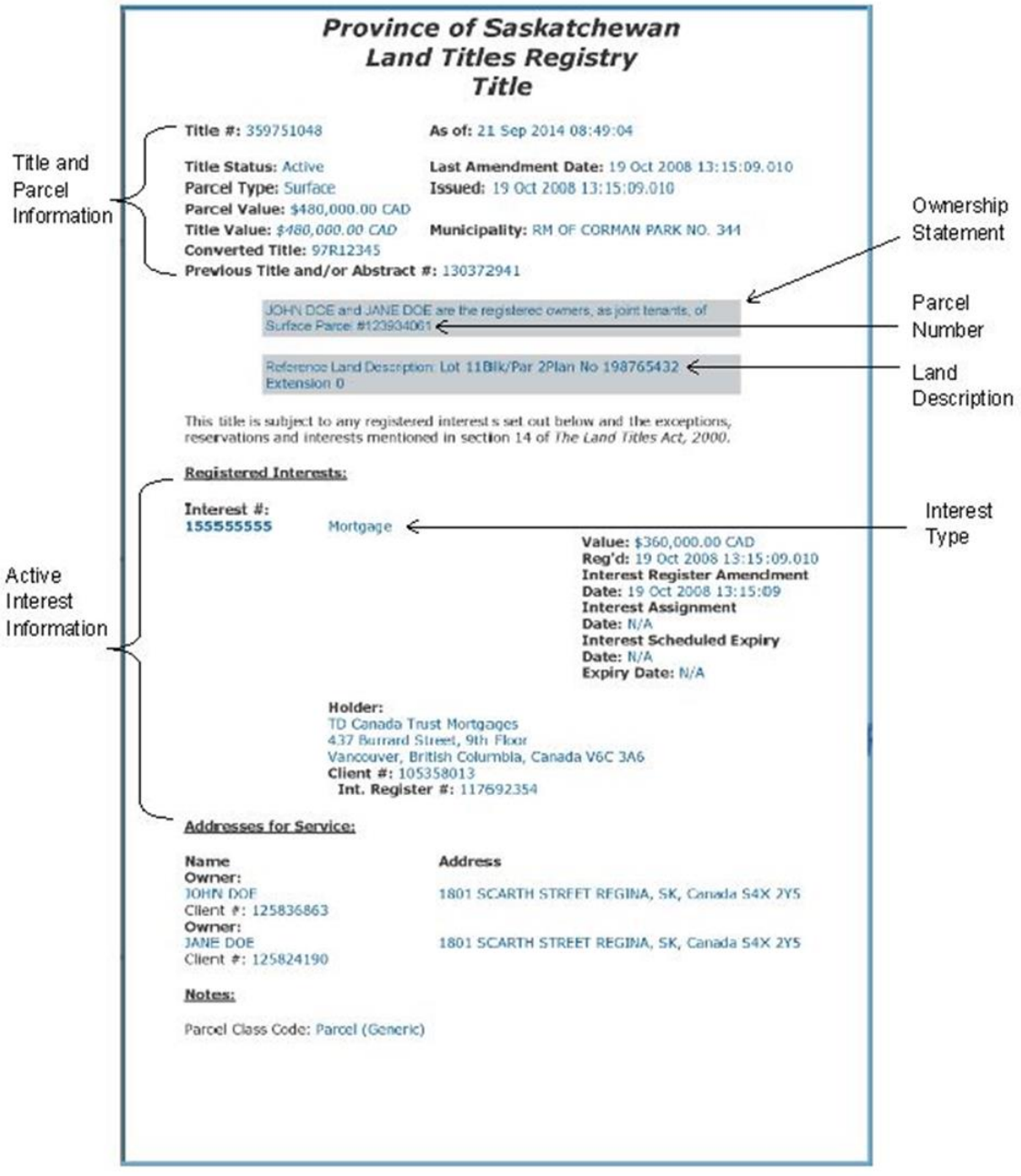
Once a source has been identified, tested and approved, a 'go / no-go' decision must be made prior to moving to planning and full scale operations. This process ensures that the most economical and efficient decisions are made. In general, pit selection is an iterative process as different variables may be changing on a day-to-day basis. The following information should be considered prior to making a decision:

Location & Ownership	Quantity	Quality & Condition	Working Conditions	Haul Route(s)	Alternatives	Environmental Concerns
✓ Owned, Leased or Private ✓ Quantity Agreement, Surface Lease or Damage Agreement ✓ R.M. Gravel By-Law	✓ Date tested and re-tested ✓ Update plan ✓ Outstanding contracts ✓ Quantities above and/or below water ✓ Stripping	✓ New pit or one previously worked on ✓ Past production records ✓ Estimate of what types can be produced ✓ Potential problems (sand equivalent, fracture, etc.)	✓ Stripping ✓ Water Table ✓ Mixing or Selective Working ✓ Oversize	✓ Haul distance and route condition ✓ Winter or summer access ✓ Easements ✓ R.M. Clearances	✓ Other availability	✓ Ground water ✓ Weed Control ✓ Safety ✓ Timber salvage ✓ Surface restoration ✓ Reforestation ✓ Other potential uses

In addition to the factors discussed, arguably the most important factor in the decision criteria should be the future needs of the RM. Preparing well in advance for the future will lead to cost-savings in the future.

E. LAND TITLES

A land title search is an important step in understanding the existing ownership information and any interests on the property. The image below is from Information Services Corporation (ISC) and highlights general information on a land title:



ISC has considerable information online that can help RMs understand land titles, including searching for liens to ensure RMs do not take on existing owner's debts. RMs should review the ISC website in gaining an understanding of land titles:

https://www.isc.ca/LandTitles/FindTitle/Pages/default.aspx

Practical Guide to Exploration

As RMs face continued challenges sourcing aggregate, having a focused approach to exploration is becoming increasingly important. As existing and easier to locate aggregate supply opportunities dry up, RMs will need to create a good system for collecting local knowledge and maintaining records of aggregate searches, while also leaning more on expert resources for locating new aggregate source opportunities. The following guide provides step-by-step recommendations on implementing an aggregate exploration system:

Consolidate Existing Local Knowledge to Identify Opportunities

1. Gather all relevant information on existing and past aggregate supply areas and areas that have been explored in the RM. Council and administration should jointly discuss any information gaps and identify knowledgeable local ratepayers that could fill in gaps or provide background on aggregate potential in various areas.
2. Gathering all relevant information and engaging with local experts may highlight some high value opportunity areas for exploration. However, if existing information and knowledge does not produce high value opportunities, an RM will need to undertake a new aggregate search program.

Aggregate Search Process

Conducting aggregate searches to identify new regional sourcing opportunities will likely require engaging expert consulting resources by an RM. Some large RMs may have some in-house engineering expertise with aggregate experience, but for the most part RMs will need to seek out experienced consultants with experience in exploration, testing and aggregate management. Experienced consultants will be the best resource to lead desktop study, field testing and lab testing work to ensure that an RM gets a clear picture of results and gains a strong understanding of the long-term potential sources highlighted by aggregate search programs.

1. Desktop Study
    a. The first step in an aggregate search process will be to conduct a desktop study that will lever existing information sources before going into the field.
    b. Core components of a Saskatchewan desktop study include:
        i. Reviewing imagery, including Google Earth and/or independent air photos.
        ii. Reviewing satellite imagery for areas that might suggest they have aggregate.
        iii. Reviewing the Water Security Agency (WSA) Water Well Information Database for drilling results in the area.
    c. A review of this information for an area, coupled with reviewing all relevant background information on past source locations and areas previously explored, will provide guidance on the best location for field analysis. Note, for areas that are known to have scarce sources of aggregate, a desktop study may not produce any locations worthy of field study.
    d. Prior to field study, the RM will need to get an exploration permit. The primary hurdles in getting an exploration permit will be consent of the landowner (if it's on private land) and a government review of any potential environmental and/or heritage issues related to the land. If potential issues exist, focusing on field testing that does not include ground disturbance can usually be undertaken before costs related to environmental or heritage studies have to be incurred.
2. Field Testing – No Ground Disturbance
    a. Electromagnetic (EM) survey equipment is a non-invasive method for searching for aggregate. These instruments can explore to various depths and produce solid

information on whether or not a location is likely to have aggregate that would justify ground disturbance in an area.

3. Field Testing – Ground Disturbance
    a. If the RM survey work highlights potential areas of aggregate, then ground disturbance would be justified to get sample material for testing.
    b. Using a back hoe for ground disturbance is the simplest and most effective equipment for a ground disturbance search as it provides visual confirmation and will provide good samples for testing.
    c. Drilling test holes could be required if an area has been deemed as potential environmentally or heritage sensitive, but using a back hoe will provide better overall information.
4. Testing
    a. If field testing work uncovers a potential source area, having material lab tested will ensure that an RM can get a clear picture on the quality of material sand potential quantities available at a specific location.
    b. Although it is preferable to have the granular materials scientifically tested, for smaller pits they can be reviewed by a local expert to determine the aggregate's quality, if there is a knowledgeable, local resource.

4.3 Pit Planning & Operations

Once an RM decides to move forward with a pit, the next major phase is the planning stage. The following section is going to look at:

1. Stripping & Extraction
2. Processing
3. Stockpiling
4. Traffic Considerations
5. Stormwater & Erosion Considerations
6. By-Product & Waste Considerations
7. Site Layout Planning
8. Risk Management

Proper planning is often critical to the success of a pit operation. Planning can reduce the number of disturbances and eliminate hazards. Putting in the proper time in advance will allow an operation to be as effective and efficient as possible. There may be significant time and effort that goes into the planning of an aggregate pit. Pit planning and utilization includes the most efficient use of the existing materials in an aggregate source. Each pit is unique and needs a unique plan.

4.3.1 Stripping & Extraction

A. Overview

The first step in pit utilization is the stripping of topsoil and overburden from potential aggregate sources. Sources with topsoil greater than 0.4m in thickness should be reviewed further to better understand the reason for the extensive thickness. The overburden is the material between the topsoil and the aggregate.

Extraction is one of the core activities that occurs when then aggregate is removed from the pre-determined area. There are several plans that are needed, focusing on both the short-term extraction and a master long-term plan. Extraction and pit utilization should be done using a systematic approach to the use of an aggregate source. For example

such things such as placing of stripping, water table considerations, and minimization of reject materials and placement of reject and identification and disposal of oversize materials.

Proper planning should include the selection of materials from a pit for the purpose for which they are intended. For example poorer quality aggregate in a specific pit area should be utilized for such things as traffic gravel. Areas with higher quality aggregate should be used for the production of base course aggregate.

The extraction plan should identify the areas of the pit to be worked as well as the direction that the pit should be worked in. It is imperative that various areas of the pit be identified for different products to gain optimal pit usage. The pit should be worked down to the bottom of the deposit to ensure minimal waste of valuable and usable aggregate resources.

There should be considerations to 'production-related' plans focusing on the actual extraction of the aggregate, while 'non-production' plans focus on other considerations, such as the noise and dust externalities. These plans can drastically reduce these externalities.

B. Required Actions

Sand & Gravel Lease:

One of the first steps before excavation should be to get an application in to the Ministry of Environment required to obtain a sand and gravel lease. Components of the application include information on: the scope of the operation, reclamation planning and more. The Ministries of Environment and Economy may also review to ensure the application meets all requirements. The maximum size of a sand and gravel lease is 640 acres and no municipality may have more than 1,280 acres under sand and gravel leases at any time.

There are fees associated with these leases as well, including:

- $200 lease agreement preparation fee, and
- $2 per acre non-refundable land holding fee.

A copy of the policy can be found in Appendix 5: Sand and Gravel Lease Policy and should be reviewed before making an application.

Further Planning:

As discussed the following four plans should be developed based on two variables. First, there should be a pit life extraction plan, which has a plan for both production and non-production related activities. Second, there should be a short-term extraction plan that also focuses on production and non-production related activities.

Plan Type	Details
Pit Life Extraction Plan	A plan for entire deposit and include discussion on noise reduction and processing. Also may include capital expenditures.
Short-Term Extraction Plan	A plan for one or two year period.
Production Related Plan	A plan that focuses on the operations of the pit. This includes planning for equipment, depth of excavation, loading and hauling, etc.
Non-Production Related Plan	Converse to the production related plan, these plans focus on the externalities that must be mitigated with respect to the aggregate pit. For example, this includes noise, dust, traffic and aesthetic mitigation.

The following table provides different items to consider in the "production" planning of the extraction.

Pit Size & Shape	– Pit width, length, extractable reserves and viability of phased mining will be determined by the deposit's shape and size, the topography and the pit rock's structure
Depth of Excavation	– Factors which may limit the depth and shape of the excavation pit or face include: – Depth to the top and bottom of the resource – Depth to the top of the groundwater table – Site steepness and lay of the land, and – The material competency or rock structure to maintain slope stability
Phased Mining Option	– Some deposits can be mined in phases – Determining factors may include: depth, thickness and shape of the deposit, the topography of the site, and the need to blend material (requiring a separate face for each type of product) – Phased mining can have numerous benefits for reclamation, environmental management and total project costs
Clearing & Grubbing	– Clear only as much area as needed over the short term – Clearing can start up to two years in advance – Erosion control should be installed before clearing starts – The By-Product and Waste Management section below provides advice on handling and storage of grubbed material
Topsoil & Overburden Removal	– The Stockpiling section provides advice on topsoil storage – Progressive mining allows for "Live Top soiling"
Berms (Landscape)	– Coordinate extraction (stripping) with berm construction
Drilling & Blasting	– Refer to qualified professionals
Location & Orientation of Working Face	– Strategic placement and orientation of the working face can significantly reduce visual, dust and noise impacts
Loading & Hauling	– Match loading and hauling equipment to each other, the deposit characteristic and processing equipment – Minimize or avoid double handling
Equipment Selection	– Equipment selection can make a difference in extraction efficiency and noise and dust reductions
Haul Roads	– Haul roads should be short, straight, with minimal hills and have sufficient stopping distances and good vision – Keep roads both dry and dust free
Primary/Secondary Processing Locations	– Processing can be continuous or intermittent – Location of the processing plant or facility can significantly reduce visual, dust and noise impacts
Water Management	– Coordinate extraction with location of settling ponds
Stockpiling	– Coordinate extraction with stockpiling

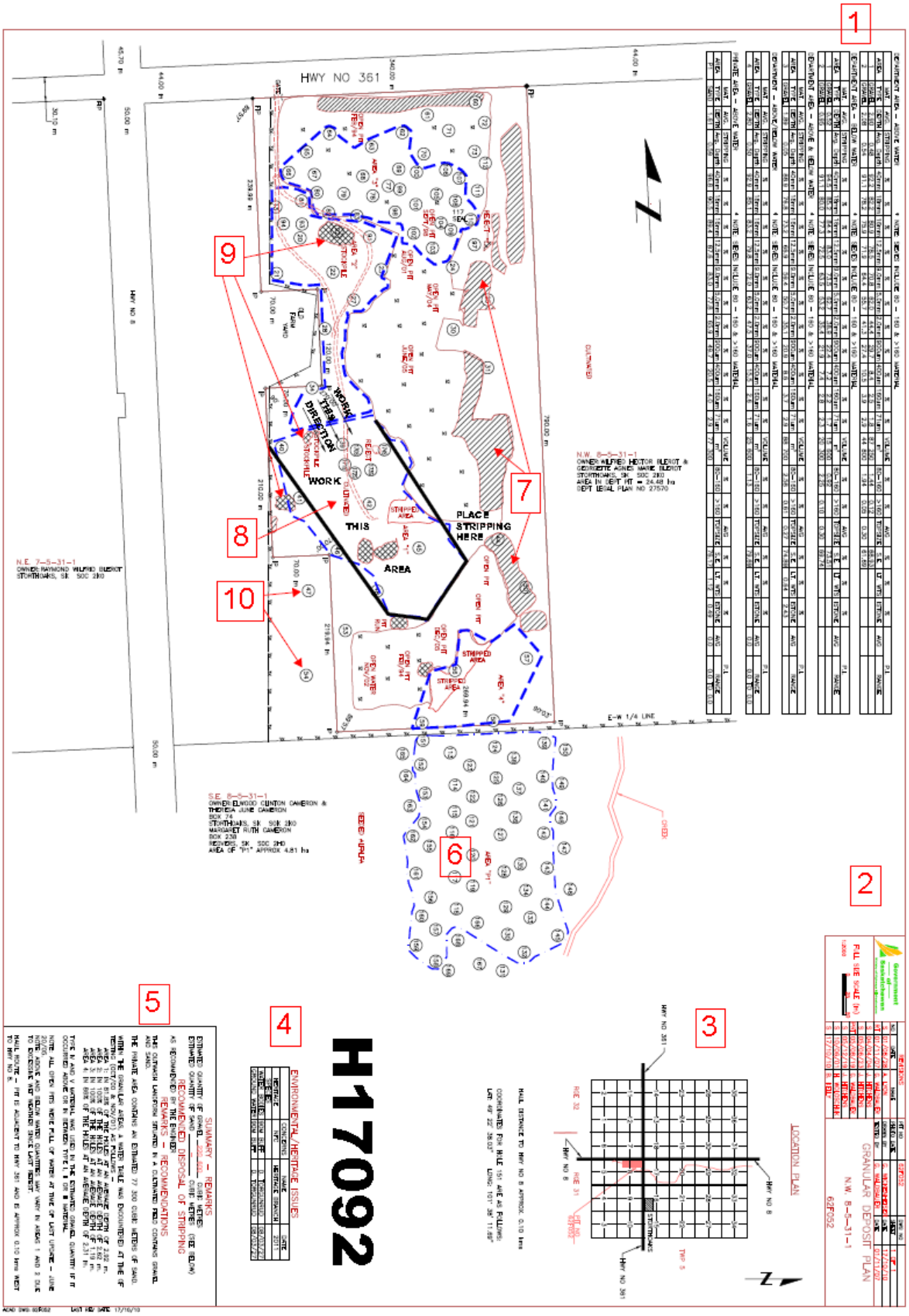
The following table provides different items to consider in the "non-production" planning of the extraction.

Noise	– Locate and orient the working face to intercept and reflect noise away from sensitive areas – Locate loading and unloading facilities in an area where noise will be absorbed and not broadcast – Generators can be particularly noisy. Locate them in an area that will dampen their noise
Visual Concerns	– Locate and orient the extraction working face and haul roads so that they are concealed from neighbours and roadways
Dust	– Locate and orient the extraction working face and haul roads so that they are not in wind "chits" or susceptible to strong winds
Traffic	– Locate the extraction working face and haul roads so that they are concealed from neighbours and roadways and protected from strong winds
Pollution Prevention	– Locate spill kits close to the working face and on equipment to handle upsets and spills – Ensure good maintenance – Ensure proper training is in place – Utilize blasting practices that minimize the release of nitrogen compounds
Erosion, Sediment and Stormwater	– Keep the extraction area and haul roads free of ponding water from rainfall and upslope sources
Environmental	– Consider/address special on-site or adjacent environmental features within the extraction plan
Reclamation	– Coordinate extraction with reclamation plans – Plan extraction to minimize reclamation work

C. ADDITIONAL INFORMATION

Pit Plan Description

1. Average Test results for each area of the pit – the results are the average of every test hole in the area and includes percentages of each size from greater than 160 mm to silt and clay sizes 71um). The material type is also listed (gravel which makes good base and asphalt aggregate and sand which is more of a subbase material and would not generally be used to produce aggregate). The average stripping depth is listed as well. The sand equivalent test averages are listed (higher the number the better) and these results look like the material is pretty good. The percent of lightweight material and iron stone is also a quality measure and lower is better for this.
2. Legend with the revision dates, land location, scale, pit number etc.
3. Location plan with pit number and referenced to nearby towns and highways.
4. Environmental and Heritage Issues summary.
5. Quantity summary, ground water summary, haul route information.
6. Privately owned pit area with numerous test holes completed.
7. Stripping piles.
8. Pit area to be worked and direction to be worked in.
9. Existing stockpiles of aggregate and/or sand and/or reject.
10. Existing test holes.


1
2
3
4
5
6
7
8
9
10
HWY NO 361
PLACE STRIPPING HERE
THIS AREA
WORK DIRECTION
H17092
GRANULAR DEPOSIT PLAN
N.W. 8-5-31-1
62F052
LOCATION PLAN
ESTIMATED QUANTITY OF SUMMARY - REMARKS
RECOMMENDED DISPOSAL OF STRIPPING
REMARKS - RECOMMENDATIONS
ENVIRONMENTAL/HERITAGE ISSUES

Extraction Map Plan:

An "extraction map plan" or "pit development map" should be developed during this phase and provide comprehensive information such as the location of the extraction face, progressive reclamation, etc. These maps can help to ensure that all workers are on the same page when it comes to different locations of piles, working spaces, access, roads and more.

Considerations:

- **Determine Space Needed at Start:** It is extremely important to understand the space requirements for the short-term and the life of the pit. It can be tempting at the beginning of the development to simply begin stockpiles near the pit in order to save time. Doing so can lead to much higher costs in the future as the stockpile will likely need to be moved again, resulting in "double handling" which, over the life of the pit, is much more expensive than moving the topsoil to its proper location.
- **Visibility:** A simple trick to reduce the visibility issue is to start at the back piece of the land. In some cases, the issue of visibility is a major concern for the RM ratepayers. By beginning at the back, it provides the least visibility at the beginning of a project, when concerns may be at their highest and can help with community relations. Another strategy that may be useful is the inclusion of tree berms, which also help with dust and noise control. Tree berms and other strategies will be discussed more in the Site Layout Planning section below.
- **Dealing with Hills:** If the extraction is occurring in hilly areas, it is best practice to begin at the top of the hill. It may be tempting to begin at the bottom of a hill in order to begin extraction as quickly as possible, but with proper planning, beginning at the top provides the best results. If extraction begins at the bottom of a hill, it increases the chance that the slope will fail. To begin at the top, use benches or lists and work down. This also could improve reclamation efforts as reclamation could begin on the different benches as the next one opens up.
- **Haul Roads:** When designing the Extraction Map Plan, it is important to think about the implication of the locations of the different areas, such as the stockpiles, processing equipment and pit. The path between the extraction point and the processing equipment should be as short as possible in order to reduce wear and tear on equipment, along with reducing time and overall production costs. In addition to length, the number of turns and the gradient of the roads should be considered.
- **Wetness:** Close attention should be placed on the general wetness of areas. If certain areas are known to become damper than others, the dry areas should have precedence in the Extraction Map Plan. Damp conditions create several issues that could create more costly conditions. Wet material is more difficult to process and wet conditions increase wear and tear on vehicles.
- **Clearing & Grubbing:** Clearing and grubbing are sometimes necessary in order to open up the space required to perform the excavation. Since trees and vegetation can help with dust and visibility issues, it is recommended that these functions occur as immediately before extraction as possible. Arrangements should be made beforehand for the removal of timber if a significant amount exists at the pit.

Trees could be hauled out and used for fence posts, cut for firewood or put to other commercial uses.

- **Reclamation Considerations:** Reclamation is an extremely important part of the extraction process and as such should be included in the pre-extraction planning phase. In addition, the concept of "Progressive Reclamation" can be very useful, that is the practice of beginning reclamation of disrupted land while working in another. This process is encouraged especially for larger pits. Reclamation should be a consideration in all phases of planning and operations, although significant effort can be reduced if progressive restoration is included in the extraction phase. Considerations should be given to the different angles, shapes and grades that could be developed during extraction, rather than at the end of the pit's life. Reclamation generally includes such activities as smoothing, contouring, replacing topsoil and re-vegetating the pit area.

D. Special Considerations with Extraction Below Water Tables

In many areas of Saskatchewan proposed aggregate extraction activities may intersect areas with a high or perched water table which pose technical, environmental, and regulatory challenges. Often aggregate extraction is required in areas where there is a direct interaction with the local water table or when resource pits have been temporarily abandoned and flooded but aggregate resources are still available for later extraction.

High Water Table – New Resource:

A previously conducted PDSA will have identified sensitive environmental features on and adjacent to the property identified for resource extraction. This study may not identify areas where a high or perched water table exists however test pitting, resource proving, geology, hydrogeology and geotechnical information, existing water well records (if available), groundwater monitoring wells (if required), and EM studies should aide in identifying these areas.

In cases where watercourses, wetlands, and groundwater resources are directly adjacent to a proposed pit and there is a high water table, a hydrological and groundwater study may be required to determine if the adjacent watercourse/wetland and groundwater resources will be affected by drainage. In these cases the following comments and recommendations apply:

- The issuance of a permit or surface lease does not exempt the proponent from other applicable legislation or permitting requirements.
- A determination of effects to existing groundwater users, permanent surface water bodies, or groundwater resources (e.g. connectivity to aquifers) may be required.
- If adjacent groundwater resources are affected by the drawdown of the water table in the resource extraction area (e.g. drained or changes in flows), additional permitting may be required.
- If adjacent wetlands are effected by the drawdown of the water table in the resource extraction area (e.g. drained or changes in flows), the proponent should apply for a drainage permit through the WSA for wetland drainage.
- If adjacent wetland habitats are affected by the drawdown of the water table in the resource extraction area (e.g. drained) the proponent should apply for an Aquatic Habitat Protection Permit prior to draining.

- In the case of changes to watercourse flows engage the Ministry of Environment and Department of Fisheries and Oceans Canada for fisheries concerns prior to draining.
- In addition; if the adjacent affect watercourse/wetland provides habitat for listed species then the Wildlife Act, Species at Risk Act, Fisheries Act, and other Acts, Regulations, and processes can apply. In these cases further environmental studies may be required to evaluate environmental effects and identify suitable mitigation measures. In these cases it is best to consult with a qualified environmental consultant prior to commencing activities.

Flooded Inactive Pits:

In many cases older pits become flooded when abandoned for an extended period. These pits can develop into wetlands and/or have habitat features that can support flora and fauna that include listed species. In these cases the following comments and recommendations apply:

- The issuance of a permit or surface lease does not exempt the proponent from other applicable environmental legislation or permitting requirements.
- Engage a qualified environmental consultant.
- Evaluate for listed and tracked species and sensitive habitats (repeat your PDSA).
- Engage with applicable environmental regulators (e.g. WSA).
- Develop specific mitigation measures as required prior to draining the Pit (e.g. measurement of surface water quality of water in the flooded pit to determine if it meets objectives prior to release).

Dewatering and Mitigation:

Dewatering directly into an adjacent watercourse or wetland is not permitted because this can have negative effects on the surrounding environment, including but not limited to, fish and fish habitat, migratory birds, and listed plant and animal species. Engagement with a qualified environmental consultant is recommended. The establishment of a dewatering plan and Environmental Protection Plan would be required. In all cases, mitigation measures (e.g. determination of water quality) should be in place for dewatering activities.

Other Considerations

In addition to the above proponents must consider adjacent land ownership and potential negative effects the drawdown of the water table may have on adjacent land use, groundwater resources, and land capability. It is recommended that engagement with adjacent landowners be conducted if adjacent lands will be affected.

4.3.2 Processing

A. Overview

A processing plant typically includes crushers (primary and/or secondary), screens, conveyor belts, feeder bins, generators and other heavy equipment. Due to the nature of the equipment it can create some concerns among ratepayers, especially with regards to the noise, dust and visual impacts.

B. Required Actions

Picking a Plant Location:

The first step to planning for the processing is determining the location of the crusher and associated equipment. The location of the crusher should take into account several different factors, including distance between haul roads and the stockpiles and attempting to minimize the distance. Additionally, the location of the crusher can help to mitigate issues such as noise, dust and visual impacts if they are towards the back or middle of the pit site. Lastly, there can be advantages based on the elevation of the crusher and control tower. Control towers and crushers placed on high ground are better for stormwater distribution while control towers and crushers placed on lower ground are better for reducing noise and dust.

Plant Types:

The following table outlines the four crusher types:

Processing Crusher Type	Description
Stationary Crusher	– Buildings and infrastructure with concrete foundations – Long-term and large operations – Large space requirements
Semi-fixed Crusher	– Less than 10 year life span expectancy – Skid-mounted equipment and mobile conveyor systems
Mobile Crusher	– Used at different locations for in-pit processing during separate phases of the pit extraction plan – Can also be used for smaller operations – Equipment is rubber-tired or skid mounted
Seasonal / Contract Crusher	– Contract processing facility – Seasonal or intermittent – Rubber tired or skid mounted equipment

As it can be seen from the table above, the stationary plant is the largest, most complicated and in turn, most expensive plant while the seasonal and mobile plants are the smaller, most mobile and least expensive. In most cases the RM aggregate processing will be undertaken using mobile or seasonal operations. However, there may be stationary operations in certain areas of the province at locations of very large aggregate deposits.

C. ADDITIONAL INFORMATION

Processing Equipment:

The following table outlines the different processing components along with their potential issues along with planning considerations.

Component	Description	Issue	Planning Notes
Crusher	– Reduces the size of the material	– Noise – Dust from feed and discharge	– Noise travels in uninterrupted lines of sight, and can reflect off barriers and buildings – Place crusher in hollow or low on the property – Use working face as noise barrier for primary crusher – Enclose or surround crusher with berms, walls or other sound barriers – Surround with or locate near thick vegetation
Screens	– Separate aggregates into various sizes	– Noise – Dust from feed and discharge – Wet screenings produces silt laden water	– Polyurethane and rubber screens are quieter than wire cloth screens
Conveyors	– Transport aggregate on powered belts	– Dust from feed and discharge – Visual	– Dampen material to reduce dust at transfer points – Variable higher conveyors may reduce dust generation and visual impacts
Chutes	– Direct falling aggregate into a feeder	– Dust from feed and discharge	–
Grizzly	– Static rejection of oversize – Removes fines to bypass primary crusher	– Dust – Noise	–
Surge Pile	– Isolates components of processing plant, smoothing out erratic production rates	– Dust – Noise – Appearance	– Sprinklers should not be used on surge piles with automated recovery tunnels, as high moisture content may limit flow rates and processing efficiency (not an issue for front-end loader recovery)
Transfer Points	– Where a stream of aggregate, such as on a conveyor, makes an abrupt change in direction or elevation	– Dust	– Hoods controls exposure to wind and reduce dust
Washing / Rinsing	– Rinsing material to remove fine particles to meet product specifications	– Silt-laden water	

Note on Processing Equipment:

Whether an RM is tendering the processing or doing it with own resources, it is important to do a thorough analysis of the equipment to ensure that it all will work in unison. For example, if a processor suggests utilizing a 24" jaw/crusher, ensure that the other equipment that is going to be provided and used will work with that. If that contractor only has a 15" grizzly, the 24" crusher is not going to provide any more value than a 15" crusher.

Equipment Marketplaces:

Some different market places for purchasing equipment include dealers and private sellers, such as:

- Finning (CAT);
- Pacesetter Equipment Ltd (Rentals and Sales);
- Certified Mining and Construction Sales and Rentals;
- General Aggregate Equipment Sales;
- ELRUS Aggregate Systems; and
- MachineryTrader.com.

4.3.3 STOCKPILING

A. OVERVIEW

Planning for stockpiling is another integral piece of the planning process before operations of a pit begin. In some cases, stockpiles can take up as much as half of the land that the operation is based on and often is one of the poorer visual externalities. The number of stockpiles that any operation may have could vary depending on the type and specification of aggregate required as well as the uniformity or lack thereof of the aggregate source existing beneath the topsoil and overburden. Stockpiles of different materials (traffic gravel versus base course) should be well separated to prevent contamination. Ideally each pile should be marked to ensure no confusion exists during removal of the various products from the site.

Stockpiles should not obstruct site lines of road users and should be centrally located in the pit area on higher ground to minimize potential flooding. The stockpiles should be placed on a fairly impermeable soil if possible. The stockpiles should be placed in such a manner so as to facilitate further use of the pit area and minimize infringement on the work area.

B. REQUIRED ACTIONS

Based on the exploration undertaken, the project manager should have a good understanding of the number of piles that may be required and their approximate size. In order to achieve the best outcomes, the following stockpiling guidelines should be followed:

- The types of stockpiles will depend on available land and equipment, quality of material and many other factors,
- Stockpiles of different materials should be well separated and signed (identified),

- Stockpiles should be placed in easily accessible areas that does not obstruct the site lines of road users,
- If possible the high end of a stockpile should face south with approximately an 8 m separation between the pile and the pit boundary,
- Aggregate stockpiles should be placed in a central location with the most direct haul route from the crusher which in turn reduces haul distances. If possible the area should be higher than the surroundings to minimize potential for flooding,
- Sites for stockpiles should be clean and level prior to storing materials,
- Aggregates should not be removed from stockpiles within 0.3 metre (1 foot) of the ground until final cleanup/removal of the stockpile,
- Layering can help to minimize moisture absorption in stockpiles, and
- Stockpiles can be located to function as sight and sound barriers.[vi]

C. ADDITIONAL INFORMATION

Issues & Considerations:

The following table outlines some of the major issues that can be seen with stockpiling and different considerations to deal with them.

Issue	Significance	Notes
Segregation The unintentional and undesirable separation of aggregate into size fractions	Depends upon type and height of stockpile, drop height, handling equipment and procedures	– Segregation can be triggered by any movement and/or vibration – Avoid end-dumping or dozing over the sides of piles – Fix improperly placed or malfunctioning conveyors – Segregated material can be re-blended by dozing stockpiles and dead surge areas – Frozen crust can increase segregation and decrease product quality
Degradation The breaking of aggregate pieces into smaller size fractions	Occurs if the aggregate is falling far enough to break on impact or if machinery is driven on top of it	– Avoid excessive machine time on top of aggregate
Location/Space	Depends upon available land	– Keep stockpile sizes to a minimum, as the material in stockpiles represents an investment in inventory – Provide room for loaders and trucks to maneuver – Located to reduce noise escaping the site – Consider prevailing wind patterns – Allow sufficient distance from fences and property boundaries to prevent overflow or spillage – Avoid proximity to utilities, whose underground structures may be damaged by ground deflection from the weight of the stockpiles – Avoid locating stockpiles under overhead wires where equipment may contact the wires – Provide sufficient area for both stockpiles and operations, such as: – Subsequent crushing and processing – Sub-contracting – Mixing plant – Weigh scales – Parking and mobile buildings

Drainage	Wet handling areas due to collected rainwater increase costs	– Use high, dry, and well drained ground – Avoid ponding – Stockpiles may compact the ground, decreasing local infiltration rates – Compact material with high fines to reduce water absorption
Safety	Depends upon size and whether automatic reclaim systems are installed Frozen ground can also be dangerous	– Avoid creating hazardous slopes, or stabilize – Prevent inadvertent and unauthorized access – Keep stockpile back from perimeter and fences to avoid entry breaches – Prevent access to top of stockpile (e.g. remove access ramp) – Falling frozen chunks/crusts can be very dangerous
Accessibility/ Orientation	Depends upon traffic flow from and to stockpiling area	– Provide for year round accessibility – For multiple vehicle access types consider separate access roads to avoid traffic conflicts – Design for safe, orderly and efficient access – Ensure optimum utilization of space for efficient existing or anticipated removal and processing operations – Provide for adequate separation from the various operations – Limit height to avoid loading out faces from becoming too high
Ground Stability	Generally only a concern in low, wet areas Frozen ground can also be unstable	– Stockpile areas should be on stable ground during all weather conditions – Stockpiles should not be adjacent to unstable ground, either up or down slope
Proximal Activities	Depends upon proximity to non-industrial neighbors	– Avoid locating stockpiling areas adjacent to public or residential areas – Stockpiles can be a major source of dust – Place stockpiles so that the prevailing wind will not create adverse dust effects on sensitive areas – Consider placing buffers on the downwind side of stockpiles – Can be used for noise and visual screens from other activities on site

4.3.4 TRAFFIC PLANNING

A. OVERVIEW

In some instances, hauling and transport represent the highest costs in the production of aggregate for an RM. Hauling of aggregate can also be one of the bigger sources of negative externalities, as it can be loud, congest roads and lead to premature deterioration of the road structure. For all of those reasons and more, it is important to plan ahead with regards to aggregate haul including haul route maximization and winter haul versus summer haul options. Considerations should be made to both on and off-site traffic planning.

B. Required Actions

On-Site Planning:

The planning for on-site traffic typically includes the development of policies and procedures that will help to reduce the negative externalities associated with pits. Considerations to review when planning include:

- Location of pit area roads,
- Types and volumes of traffic likely to use on-site roads,
- Speed limits,
- Noise, dust and visual impacts that may affect proximal features and facilities
- Entrance and exit requirements,
- A right-of-way hierarchy,
- Entrance/exits, loading facilities and pit area-road layout to avoid unnecessary noise, dust and detracting views,
- Traffic and personnel transport protocols and procedures,
- An on-site traffic map,
- Runaway lanes or retardation barriers on steep grades,
- Posting maps, routes, protocols and procedures at the entrance, office, control tower, parking area, etc., and
- Training on-site workers and preparing an "on-site traffic expectation handout" for contractors entering site.[vii]

The following table provides insight into some of the different considerations that should be looked at when planning and whether or not they improve dust, noise or visual impacts.

Measures	Description	Dust	Noise	Visual
Speed Controls	Reducing truck speeds from unregulated to: – 50 km/h can reduce dust by 25% – 30 km/h can reduce dust by 65% – 25 km/h can reduce dust by 80%	✓		
Sheet Vehicles	– Covering loads with tarps or sheets	✓		
Road Surfacing	– Topping or paving high volume on-site roads with dust free material to reduce dust generation and create a smoother, quieter running surface. Dust generation from traffic may account for up to 40% of all dust generated at a gravel pit – Paving roads between washing facilities and site exits	✓ ✓	✓ ✓	✓
Sweeping	– Sweeping surfaced roads to reduce dust	✓		
Drop Height	– Reducing drop height into trucks can reduce dust generation by up to 25% for that activity and can reduce noise and energy cost to lift the material	✓	✓	
Spray Facilities	– Spraying loads in unsheeted trucks with water or stabilizer can reduce dust	✓		
Wheel Washer	– Installing a wheel washer will prevent mud from leaving the site, reduce dust and make the overall site and adjacent roads cleaner	✓		✓
Road Spray	– Regularly spraying roads with water or dust retardant can reduce road dust by as much as 50%	✓		

Site Layout	– Locating roads at the lowest possible elevation on site reduces noise transmission, dust dispersal and visual intrusion – Not placing road along a ridge, or allowing it to cross ridges, as that would create a conspicuous break in the skyline – Keeping roads off of ridges also reduces the visibility and spread of dust – Using the lay of the land to hide roads, reduce exposure to wind and to muffle noise – Locating roads downwind from sensitive neighbours reduces dust and noise mitigation towards those neighbours	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓ ✓
Refusal to Overload	– Overloading trucks can cause material loss on-site and off-site, which eventually becomes fugitive dust	✓		
Road Maintenance	– Grading and compacting road surfaces to prevent uneven running surfaces, which create both noise and dust	✓	✓	
Upswept Exhaust	– Using upswept exhausts to avoid dust generation	✓		
Dust Skirt Loaders	– Applying dusk skirts on overhead bin or conveyor loadout facilities for trucks can reduce dust by 75% during the loading process	✓		
Protect/Screen Roads	– Placing berms, trees, shrubs, or fences upwind of haul roads to reduce wind exposure and interrupt noise and sightlines	✓	✓	✓
Strobe Back-up Alarms	– Using strobe lights as an alternative to back up alarms. Request for a variance from the Code requirement for audible alarms to your regional pit inspector.		✓	
Radios	– Using radio communications instead of horn signals		✓	
Maintenance	– Tightening loose and rattling hitches, etc.		✓	
Non-engine Brakes	– Avoiding use of engine retarder brakes within urban areas		✓	
Entrance Layout	– Staggering, off-setting or curving the site access to prevent direct views into the site.			✓
Loading Facilities	– Locating loading facilities to shield visibility from off-site locations			✓

Off-Site Planning:

With off-site planning, there are additional externalities that must be accounted for since it involves areas not just in the aggregate pit. Concerns around road quality, safety and intimidation can also be a concern in addition to the dust, visual and noise concerns.

A clear list of responsibilities and actions should be designed and communicated between the Producer, the Trucking Company (driver) and Road Authority. A suggested breakdown could be as follows:

Producer	Trucking Company	Road Authority
– Receiving, recording and acting on complaints – Avoiding overload – Spraying or covering outgoing loads – Refusing to load certain	– Sheeting trucks – Reducing speed – Driver training – Trip timing to avoid rush hours – Equipment selection	– Trimming roadside vegetation for visibility – Crossing lights – Signage – Signal lights – Planning for wide roads with

drivers – Washing wheels – Loading with chutes to avoid spillage	– Washing trucks – Painting trucks with visually appealing images or colours	adequate shoulders – Upgrading roads around aggregate supply areas

Other off-site planning considerations include:

- Estimates of possible truck traffic volumes,
- Sensitive facilities,
- Low-ballast roads,
- Overgrown roadside vegetation affecting safety, visibility and pedestrians,
- Preferred truck route(s),
- Reduced speed zones for aggregate traffic,
- Driver training and protocols,
- Signage and traffic control measures such as weight-activated turning lights,
- Enhanced pedestrian crossing aids,
- Roadside improvements and cost-sharing,
- Refusal to load rogue truck drivers,
- Avoiding overloads,
- Wheel washer to remove dust and mud,
- Dust skirts on overhead loadout facilities to reduce dust generation,
- Preventing aggregate from landing on vehicle surfaces, outside box, or sweeping off before hauling, and
- Covering or spraying loads to reduce blow-off.[viii]

Ensuring Proper Aggregate Measurements:

If there are private contractors operating pits within municipalities it is important to ensure that they are reporting accurate amounts of aggregate being hauled out of the pit. One reason is to ensure that there are adequate fees paid through the road haul agreements. There are three main options for ensuring that the proper amount of aggregate that is being hauled is being reported:

1. **Employee Oversight:** The simplest of options is to hire someone as a 'gravel checker' who is positioned at the pit each day and is responsible for counting the aggregate leaving the operation. One RM using this approach mentioned that their gravel checker "pays for their own wage".
2. **Weigh Scale:** Another option may be to require that pit operators supply and operate their own weigh scale. The operator would then need to remit their weigh slips to the RM which would serve as proof that they are reporting their weights accurately.
3. **Drones:** One of the more technologically advanced methods for overseeing the aggregate being hauled out of a pit is by using drones with capabilities to accurately determine the amount of aggregate in a stockpile. By doing so twice a year, once at the beginning and once at the end of the season, it can eliminate some of the hassle associated with the other options. Additionally, it has been found to be extremely accurate.

4.3.5 Stormwater & Erosion Considerations

A. Overview

Stormwater is the water that comes from rain, snow or melting that does not immediately infiltrate or evaporate. Stormwater will runoff and end up in another body of water. It is important to plan for and to understand since stormwater can lead to erosion and/or collect other sediments or pollutants. Additionally, wet surfaces and working areas create more difficult and dangerous work areas. The goal of planning for stormwater management is to control the flow of water across a site, control erosion by stormwater, manage sedimentation caused by stormwater and ensure that any discharge from the site is free of pollutants or sediment. If at all possible, sites that have direct drainage to existing waterways should be avoided or at minimum a water management plan should be implemented to prevent run-off from the site to any existing waterways.

The goal of planning for stormwater management is to:

- Control the flow of water across a site through the use of dykes, swales, ditches, curbs or berms;
- Control erosion by stormwater at a site through construction and maintenance of erosion control measures;
- Manage sedimentation caused by stormwater at a site through the use of sediment basins, sediment traps and other BMPs; and
- Ensure that any discharge from the site is free of pollutants or sediment.

Erosion is the gradual wearing away, dislodgement and loss of material from its original location. Specific to this case, water erosion wears away the topsoil, silt and/or clay. There are four types of water erosion:

- **Splash Erosion:** the impact of falling droplets of rain mechanically dislodging soil particles causing them to be carried away by runoff.
- **Sheet Erosion:** before concentrating into small channels, raindrop splash and runoff moves as broad sheets over the land and removes layers of exposed soil.
- **Rill and Gully Erosion:** As runoff concentrates in rivulets, it cuts grooves called rills. If the flow of water is sufficient, rills will develop into gullies.
- **Stream and Channel Erosion:** Large volumes of fast flowing water in unprotected channels will cause stream bank and stream bottom instability, scouring and removal of significant portions of the stream or channel banks and stream bottoms.[ix]

B. Required Actions

Stormwater Diversion:

- **Identify Natural Systems:** During the planning phase, it is important to identify the natural drainage systems in the pit area and adjacent to the pit. It is important to identify natural drainage patterns, as well as natural water sources where the water may be redirected.

- **Incorporate Tools and Structures:** Once natural patterns are identified and the natural flow of rainwater has been identified, certain tools and structures can be incorporated into the stormwater and erosion plan. These tools include ditches, swales, berms and retention areas. Additionally, pit floors should be designed so that they are at a gradual slope so that water naturally flows towards one end of the pit bottom. The gradual slope should be approximately 3 to 5%.
- **Regularly Dispose of Water:** If all occurs according to plan, through assistance of the natural systems and man-made tools and structures, the water should naturally be diverted back into the natural drainage system. If this does not occur, there should be procedures in place in case water begins to accumulate in the pit area. In that case, it should be routinely disposed of. The longer water accumulates and is left in a pool, the higher the chance it can become contaminated.

Erosion Prevention:

The main principle of Erosion Prevention is to keep the soil where it is and to prevent displacement. The following principles should be considered when designing a plan for erosion prevention:

- "Use the natural topography and vegetation onsite;
- Minimize disturbance to the natural vegetation onsite by clearing only where necessary;
- Minimize the amount of exposed soil at any one time through the use of progressive reclamation;
- Vegetate exposed soils as soon as possible;
- Vegetate temporary soil stockpiles;
- Minimize concentrated flows and divert runoff away from slopes or critical areas;
- Minimize slop steepness and slope length;
- Use temporary drainage structures, such as ditches, to divert upstream water around a site; and
- Use channel linings and other control features, such as check dams, to reduce velocities in temporary drainage structures"[x]

Managing Stormwater & Erosion:

Stabilization (Prevention)	Structural (Treatment)	Inspections
– Buffer Zone – Bioengineering – Ditches – Erosion Control Blanket – Tarp – Vegetation Cover – Benching – Hydroseeding – Limit Clearing – Tree Protection	– Check Dam – Ditches – Outlet Protection – Retention Basin – Settling Pond – Silt Fence – Swales	– Post-storm Events – Weekly

The stabilization practices help to prevent erosion, while some of the structural practices help to divert stormwaters. Inspections should be completed at least once every week and within 24 hours of any storm. It is good practice to keep a logbook of these inspections including the date, any rainfall and any damage that may have occurred. The following table looks at stormwater and erosion control issues along with planning considerations.

Component	Considerations & Suggestions
Precipitation	– Stormwater starts as rain or snow – Contact the Ministry of Environment for estimates of expected rainfall and wet seasons – Rainfall estimates (seasonal & peak storms) multiplied by the surface area of the site will yield rough run-off volumes that can be used to set performance targets
Adjacent Areas	– The type of adjacent land uses will determine runoff volumes; for example, hard surfaces such as parking lots will result in high runoff – Stormwater flows from upslope or upstream may impact the operation if they pass through the property – Where will the stormwater go once it leaves the site? What path will it take and what may it affect (streams, lakes, wetlands, residential areas, roads, etc.)?
Site Characteristics	– How does stormwater flow over the undisturbed site? – What existing onsite drainage features are significant, and can they be used to assist in managing stormwater? – What are the existing topography and vegetation, and how do they affect stormwater?
Critical Areas	– Some areas are more susceptible to impact from unmanaged stormwater than others, such as a salmonid stream – Critical areas may include water wells, wetlands, riparian areas or fish streams
Soils	– Where soils have not been stripped for aggregate extraction, they can play an important role in stormwater management by absorbing stormwater like a sponge – Exposed and unprotected soils are highly susceptible to erosion by stormwater
Erosion Problem Areas	– Size, shape, steepness and slope length can make some areas more susceptible to erosion than others – Some topsoil, silt and clays are more susceptible to erosion due to their composition
Clearing, Grubbing and Stripping	– Clearing, and especially grubbing, expose soils to stormwater and erosion, potentially causing siltation – Limit the extent of clearing and grubbing to what is immediately necessary – Clearly mark clearing boundaries to avoid inadvertent excessive clearing
Ditches	– Divert surface flows around/away from exposed soils (*Water Act* approval required) – Convey stormwater around the property – Channel water into sediment basins
Flow Controls	– Slower water flows have less energy to cause erosion and transport sediment – Check damns, swales, retention basins and vegetation can decrease flow rates within ditches – Divert runoff away from exposed areas wherever possible
Source Control of Pollutants	– Preventing pollutant release through source control BMPs is preferred over treatment (e.g. oil/water removers)
Sediment Control	– Sediment free stormwater is the goal of stormwater management – Minimize the amount and rate of runoff and that will reduce sediment entrapment – Remove any entrained sediment from the stormwater using swales, retention basins and silt traps before discharging
Stabilize Soils	– Exposed soils can be eroded by raindrop impact and flowing water – Preserve existing vegetation and/or establish new ground cover – Exposed soil stockpiles can be covered with tarps
Protect Slopes	– Stormwater flowing down slopes picks up speed (energy) increasing its ability to cause erosion and pick up sediment – Minimize slope length and steepness with terracing and diversions – Divert runoff around the top of a slope – Slopes can be protected with hydroseeding, erosion control blankets and tarps

Discharge	– Stormwater discharge options include: 1. Recycle into processing water 2. Land application (field application, irrigation, level spreader, swale) 3. Surface water application

Developing a Stormwater Plan:

A stormwater plan map may help to determine which issues may be experienced with stormwater and erosion. The following checklist provides examples of things that an RM may look for when developing this type of plan.

Stormwater Plan Map Feature Checklist	
Exposed Soil	– Show areas where soils are currently exposed, by natural processes or by current or previous work – Steep or long slopes – Exposed soils – Erodible soils – Proposed clearing sites
Vegetation	– Indicate existing tree lines, ground cover and grassy areas on the site that can be used to help control stormwater
Erosion Problem Areas	– Identify potential erosion problem areas
Critical Areas	– Identify any on-site and adjacent critical or sensitive receiving areas
Adjacent Areas	– Indicate if stormwater may come onto the site from adjacent areas – Indicate where the stormwater will go if it leaves the site – Indicate what may be affected (e.g. streams, lakes, wetlands, residences, etc.)
Drainage Areas & Patterns	– Show how stormwater currently flows about the property – Identify collection areas (often called basins or watersheds), waterways and natural discharge points
Clearing Areas	– Show areas that are to be cleared, grubbed and stripped
Ditches	– Show on the map the following ditches: – Diversion ditches to divert stormwater away from extraction, stockpiling, problem and cleared areas and roads – Conveyance ditches that move stormwater around the site (e.g. to sediment basins or other control features)
BMPs	– Plot location of BMPs (ditches, check dams, swales, vegetation, bioengineering, retention basin, etc.)

4.3.6 By-Products & Waste Considerations

A. Overview

A by-product is an incidental product that comes from the process of developing or manufacturing another product. In the case of aggregate pits, the main by-product is any topsoil and overburden that cover the usable aggregate below. These products have no added value to the aggregate production so cost recovery for removal of these materials is generally included in the aggregate production costs.

Garbage and waste is unwanted material and the unusable remains of developing or manufacturing another product. In the case of aggregate pits reject material, oversize material garbage and used petroleum products are often the largest waste sources.

Reject could potentially be used as a subbase depending on the quality and oversize could potentially be broken down with a primary crusher (jaw) for use in aggregate production. Garbage and petroleum products would need to be disposed of as per contract specifications which should include any environmental requirements for proper disposal of these materials.

The following table provides more examples of aggregate by-products and waste.

By-Products	Waste
Overburden: material below topsoil and above salable gravel and rock **Oversized/Coarse Rock:** boulders, cobbles, etc. that are removed by screening **Wash Plant Fines:** silt, sand and clay **Sediment Pond Fines:** silt, sand and clay **Screenings/Undersize Material:** natural sands, dirty sands, undersized material **Grubbing Material:** stumps, woody debris, slash	**Used Oil:** used engine oil and hydraulic fluids **Site Garbage:** garbage from office building, vehicle maintenance, lunch room, etc. **Septic Effluent:** sewage **Decommissioned Equipment:** major equipment and attachments **Used Barrels:** oil, lubricants, surface treatments

B. Required Actions

There are four key steps / principles that should be followed when considering by-product and waste management.

1. Minimize the production of by-products and waste,
2. Plan for the adequate space to handle and store them,
3. Fund uses or destination sites, and
4. Minimize handling.

Planning ahead of time will allow for more efficient use of these strategies and potentially reduce costs, space concerns and environmental damage. Keeping these principles in mind, the next sections will look at managing by-products and managing waste.

Managing By-Products:

- **Minimize Production:** There are three strategies that can be used to minimize by-products:
    1. Only strip areas of overburden where extraction will immediately take place
    2. Avoid extraction of particularly clay-rich materials if site conditions permit selective mining
    3. Tune processing plant for maximum recovery of salable fines to avoid including them with wash plant fines
- **Planning for Adequate Space:** Refer to the Stockpiling Planning section above with respect to planning.
- **Finding a Use:** There are three different uses for by-products of aggregate production. These options are placed in order from most to least desirable options. By immediately using the by-products, it reduces double handling.

1. **Immediate On-Site Uses:** Progressive reclamation is an ideal use where overburden can be immediately used to reclaim other areas of the pit. Other options include berm construction, soil treatments and progressive reclamation grading.
2. **Immediate Off-Site Uses:** These uses should be pre-arranged as to reduce double handling and stockpiling.
3. **On-Site Storage with Delayed Uses:** This use is the least desirable as it likely requires double handling to stockpile and additional effort to find an appropriate use. It may be possible that no uses are found as well.

Managing Waste:

The following table provides specific information on certain by-products and uses and applications.

By-Product	Production	Significance	Storage	Possible Uses & Applications
Overburden	Periodic – only during stripping	Overburden depths vary throughout the province. May be clay rich, leading to erosion concerns	Stockpile Berms	Used for reclamation fill Sold as fill Used to make berms
Oversized Rock	Continuous – during normal extraction	Not all sand and gravel deposits have a significant coarse component, and it may vary throughout the deposit	Stockpile Berms	Stockpiled and crushed Sold as rip rap Sold as fill Used as reclamation fill Sold as landscaping material Used in stream rehabilitation programs Used for on-site erosion control
Clay	Period – only when present during extraction	Not all sand and gravel deposits have a significant clay content and it may vary throughout the deposit	Stockpile Berms Cover to minimize erosion	Used for reclamation Made into perimeter berms and vegetated Sold as fill Sold as landfill liner & cover material Sold as soil supplement for agricultural applications
Wash Plant Fines	Continuous – during normal processing activity	Not all operations wash aggregate. Also depends on fine content of deposit, washing equipment and process efficiencies	In situ Holding cells	Sold as agricultural supplement Use for reclamation fill Used for growth medium during reclamation
Sediment Pond Fines	Variable – during normal processing activity and during the storm season	Depends on rainfall and fine content of deposit.	In situ Holding pen	Sold as agricultural supplement
Baghouse Fines	Continuous – during normal processing activity	Baghouses are large vacuum systems used to extract dust from enclosed processing operations	Bags	Used for asphalt mineral filler Sold as a soil supplement for agricultural applications Used for growth medium during reclamation and reclamation fill

Grubbing Materials	Periodic – only during stripping	Not generally a significant amount of material	Stockpile (not chipped material)	Harvest of merchantable timber Burned Chipped Chipped and blended with soil Buried (with permission) Hauled off-site Spread off-site on right-of-way Composted Mixed in berm material

In addition to by-products, there are also different types of waste that need to be disposed of.

Waste	Production	Storage	Disposal Options
Used Oil	Continuous – product of regular maintenance	– Barrels	– Return to seller – Collected by recycler
Site Garbage	Continuous – product of regular business	– Dumpster – Recycling bins	– Dumpster pickup – Burning – Recycling
Septic Effluent	Continuous – if municipal sewer system is not available	– Septic field – Holding tank	– Septic field – Pumped out
Decommissioned Equipment	Periodic – decommissioning of major equipment is relatively rare	– Yard	– Sell as used equipment – Sell as scrap – Sell for parts – Remove to appropriate waste disposal site
Double Walled Enviro-Tanks	Periodic – only as bulk-supplied products are used		– Return for deposit – Give to barrel dealer

4.3.7 Site Layout Planning

A. Overview

In general, there are three major negative externalities that may become issues as an RM develops an aggregate pit (although in actuality there are many others). The externalities are noise, dust and visual (or aesthetics). Proper planning in advance will help to limit these externalities and help mitigate potential issues with community members. Considerations for such things as controlled time(s) of operation, operations during extreme weather events (high winds) and operations during designated holidays should be considered to minimize negative public perception for aggregate production activities.

1. **Noise:** is a very profound issue with regards to aggregate operations. There are many different procedures that create high levels of noise, including: blasting, crushing, loading, hauling and more.
2. **Dust:** is also very profound externality. Most aspects of an aggregate pit create a disruption of the soil which generates dust that can move quickly across an RM.
3. **Visual:** Managing the appearance of aggregate pits has become more of a conversation topic in recent times. It is important to have a balance between the economic efficiency of a crushing operation, while understanding the aesthetic concerns of the RM.

Stockpiles should be located in areas with the most direct haul route from the site while ensuring that lines of site for traveling public are not negatively affected. Stockpiles should be placed with the high side of the pile facing south (if possible) and should have a proper separation from any property lines or boundaries (minimum of 8.0 m).

The following section will help by providing different strategies and things to look for to help to reduce the effects of these issues. The section follows a slightly altered design as it focuses on the three externalities rather than the typical "Key Steps" section. Each section discusses an overview of the externality followed by outlining considerations that may be useful in the design and implementation of a Site Layout Map for the aggregate operation.

B. Noise (Externality 1 of 3)

Overview:

Noise is the 'intensity of sound' and is measured in the decibels (dB). It is not linear as in two trucks that both emit 50 dB of sound would not create an intensity of 100 dB but rather 53 dB. In order to approximate the sound heard by a human ear, a technique called "a-weighting", measured in dBA is used. Due to the heavy equipment nature of an aggregate pit, noise is often an issue. This is especially true in some areas of Saskatchewan that are relatively flat and low on surrounding vegetation and natural noise barriers.

The following table looks at projections for noise levels for common aggregate machinery

		Projected Noise Levels		
Noise Source	**Measurements**	**1,000 ft.**	**2,000 ft.**	**3,000 ft.**
Primary and Secondary Crusher	89 dBA at 100 ft.	69.0 dBA	63.0 dbA	59.5 dBA
Hitachi 501 shovel, loading	92 dBA at 50 ft.	66.0 dBA	60.0 dBA	56.5 dBA
Euclid R-50 pit truck, loaded	90 dBA at 50 ft.	64.0 dBA	58.0 dBA	54.4 dBA
Caterpillar 988 loader	80 dBA at 300 ft.	69.5 dBA	63.5 dBA	60.0 dBA

Levels between 80 and 90 represent average street traffic while between 60 and 70 can be represented by conversational speech or business offices. A dBA of 140 is the approximate threshold of pain.

The following table looks at common noise generating activities and their potential impacts.

Activity	Duration (D) & Potential Impact (I)	Noise Producers
Tree Removal, Grading and Topsoil & Overburden Handling	D – Intermittent and temporary I – Medium	Moving vehicles such as skidders, bulldozers, haul trucks, excavators and chains saws
Drilling & Blasting	D – Intermittent I – Low	Drilling rig, power plant for drilling rig, moving the rig, detonation
Extraction & Handling	D – Moderate I – Moderate	Moving vehicles such as front-end loaders, excavators, bulldozers and haul trucks
Processing & Crushing	D – Continuous I – High	Loaders to feed crushers, haul trucks to deliver material to the crusher and remove crushed material; powering of crushing plant (primary and secondary); crushing of material; excavator-mounted hydraulic hammers to pre-crush large rocks
Grading	D – Intermittent I – Medium	Bulldozers, haul trucks, excavators, graders and scrapers
Stockpiling	D – Continuous I – Low	Moving vehicles such as front-end loaders, bulldozers, haul trucks and conveyors to build stockpiles
Conveying	D – Continuous I – Medium	Powering of conveyors, roller noise, belt slap and material fall noise
Onsite Transportation – Truck	D – Continuous I – Low	Haul trucks
Loading	D – Intermittent I – Low	Front-end loaders, material drop noise and honking, material falling onto grizzly

The following table looks at different noise management and control methods.

Management Option	Noise Management & Control Methods
SITE LAYOUT Containment & Dampening	– Locate haul-roads away from ridge tops and in topographic lows – Place processing equipment within natural or excavated hollows, such as the pit floor – Minimize the fall height of material – Construct stockpiles to intercept point source and ambient noise – Use crushing and screening plants within their design capacity – Plan orientation of working faces to reflect noise into dampening areas – Use first stage operations to act as screening for noise sensitive areas and receptors – Group and position buildings to act as an acoustic barrier – Restrict noise generating activities to sheltered areas – Create 'sensitive zones' within which activities are limited
OPERATIONS Source Prevention & Escape	– Select low noise emission equipment – Ensure smooth road running surfaces – Start plant engines one at a time – Maintain, repair and lubricate equipment – Alert and train staff to reduce noise emissions – Limit drop heights during handling – Fit acoustic barriers to processing equipment – Minimize mobile equipment speeds – Use alternative non-audible back-up alarms – Vegetate exposed surfaces such as overburden mounds with quick growing ground cover and plants – Use rubber lining in chutes, dumpers and transfer points to reduce the noise of rock falling onto metal surfaces – Use simple baffles around washing drums and rubber mats around screening, crushing and coating plants

	– Switch off equipment when not in use – Avoid unnecessary revving of engines – Direct noise away from sensitive areas whenever possible, if the noise source is highly directional – Enclose sources of significant noise, such as conveyors and process plants – Keep truck tailgates closed where possible
INTERCEPTION Ambient Reduction	– Retain and plant trees or shrubs around the site – Place treed berms near noise generation activities (source), receptors or at the perimeter of the site – Install acoustic fencing – Ensure there are not gaps in acoustic barriers, as noise will leak out

There are four main factors of noise that should be considered when performing the planning.

1. **Existing Levels of Noise:** If the site is located near other high noise operations, there will be less of a noticeable increase in noise than if the operation is located in quiet rural or urban area. Since dBs and dBA are not a linear scale, the addition of noisy equipment to an already noisy environment will have a marginally smaller effect on the noise levels. Additionally, if the pit is located in an already noisy area, it is likely that the neighbouring stakeholders will have a higher tolerance for noise than if it is located in a quiet area near schools, churches, etc.
2. **Site Location:** The location of the site and its surroundings has a big effect on the noise levels. As is the case with many RMs in Saskatchewan, they are flat and low on vegetation, creating fewer barriers to absorb the sound. In areas where there is more vegetation, it can help to absorb the sound and lessen the effects as it travels towards community members. The climate also has an effect on the noise. During colder months, as the air becomes denser the noise will travel further and faster. Low cloud cover also reflects the sound, compared to clear conditions. Wind can also affect sound, depending on the direction it may push or pull the sound.
3. **Equipment and Activities:** Another variable is the equipment that is used on an aggregate pit site. This should be a consideration when purchasing heavy equipment.
4. **Layout and Plant Location:** There are ways in which the layout and location of the crusher can also reduce noise. Locating the plant in the lowest possible spot will help to reduce the noise. Berms, tree barriers and acoustic fences are also effective tools that can be located near a crusher to help reduce noise.

Site Layout Map Considerations:

The following are several strategies that can be employed in order to manage the noise. First, working with the community can be one avenue to understand specific issues that might be relevant to a certain community. Items such as time of day, certain days and other time periods when there is preference for low-noise periods are all items that should be discussed. This can not only lead to mutually beneficial arrangements, but can also help with relationship building and allow the public to feel heard.

Second, noise can be controlled through several different strategies:

- Source control,
- Containment,
- Site layout (stationary objects),
- Operations (activities or moving objects), and
- Interception (perimeter structures.

Last, the construction of a Site Layout Map could incorporate all negative externalities, along with mitigation strategies. The noise control portion of it could include the following items:

- Noise-generating activities,
- Off-site facilities that are noise-sensitive,
- Potential noise reflectors, topographic hollows and noise absorbing areas,
- Placement of berms, stockpiles and tree buffers to create or enhance noise-dampening locations for the site or to act as noise barriers,
- Plans to locate noise-generating activities and haul roads in suppressing locations and away far from noise-sensitive facilities,
- Procedures to avoid noise generation and contain noise, and
- Designation of existing trees and shrubs as perimeter barriers on noise sensitive sides of the operation.

C. DUST (EXTERNALITY 2 OF 3)

Overview:

Dust can be defined as any fine particles (sometimes defined by any particle up to 75 microns (µm)) which are one millionth of a metre. Dust can be a health concern and the smaller the particle the more dangerous it can be. Mining actually produces a relatively small amount of dust, compared to the roads on which the haulers are driving on. The PM_{10} figure accounts for Particulate Matter smaller than 10 µm and can be used with other particle sizes.

Sources of Fugitive Dust (PM_{10})	Percentage of Total Dust Generation
Unpaved Roads	28%
Construction	23%
Agriculture	19%
Paved Roads	15%
Wind Erosion	5%
Mining	1%

In addition to the relatively low creation of dust by the mining of aggregate, most aggregate does not create a health issue, as outlined by the table below:

Dust Size Categories	Size µm	Concerns	Percentage
Large Dust	10 – 75 µm	Nuisance	94%
PM_{10}	2.5 – 10 µm	Health (respiratory)	3%
$PM_{2.5}$	< 2.5 µm	Health (respiratory)	3%

The following information is from an American study that looked at how much dust was generated during the loading, transportation and reclamation from stockpiles along with wind erosion.

Source Activity	% Total Emission	Emission Factor (Kg dust/tonne aggregate)
Loading into storage	12	0.016
Transportation	40	0.050
Reclaim from stockpiles	15	0.020
Wind erosion	33	0.045

The human respiratory system cannot filter out dust particles smaller than PM10. For the most part though, pits are relatively safe since 94% of the particles emitted fall under the classification of nuisance.

Dust Categories	Size µm	Distance Travelled
Large Dust (a)	30 – 75 µm	100 m
Large Dust (b)	10 – 30 µm	200 – 500 m
PM_{10}	2.5 – 10 µm	1000 m
$PM_{2.5}$	< 2.5 µm	> 1000 m

Site Layout Map Considerations:

Research from the US Environmental Protection Agency shows the effectiveness of some of these measures:

Activity	Control Method	Control Efficiency
Loading Stockpile	Reducing drop weight	25%
	Telescopic chutes	75%
	Conveyor sprays	75%
Wind Erosion from Stockpile	Regular watering	80%
	Surface crusting agent	Up to 99%
	Vegetative wind break	30%
	Lower pile height	30%

Speed Control **(compared to no control)**	Chemical surface treatment	50%
	Speed control: 30 mph	25%
	Speed control: 20 mph	65%
	Speed control: 15 mph	80%

When planning and developing a Site Layout Map, the following components could be included:

- Dust generating activities,
- Off-site facilities that are sensitive to dust,
- Prevailing wind direction(s) and onsite wind patterns, placement of berms, stockpiles and tree buffers to create or enhance wind shadows,
- Possible location of dust-generating activities and haul roads in calm location and far from dust sensitive facilities, and
- Location of existing trees and shrubs to create wind breaks.

The following table shows some of the main dust generating activities.

Activity	Duration of Activity	Potential Dust Emission for Uncontrolled Activity
Topsoil & Overburden Handling	– Short – Periodic	Depends on moisture, silt and clay content of the material and transportation to stockpiles on the site, particularly during the unloading and haulage stages
Drilling & Blasting	– Short – May be frequent	Properly designed and controlled blasts create less dust
Extraction & Handling	– Long – Can be continual	Depends on the equipment and technique used, content of material and exposure of the face
Loading	– Ongoing during extraction	Depends on the nature of the material, whether it is wet or dry, volumes handled and equipment used
Processing: Crushing & Sizing	– Ongoing	Depends on type of equipment, exposure to wind and fine contents of material
Stockpiling	– Ongoing	Depends on the volume and particle size of stored material, whether it is wet or dry and exposure to wind
Conveyor Transport	– Ongoing	Depends upon the conveyor system, nature of material and exposure to wind
Transport: Onsite Truck	– Ongoing	Depends on type of road surfacing, road location and size and speed of trucks
Transport: Offsite Truck	– Ongoing	Depends on road, speeds and truck equipment

The following table outlines different control strategies and options for dust control.

Control Strategies	Dust Control Options
SITE LAYOUT Minimize Creation	– Locate haul-roads, dump sites and stockpiles away and down-wind from neighbours – Minimize the height from which material falls – Surface roads with dust-free material – Lay out and construct stockpiles to minimize dust creation; use gentle slopes and avoid sharp changes of shape – Use crushing and screening plants within design capacity – Use conveyors rather than haul-roads – Restrict dust generating activities to sheltered areas – Create 'sensitive zones' within which dust activities are limited
OPERATIONS Control Escape	– Limit spillage by not overloading trucks – Enclose or provide wind protection for conveyors, chutes, process plant, stockpiles – Install a dust removal system (bag system) for the plant – Use sprays and mists at dust sources – Fit outlets with cyclones, wet-scrubbers and filters – Insist on good maintenance and house keeping – Compact, grade, surface and maintain haul-roads – Fit dust extractors, filters and collectors on drilling rigs – Use mats when blasting – Use wind-breaks/netting screens/semi-permeable fences – Limit drop heights – Fit wind-boards/hoods at conveyors/transfer points – Reduce speeds and limit movement of vehicles, use upswept exhausts – Spray exposed surfaces with binders – Vegetate exposed surfaces, such as overburden stockpiles, with quick growing plants – Pave and sweep haul-roads and other high use semi-permanent dusty surfaces – Shake dirt off of trucks with rumble bars and provide vehicle washing facilities – Provide a surfaced road between vehicle washing facilities and site exit – Use closed or sheeted vehicles to carry dry material
AIR QUALITY Dust Removal	– Use trees or shrubs around the site as coarse air filters – Place treed berms near dust generators, receptors or at the perimeter of the site – Use sprinklers, sprayers or mist, with or without additives
CESSATION	– Shut down the operation if, due to unique weather conditions, the extended dispersion of dust cannot be avoided

D. VISUAL (EXTERNALITY 3 OF 3)

Overview:

Visual appearance can be a big issue within communities. It can particularly be a big issue in Saskatchewan where the land is generally flat and in parts of the province there is little tree coverage. There are often three different types of factors that lead to unacceptance of a visual disruption in a community.

1. **Landscape Character:** how the appearance of the operation contrasts in form, height, mass and colour with the surrounding natural and built landscape
2. **Negative Associations:** perceived negative associations with industrial operations, dereliction and disturbance
3. **Sense of Permanence:** even though aggregate operations are a temporary land use, they are often perceived as permanent

These impacts come from two different sources:

- **Obstruction:** Blocking a pre-existing view, such as with a stockpile
- **Intrusion:** When something new is added that seems out of place

Some examples of visual landscape impacts and sources include:

Potential Source	Visual Landscape Impacts
Pit Landforms	– Stockpiles – Working faces – Haul roads, embankments and ramps – Settling pond, soil and overburden storage stockpiles – Waste heaps – including scrap
Mobile Equipment	– Mobile processing equipment – Aggregate hauling trucks – Transport and pick-up trucks
Building & Structures	– Storage hoppers – Crushing and screening plant – Conveyors – Fences
Miscellaneous Sources	– Air pollution – Dust deposits – Mud on roads – Lighting
Other Sources	– Long term alteration to the existing landform profile – Out of place perimeter planning

A popular approach to evaluating visual impacts is to perform a 'key viewpoint approach'. The steps to this approach are as follows:

Steps	Details
Step 1	Identify key viewpoints (such as from roads, residential areas, footpaths, etc.)
Step 2	Determine the extent of potential visibility (directions and distances) Evaluate sensitivity of viewpoint
Step 3	Determine degree of obstruction or intrusion that will occur Determine the potential changes or the visual impact
Step 4	Modify the pit layout and operations to minimize visual concerns

Site Layout Map Considerations:

The following table outlines different control strategies for visual landscape.

Control Strategies	Visual Landscape Control Options
CONCENTRATION	– Concentrate as many activities within an area as possible – Move extraction and related activities systematically from one area to the next – Re-contour and re-vegetate as you go
INTERIM	– Hydro-seed berms and stockpiles (also a theft detector)
CONCEALMENT	– Site Selection – Orient operation to limit visibility of working faces – Stagger, offset or curve the pit access to prevent direct views into the site – Ensure sufficient land is available to enable landform modelling, off-site planting and perimeter treatment – Consider the topographic position and the potential for natural screening – Keep pit elements a similar size and scale to that of the local landscape – Design lighting to minimize stray light (light pollution) – Method of Working – Work in a direction away from major sight lines – Phase extraction to limit the area of active disturbance – Perform progressive reclamation – Consider alternative extraction methods – Design and locate processing plant to reduce visibility, giving attention to colour, cladding, height of structures, etc. – Screening – Construct and plant berms – Build rock/earth walls rather than fencing – Retain existing vegetation wherever possible – Consider temporary planting at long term operating sites – Camouflage – Consider colour and cladding of buildings and plant, within safety margins – Limit the height of structures, stockpiles and waste dumps as far as possible and design with shallow gradients – Haulage – Locate loading facilities to minimize their visibility – Route internal haul roads to avoid punctuating the skyline – Route external truck routes to avoid sensitive properties and landscapes – Screen internal and external routes with berms where necessary – Housekeeping – Maintain the internal pit environment – especially where visible externally (e.g. remove scrap and keep stockpile and waste disposal areas tidy) – Undertake regular weed control of on and off site planting areas – Keep external roads clean and mud-free, including the access and visitor facilities
INNOVATIVE	– Site tour to familiarize community with operation's visual elements – Construct viewpoints – Informative signage

Additions to the Site Layout Map could include:

- Key viewpoints and viewscapes
- Visual landscape concerns for the operation, such as industrial structures
- Character of local landscape

4.3.8 Risk Management

A. Overview

The following section will look at several of the major risks and ways to mitigate or even eliminate them. The risks considerations that will be discussed include:

- Emergency Spill Response Plan & Hazardous Materials
- Employee Training
- Community Relations

B. Emergency Spill Response Plan & Hazardous Materials

All aggregate pit operations will more likely than not have petroleum fuels located on or nearby the operations. For this reason, an Emergency Spill Response plan should be developed in the case of an emergency so that the operation can respond quickly to emergencies and spills.

Emergency Spill Response Plan:

Typically, the items that need to be included are:

- Company Information
- Site map
- Marshalling area establishment
- Hazard and hazardous material review
- Pollution prevention measures
- Summary of roles and responsibility
- Emergency systems and equipment
- Emergency response guidelines
- Listing of emergency telephone numbers
- Emergency response training
- Notification and reporting requirements
- Containment and clean-up techniques/options

A site map should be included that has all of the facilities, roads, structures, hazardous materials and marshalling yards. The operation should ensure that these maps are posted at several locations on the pit site.

Pollution Prevention Measures:

Go to the Ministry of Environment website for more information on Disaster Prevention and Preparedness:

http://www.saskatchewan.ca/residents/environment-public-health-and-safety/disaster-prevention

Notification and Reporting Requirements:

In Saskatchewan, any spill or emergency that may pose harm to the environment of public health and safety must be reported immediately. These reports can be completed online at:

https://www.saskatchewan.ca/business/environmental-protection-and-sustainability/hazardous-materials-and-safe-waste-management/report-hazardous-spills

When in doubt it is always best to report by calling the Ministry of Environment at **1-800-667-7525**.

C. Hazard and Hazardous Material Review

The following table outlines what many the typical tanks may look like that are included on an aggregate pit operation.

Hazardous Materials	Typical Quantities	Material Safety Data Sheet	Typical Locations
Propane	20,000 litre tank Five 20 kg bottles	Yes	Propane station
Diesel	500 litre tank	Yes	Fueling station
Gasoline	200 litre tank	Yes	Fueling station
Fuel Oil #1	200 litre tank	Yes	Fueling station
Lubricants	10 lube cubes	No	Covered storage
Hydraulic Fuel	Five 170 litre drums	Yes	Covered storage

D. Employee Training

Employee training is an important investment that will pay off for any aggregate pit operation. Whether it is training on equipment to improve the longevity of the equipment and reduce workplace injuries or safety training such as First Aid, it is likely always a positive cost-benefit to improve training. Sometimes, industry associations will help to cover the cost of these types of training and more information can be found by reaching out to these groups.

Minimum Requirements:

Although additional training is always a beneficial endeavour, there are minimum requirements for training that employees must have, as per *The Mine Regulations, 2003*. Section 20 of the regulations outlines these requirements. An employer must:

1. Develop a written program for the training of workers and appoint a person to direct the training program;
2. The program must outline the content of the training and the timeframe;
3. Keep records of the training; and,
4. Ensure that the person providing the training is competent and has the time and facilities to provide the training.

Note: If a worker has previous experience and meets the standards of the person providing the training then the trainer may accept the worker's experience as a pass for the training.

Training Guidelines:

In general, the following are some suggestions for training for employees on an aggregate operation.

Employee/Task Identifier	Training Suggestions
New Miner	– Safety orientation – Job specific subjects – prior to starting work – Primary task training – should ensure a good understanding of what is specifically required – First aid and WHMIS training
Newly Hired Experienced Miner	– Safety orientation – General review to ensure job-specific knowledge is current – Review of certificate for validity and expiry dates
New Task Training	– Specific task training – whenever a miner is assigned to a new task – Training times – will vary for each task and should be included in the pit's training plan
Site Specific Hazard Awareness Training	– Will vary depending on the worker's exposure to hazards – Should consider the presence of non-miners on the pit site

Additional training requirements could also include:

- WHMIS
- Supervision
- Industrial First Aid
- Blasting
- Driver Training
- Fire Fighting

E. Community Relations

As discussed in the by-product and waste sections, there is an increasingly large focus on community engagement. This primarily comes from heightened curiosity and expectations around controlling externalities such as dust, visual infringements and sound. Another major factor is added environmental expectations. Some strategies that can be used to engage with the community include:

1. Community open houses;
2. School visits;
3. Community liaison committees; and,
4. Participation in community activities.

F. Resources

Emergency Spill Response Resources

For more information on the Storage Tank Systems for Petroleum Products and Allied Petroleum Product Regulations please go to:

https://www.canada.ca/en/environment-climate-change/services/pollutants/storage-tanks-petroleum-allied-products.html

4.4 Reclamation

4.4.1 Overview

Reclamation and restoration is an integral part of the extraction process and as such should always be included in the pre-extraction planning process. The main objective of reclamation and restoration is to return the land disturbed through mining into the most appropriate and productive condition after use of the site. The planning process for reclamation should include all stakeholders including landowners, operators, approving agency, local authorities and any others with a vested interest in the property.

Reclamation and restoration should occur during mining operations (progressive restoration) or as soon as possible after mining has been completed (post excavation).

4.4.2 Required Actions

Pre-Planning Considerations:

Before completing any concrete plans, there are some pre-planning considerations which should be addressed prior to developing the plans. As part of the process a practical after use should be selected as early as is possible. Factors to consider when determining after use are pit location, availability of topsoil and water, zoning and other restrictions, and, cost effectiveness. All stakeholders (operator, landowner, approving agency/local authority) should undertake this process jointly.

TIMING:

The following table outlines general reclamation strategies:

Reclamation Strategy	Notes
Post-Extraction Reclamation	Reclamation initiated only after all extraction stops
Interim Reclamation	Temporary reclamation during operation to stabilize disturbed areas
Concurrent Reclamation (Progressive or Continuous)	On-going reclamation as aggregate resources are removed Overburden and soil is immediately replaced
Segmented Reclamation	Reclamation after extraction has stopped in one area of the pit

As mentioned in the overview, reclamation should occur as soon as possible after mining, thus it is preferable for the pit operation to use the concurrent reclamation.

CONCEPTS:

1. **Extraction is temporary:** operators should ensure not to limit post-extraction land uses and act to move land back to its primary state. In general, agriculture lands should be reclaimed to similar soil quality as before and native prairie and wetlands should be replaced in approximately the same amounts as before.
2. **Plan the end use first:** a specific land use can be determined during permitting. May be difficult the longer the crusher is expected to be in operation.
3. **Plan for reclamation:** operator, landowner, approving agency and local authority should plan for reclamation jointly. This planning can reduce costs by decreasing double handling and will ensure all stakeholders have input into the planning process.
4. **Account for uniqueness of the pit:** this includes pit locations, the grade, and the scale of the operation, the geometry of the deposit, the surface geometry, and the grade distribution of the deposit, surrounding area, zoning and other restrictions.

IMPORTANT GUIDELINES:

1. **Soil Salvage:** in general, soil should be left in the same condition in which it was found.
2. **Recontouring:** should shape the land in a manner that is appropriate to its post-mining use through contouring of slopes and smoothing. Slopes should be left no steeper than 4:1 where possible while remaining consistent with surrounding terrain.
3. **Surface Drainage:** in cropland, there should be drainage to minimize ponding while in wetlands it should be adequate to promote a diversity of habitats.
4. **Soil Replacement:** subsoil and topsoil should be replaced and re-vegetated. Re-vegetation should be completed as soon as possible after re-contouring.
5. **Haul Roads and Access Roads:** the operator should restore access and haul roads required for the crushing operation but no longer required post construction.
6. **Other Important Guidelines:** includes revegetation, soil sampling and maintenance and monitoring.

Note: When in doubt a safe assumption when it comes to making decisions on reclamation is that objective of reclamation is to bring the land to an appropriate and productive after use.

CRITERIA & GUIDELINES FOR RECLAMATION[xi]

The following criterion outlines what standards the developers should aim to reclaim the pit to in terms of three main areas: vegetation, soil and landscape.

Vegetation Criteria

- Live plant cover should reflect the seed mixture used for revegetation; average plant cover of the three dominant species should be included with the restoration statement.
- Ensure there are no noxious weeds.
- Total live plant cover should be 65% of pre-disturbance or adjacent site conditions and should be evenly distributed on the site.

Soil Guidelines

- Surface and subsoil must be replaced evenly as possible and the average depth must be 70% of pre-disturbance of adjacent soil conditions.
- No mixing of topsoil and subsoil.
- Soil texture should be consistent with pre-disturbance or adjacent conditions.
- No addition of off-site topsoil is permitted.

Landscape Criteria

- Site drainage should be consistent with surrounding landscape patterns, direction and flow rates and pre-disturbance conditions.
- Erosion should be no more that on the adjacent landscape.
- With regards to contour and stability, no slope movement, slumping or subsidence is allowed.
- With regards to gravel and rocks, no piling or concentrations of gravel and/or rocks is allowed.
- All woody debris must be salvaged where so required as part of the lease agreement, easement, permit or approval.
- No industrial or domestic debris is allowed.

RECLAMATION PROCEDURES

Rehabilitation and reclamation should include the following:

- Covering of bare rock and subsoil,
- Placement of screening, oversize and other non-useable materials in the pit bottom,
- Re-contour slopes to at least 4:1 where possible or to a condition similar to surrounding terrain,
- Replace topsoil to the newly contoured slopes as soon as possible (5 to 10 cm deep is recommended) with side slopes receiving priority,
- Re-vegetate as soon as possible,
- Need to achieve a rapid establishment of ground cover (grasses are generally the best option for this, use fertilizers to enhance growth),

- Underwater slopes should be reclaimed with a gentle slope/grade to encourage wildlife,
- Restore access and haul roads that will no longer be required by the landowner,
- Where possible restoration/reclamation of areas within the pit but outside the actual work area should be undertaken provided funding requirements are not excessive in order to do so.,
- Arrange for removal of timber well in advance of gravel extraction, and
- Refuse and toxic or polluting materials should be remove to approved dump site or facilities. This material should never be left in the pit area. Surplus rock or oversize rock should be buried or piled so that it can be used for rip-rap.

Notwithstanding the above, all pit reclamation and restoration procedures should be coordinated through the appropriate agency to ensure all environmental requirements are met (it is advisable to obtain the services of a consultant specializing in this area to ensure that these are met). Areas within the pit boundary where aggregate stockpiles previously existed should also be restored to a condition that is equal to or better than the conditions prior to placing the stockpiles. These conditions should also be suitable to the landowner.

PIT CLOSURE:

In a scan of legislation, pit closure does not seem to be in any particular acts or regulations pertaining specifically to closure of an aggregate pit. The principles and guidelines above should be followed in order to restore the area back to a similar condition to pre-mining activities. Provided in the Additional Information section is an Environmental Best Practices Manual which may help with closure activities.

4.4.3 ADDITIONAL INFORMATION

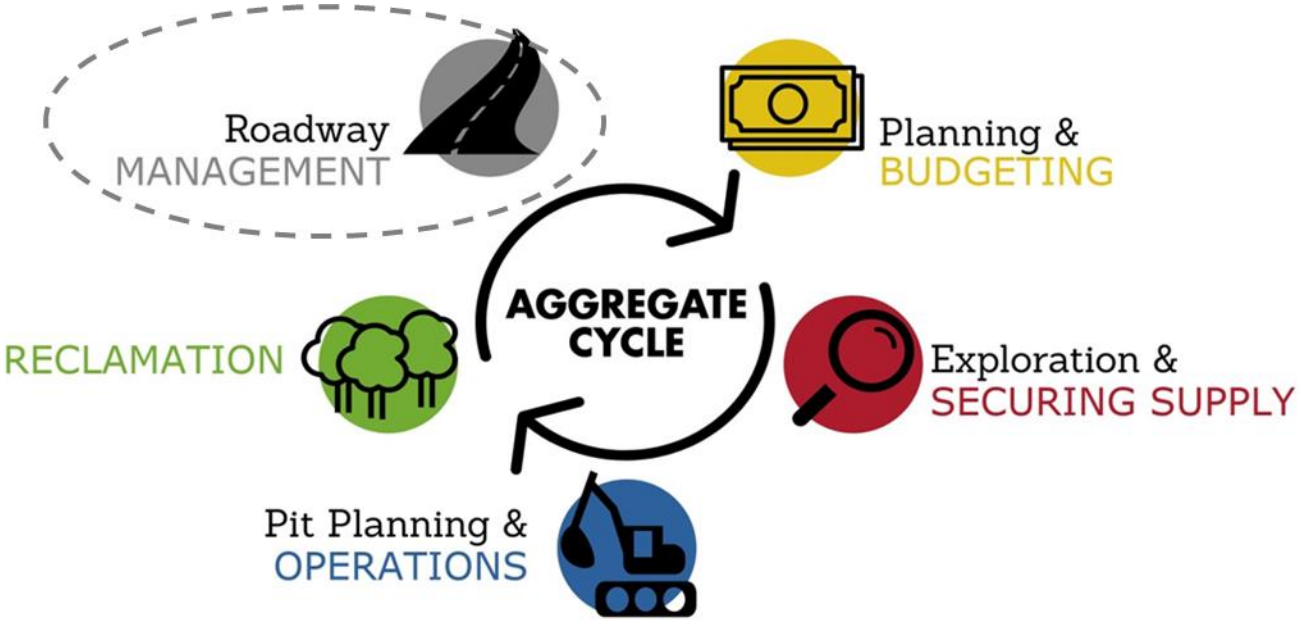
The following ***Environmental Best Practices Manual*** from the Ministry of Highways and Infrastructure is a part of the Doing Business with the Ministry webpage. It discusses erosion, sediment control and replacement of topsoil which is all helpful for pit closure activities. It can be found at:

http://www.highways.gov.sk.ca/business

The Mineral Industry Environmental Protection Regulations, 1996 can be found here:

http://www.qp.gov.sk.ca/documents/English/Regulations/Regulations/E10-2R7.pdf

4.5 Roadway Management



There are several best management practices that an RM and/or the aggregate producer can implement to ensure that damage to existing infrastructure is kept to a minimum while ensuring that any negative perceptions of the public are also kept to a minimum. Where possible it would be economically beneficial to limit the haul routes to roads with better strength and stability. Upgrades to the potential haul routes should be undertaken prior to the hauling of aggregate. Proper selection of aggregate haul routes and timely road upgrading prior to the beginning of hauling will provide efficiencies with respect to travel time, vehicle maintenance and roadway performance.

Aggregate producers should receive and attend to any complaints as soon as possible after they are received. Standard practices such as avoidance of overloading haul trucks, covering loads, removing non-compliant haulers from the contract limits and loading haul trucks with shutes to avoid spillage are some of the practices that should be implemented as roadway management options. Other options such as covering loads, reducing speeds along haul routes, implementation of driver training, safety training, and avoidance of rush hours and/or school start and finish times can be utilized.

4.5.1 Overview

Routine maintenance and rehabilitation activities are a factor in aggregate management. Standard activities such as maintaining a proper cross section and shoulder of roadways are important to promote proper drainage from rainfall events. Standing water on existing roads leads to loss of surface aggregate through softening of the grade causing failures which in turn forces gravel out. Improper blading techniques for gravel roads such as improper operating speed, improper mold board angle and pitch and motograder stability may create issues. Mowing of shoulders is very important as properly mowed shoulders will make the recovery of gravel that has drifted to the edge of the roadway much easier. Proper failure repair techniques, incorporation of adequate drainage in

ditches and culverts, and proper use of "good surface gravel" are all important. Dust control programs will lead to cost savings through reduced gravel loss, reduced blade maintenance requirements and reduced overall maintenance requirements. Finally, innovation in gravel road maintenance is extremely important due to the changes in the type of traffic coupled with constant pressure on funding and staffing resources.

4.5.2 Required Actions

Routine Maintenance and Rehabilitation of Gravel Roads

Everyone involved in gravel road maintenance must understand the correct shape for a typical cross section including the crown, shoulder area and ditch. Proper maintenance to keep the proper crown and shape is critical to prevent premature deterioration of gravel roads. Wet conditions are generally the most critical due to weak subgrade strength and marginal gravel depth so equipment operators must constantly focus on maintaining these roads to prevent aggregate loss and premature deterioration of the road structure.

Routine shaping and motograding of gravel roads is also a factor in roadway management for several reasons including management of gravel loss. For example, operating a motograder too fast can cause bouncing of the machine leading to depressions and ridges in the road surface. This leads to ponding of water during rain events, which in turn accelerates gravel loss from the road surface.

The recovery of loose aggregate from the shoulder of the roadway is also much more effective and efficient if a proper angle is maintained on the moldboard. Operating the moldboard with an angle between 30 and 45 degrees is recommended. Operating with an angle less than that makes it a challenge to recover loose aggregate from the shoulder of the roadway without spilling the material around the leading edge of the moldboard.

Moldboard pitch during motograding operations is also important in terms of gravel management. For example if the moldboard is pitched back too far the material will build up too much and will not fall forward leading to excess loss from the toe of the moldboard. This also reduces the mixing action that is desirable during recovery of gravel from the shoulder. The moldboard pitched too far back simply pushes gravel and does not allow it to move forward which separates the stone from the sand and fine sized material. This in turn leads to small potholes and an uneven surface which in turn accelerates gravel loss from the surface.

Recovering gravel from the shoulder (pulling the shoulder) and spreading it on the road surface is also an important maintenance activity on gravel roads. It serves two purposes: 1) conservation of loose gravel and placing it back on the road surface; and, 2) restore shoulder drainage.

Mowing is an important maintenance activity on gravel roads in terms of dealing with high shoulders and from a gravel recovery perspective. It is much easier to recover gravel that has drifted to the edge of the roadway when the vegetation is removed through mowing.

Repair of soft and weak subgrades is also a critical component of gravel road maintenance. Proper repair of these areas will save money on future maintenance costs

of the roadway and will also help to preserve the use of gravel for both the failure repair itself and for the surface gravel. In general the soft area should be excavated and the weak material removed. A geotextile fabric is then placed on the subgrade prior to placing the select material (granular). The geotextile acts as a separator between the weak soil below and the select material above. This prevents contamination of the select material from wet silt and clay soils due to pumping action and subsequent migration of the fines into the select granular material. The contamination will weaken the select material very quickly making it unstable and undrainable. The fabric prevents the contamination by filtering out the fine soils while at the same time allowing the water to pass through it and drain out the clean granular material.

SURFACE GRAVEL

A key point to note when acquiring surface gravel for gravel roads is to make sure the material has sufficient fine material in it to provide a plastic or "binding" characteristic on the road surface. Too often surface gravel is taken from existing stockpiles that have been produced for other uses such as base course for paved road construction or even fill material for use at building sites. These materials are generally cleaner and may contain more sand than a good quality surface gravel so they will not form a crust to keep the material bound together and subsequently on the roadway surface. Good quality surface gravel may cost more to produce but is often worth the extra cost in terms of future maintenance savings and conservation of surface aggregate. Crushed surface gravel will also be of significant benefit as the larger stones will embed into the surface of a gravel road much better than rounded and non-processed gravels. This in turn helps with conservation of surface gravel by minimizing loss of larger size stones.

Aggregate testing of surface gravel is also very important to quantify such items as gradation, plasticity index, hardness and percent of fractured stone all of which affect the performance of the surface gravel. For example, surface gravels require more fine material than would a good base material which can be determined through the sieve analysis. The surface gravel would also need some natural clays in order to produce the "binding characteristic" which can be determined through the plasticity index test. By spending money on quality control testing of surface gravel the overall maintenance cost will be reduced.

Good gravel that has proper gradation and plasticity will compact well leading to less surface gravel loss and will develop a tightly bound surface that requires less maintenance. A study conducted in South Dakota showed that the use of higher quality surface aggregate (as opposed to sub-standard gravel) decreased the amount of loose gravel existing on the surface by as much as 50 percent in a three year test period. The substandard section was essentially impossible to maintain due to loose aggregate while the section using good quality gravel required up to 75 percent less maintenance. Loose aggregate is a major cause of washboarding and also accelerates gravel loss from the roadway surface leading to premature depletion of aggregate resources.

Another consideration when attempting to maximize the use of surface aggregate is proper quantity calculation for the amount of gravel to be hauled to construct a new gravel layer on a road. Too much surface gravel creates an unsafe condition for motorists and also leads to waste of surface gravel material. One aspect often overlooked during

placement of surface gravel is the shrinkage that occurs form ordinary compaction due to material being placed, blade maintenance and absorbing moisture from rainfall then having traffic pass over it. Too often the volume of material is calculated in a loose state as it exists in the stockpile of as it is dumped from the truck which has a very low density and is very loose. Always remember to allow for shrinkage when calculating the required gravel depth required after the job is compacted and completed. This will ensure the optimal amount of gravel is placed on the roadway surface minimizing waste and ensuring proper performance for the roadway user.

DUST CONTROL AND STABILIZATION

Good analysis of annual maintenance costs could show the application of dust control will pay for itself on roads with higher traffic volumes. This comes from reduced material loss from the road surface and decreased frequency of blade maintenance. Dust control can be an economic benefit when working well and utilized in conjunction with good quality surface gravel. Good dust control products will prevent the fine material from loosening up and dusting away. In turn this means that the course aggregate in the gravel will tend to remain embedded in the surface and will not be lost to the edge of the road or whipped off into the ditch from heavy traffic. Some studies in the US have shown that as much as one ton (1.5 tonnes per kilometer) is lost each year for each vehicle that passes over a road daily. This converts to 200 tons of aggregate per mile (292 tonnes per kilometer) lost for a road carrying 200 vehicle per day. This example shows the added benefit of dust control which is retaining (conserving) aggregate.

The need for "good surface gravel" is paramount when considering the application of dust control. The surface gravel requires proper gradation and good percentage of fine material with some plasticity. For chloride products used for dust control this is extremely important since the chloride products merely draw moisture form the air. This will give the gravel a good binding characteristic due to the natural fines present and the chlorides will keep the surface damp helping to keep the surface gravel bound and preventing loss of fines in the form of dust helping to minimize aggregate loss from the surface. Chloride treatments will essentially be wasted and surface aggregate loss will be accelerated if good gravel is not present during the application of chloride dust control products.

INNOVATIONS

Today, aggressive reshaping of a gravel road surface is common due to the amount of heavy traffic utilizing the road. The reshaping of the road includes the recovery of gravel and moving it back to the road surface. The recovered gravel is generally in the form of a windrow which can be recycled in place and reused on the road. This can be accomplished by blading the material back and forth using traditional methods or it can be done very quickly using pulverizers which make the job quicker, easier and safer while at the same time maximizing the use of recovered gravel. Recycling and milling equipment generally used for pavement rehabilitation can also be used to pulverize and mix reclaimed gravel.

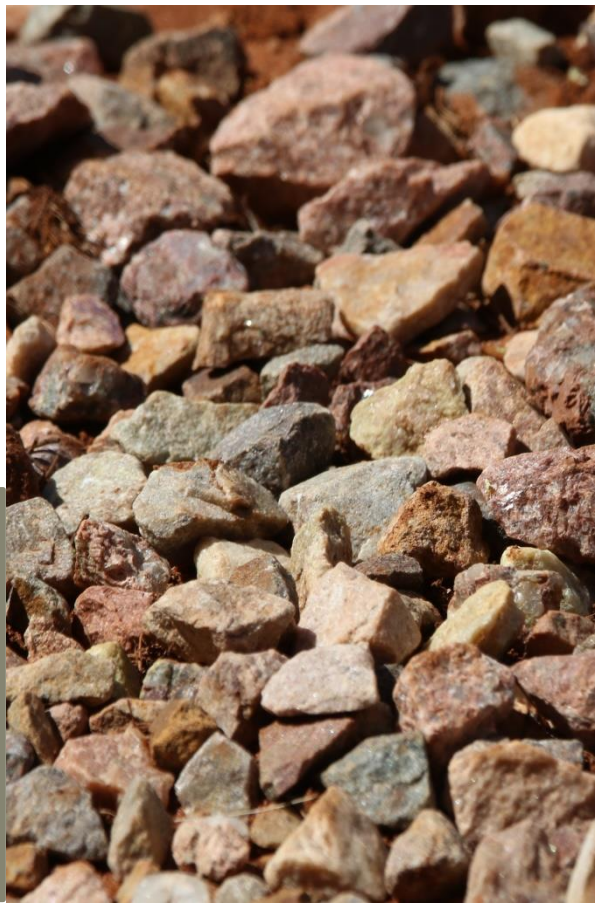
Tractor mounted crushers are also coming on the market. This small piece of equipment has the capability of crushing material in place on the road without removing it to a central plant for processing. This creates several options that contribute to conservation

of aggregate. For example, an old and failing asphalt surface that can no longer be maintained could be used as gravel surfacing if ripped, processed and mixed with base aggregate.

Additional Information

"US Department of Transportation and the Federal Highway Administration for the Gravel Roads Construction and Maintenance Manual August 2015".

5. COST CONSIDERATIONS



5.1 Cost Breakdowns

5.1.1 Gravel Extraction Fees

The Government of Saskatchewan enforces a maximum fee in which Municipalities can charge gravel crusher and extractors.

In 2016 and 2017 the fees were as follows:

- $0.160 per cubic metre
- $0.122 per cubic yard
- $0.086 per cubic tonne
- $0.080 per ton

The fee is determined by using a formula that came into force on January 1, 2010. It is explained in detail in Section 8.1 of *The Municipalities Act*. In short, it is updated every two years base on the expected inflation. In the majority of the RM agreements analyzed, the maximum rates were used.

Hauling Fees

As outlined in the "Got Gravel" report, the average cost for hauling for RMs in SARM's divisions two through six constantly hovered around $0.30 per yard/km. In division one, in the southeast corner of the province, costs were considerable higher at approximately $0.55 per yard/km.

Road Maintenance Agreement Fees

The Municipalities Act outlines the ability of a Municipality (Section 22) to go into agreement with any person or contractor if it is believed that the movement of the vehicles and their goods will likely damage the streets or roads. These agreements, known as, Road Maintenance Agreements outline the fees that a contractor or hauler are responsible for paying a Municipality and outline the details as to how and when they should be paid. In addition to the Road Maintenance Agreement, a form follows which is the Haul Declaration for the Road Maintenance Agreement, which is a declaration form outlining the amount of mileage driven in a certain period.

The Municipalities Regulations outlines maximum fees that can be charged to haulers for the use of the roads (Section 12). There are two separate fees which are for "Maintenance and Restoration of Roads" and "Shortening of Lifetime of Municipal Roads". Together, they create a total fee which can be charged to the hauler. Additionally, there are separate fees for winter and for summer hauling.

They are as follows:

Maximum Fees Charged to Haulers

Maintenance & Restoration of Roads			
Season	**Basis**	**2013**	**2014 Onwards**
Maximum Rate:			
Summer	¢ per tonne per km	1.86	2.15
Winter	¢ per tonne per km	0.93	1.075
Summer	¢ per cubic metre km	3.31	3.83
Winter	¢ per cubic metre km	1.655	1.915
Payment for Shortening of Lifetime of Municipal Roads			
Summer	¢ per tonne km	1.59	1.84
Winter	¢ per tonne km	0.795	0.92
Summer	¢ per cubic metre km	2.83	3.27
Winter	¢ per cubic metre km	1.415	1.635
TOTAL			
Summer	¢ per tonne km	3.45	3.99
Winter	¢ per tonne km	1.725	1.995
Summer	¢ per cubic metre km	6.14	7.10
Winter	¢ per cubic metre km	3.07	3.55

As per the regulations, the hauler is required to pay whichever is less between the per tonnage and per cubic metre measurements. Winter hauling includes January 1 to March 15 and November 15 to December 31. Summer hauling includes March 16 to November 14.

Additionally, there are minimum rates at which haulers must ensure are paid for the maintenance and restoration of roads. They are as follows.

Minimum Fees Charged to Haulers

Maintenance & Restoration of Roads Minimum Rate		2013	2014 Onwards
Summer	$ per kilometre	71.10	82.26
Winter	$ per kilometre	35.55	41.13

An example of a Road Maintenance Agreement can be found in the Tools & Templates 1: Road Maintenance Agreement. Another, longer, template that was developed by the Government of Saskatchewan can be found in the Tools & Templates 2: Road Maintenance Template – Government of Saskatchewan.

5.1.2 All-in Costs for Gravel

The cost of aggregate has increased substantially over the last several decades. Data from Statistics Canada show that between 2010 and the end of 2017 aggregate costs have increased by 59.5%. The largest increase came between 2000 and 2010, an

increase of nearly 4% each year and the largest growth being during the height of the provincial economic boom from 2009 to 2010 at 6%.

The following costing information came from a survey from the Ministry of Highways and Infrastructure. A total of 95 responses were summarized in order to determine the average costs based on the type of aggregate, as well as for the division. It should be noted that extreme outliers were removed from this analysis. MHI committed to only sharing summary information from the study publicly and has agreed to share that information with SARM for use in the Aggregate Resource Manual.

AGGREGATE TYPE

The table below outlines the different costs based on aggregate type. Each average cost for the aggregate types includes information from different RMs in different divisions, as well as RMs who procure aggregate in different ways (such as full tender, extraction from private land, extraction from RM land, etc.).

All-in Costs for Aggregate, by Aggregate Type (Yards)

Aggregate Type	Average	Low	High	Number
Traffic Gravel	$10.87	$2.00	$29.66	40
Sand	$6.93	$1.00	$17.19	8
Pit Run/Raw Aggregate	$5.35	$1.00	$14.37	29
Base	$13.52	$1.00	$24.19	8
Other	$7.77	$0.12	$34.19	10

DIVISION

The table below outlines the different 'all-in' costs based on the division. Each average cost for the divisions includes information across all aggregate types, as well as across different procurement strategies.

All-in Costs for Aggregate, by Division (Yards)

Division	Average	Low	High	Number
1	$8.09	$1.75	$22.50	16
2	$10.73	$1.75	$25.50	8
3	$9.33	$1.00	$25.50	13
4	$7.23	$1.00	$29.66	12
5	$5.99	$0.12	$20.00	24
6	$11.99	$3.50	$34.19	22
Total	**$8.75**	**$0.12**	**$34.19**	**95**

This information is noted to be in line with the approximate range for production for Ministry of Highways and Infrastructure contracts. A "ball park" figure for these contracts is approximately between $5.50 and $10.50 per contractor supply. For contractor supply to place in stockpiles, the approximate range would be $9.00 to $12.00 per tonne for MHI contracts.

Evaluation of Cost Survey

The results of the MHI study showed wide variability on costing for both aggregate type and aggregate costing by division. The extreme range for cost by aggregate type show just how much variation can come from cost drivers including gravel supply scarcity, economic activity and competition. While the analysis by division showed less volatility, it also highlighted that even in similar general areas costs could vary by as much as double. The following factors can be used to explain variation in costing from the MHI study:

- **Varying Supply within a Division**: Aggregate supply among RMs within a division can vary considerably with those RMs that own and/or manage pits within their own division having natural advantages over RMs that need to go outside of their own division for supply.
- **Proximity to Demand:** A deeper analysis of findings highlighted that RMs closer to major population centres saw escalated costs, which is to be expected but does not get highlighted in summary level data tables.
- **Varying Cost Components:** MHI noted that cost information provided may have included some variation in all the costs that were included or on what components of costs RMs include in their total all-in price.
- **Selection Bias:** Although not confirmed in any way, there is a chance that there was some selection bias in responses. For example, some RMs may not have responded to the survey if they felt they may have high costs or similarly some RMs with very low costs may have preferred to keep that information confidential.

The survey information is useful in providing data that confirms the challenge that RMs are faced with trying to understand if they are getting value for money for their gravel management programs when faced with considerable variability between costs among RMs. Summary level information can be useful for general benchmarking, but detailed comparison information, particularly among immediate neighbours, is a much better gauge of costs.

Cost Collaboration Model

There are some areas of the province that are currently working together to openly share information, which provides a roadmap for RMs to work together to significantly enhance their understanding of regional conditions and better articulate if they are receiving value for money for their aggregate. The benefits of developing an information-sharing environment include:

- Understanding regional 'all-in' aggregate costs;
- Understanding component costs (such as crushing, loading, hauling);
- Knowing the different contractors that operate in the region;
- Understanding different employee structures and pay scales;
- Understanding the different equipment owned by adjacent RMs;
- Maintaining and understanding of the aggregate landscape in the area; and
- Becoming aware of different innovations used.

In addition to the obvious benefits of being able to compare your RMs cost environment to that of comparable RMs in your region, some of these opportunities to work together may include utilizing innovative practices to source and conserve aggregate. Many innovative

approaches are discussed in the Strategic Gravel Supply Best Practices section of the Aggregate Resource Manual. The following figure outlines a document that could be used to share information on aggregate operations in an area.

Aggregate Information Sharing Template

	RM #1	RM #2	RM #3	RM #4
MAINTENANCE WAGES (PER HR)				
Foreman				
Grader Operator				
Buggy Operator				
CAT Operator				
Mower Operator				
Other				
Labourer				
Number of Full Time Employees				
Number of Seasonal Employees				
Number of Casual Employees				
EQUIPMENT				
Graders				
Graders				
Grader Contractor Name				
Mowing				
Mowers				
Mowing Contractors Name				
Construction Equipment				
GRAVEL				
Crushing (per cubic yard)				
Method of Measurement				
Large Rock Breaker (if extra)				
Loading (per cubic yard)				
Hauling (per yard per km)				
Royalties (per cubic yard)				
Average Cost				
EFFECTIVE RATE FOR ANALYSIS				
Total Spent				
Gravel Pit-Owned/Private/Lease				
Gravel Crushing Contractor				
Gravel Hauling Contractor				
Pay Gravel Shrinkage/Compaction (Y/N)				
If Yes - Percentage Paid				
ROAD CONSTRUCTION				
Miles Completed in 2017				
Purchased Right-of-Ways				

Purchased Diversions				
Purchased Clay Pits				
Fence Removal ($ per km)				
Fence Replacement ($ per ½ km)				

There are groups that exist today that are openly sharing this information in Saskatchewan. The table above represents a good internal tracking framework and would also be ideal for information-sharing with other RMs in the area.

5.1.3 Cost-Benefit Analysis

Approach & Information

A cost-benefit analysis (CBA) is a useful tool that can be used when looking at alternative investment options to achieve the same outcome. Specific to aggregate management in RMs, a CBA could be conducted to consider alternatives related to gravel sourcing, using innovative materials or using internal vs. outsourced resources. RMs have a responsibility to their ratepayers to provide services in the most efficient and cost-effective manner as possible. CBAs can be a powerful tool that can look at various different scenarios and how they affect the long-term economic outlook for an RM.

Cost-benefit analysis that considers two alternatives over multiple years that have different operating costs can be analyze by looking at the simple difference in annual cost, or by looking at the Net Present Value (NPV) over a period of time, often 25 years or longer for infrastructure analysis. Simple alternatives should be analyzed by comparing the annual cost difference, but NPV analysis may be required if operating costs will change for the two alternatives over time. A prime example would relate to comparing a capital investment that will have debt repayment over a period of time, say 10 years, against an alternative that may require little or no capital investment but carry a higher ongoing or operating cost. If a RM purchases land for gravel and rolls the upfront capital cost into annual debt repayments and compares that option against a quantity agreement in a lease, then the financial analysis will be considerably different once the debt has been paid off, so a longer term NPV analysis would be required to get a true picture of the cost-benefit. A discount rate of 5% has been applied to the NPV analysis and as a rule of thumb could generally be a rate set at which a RM would incur debt.

This particular CBA has been developed for SARM and is available from SARM members as part of the Aggregate Resource Manual. The CBA template includes a simple fillable version outlined on the following page and a Microsoft Excel version in the Tools and Templates 12: Cost-Benefit Analysis Model & Instructions. The Microsoft Excel version is best suited to the analysis and performs the NPV analysis automatically to support informed decision making. A user will need to fill in capital investment and operating cost projections into the document, and the Microsoft Excel version will highlight the NPV for the option. When a user fills in worksheets for two or more options, it can then compare the total costs of the alternatives with the lower cost option representing the best financial value. The following image is a shortened version of the Excel document, whereas the real document stretches out to 25 years.

Aggregate Resource Manaual
Cost Benefit Analysis

25 Year NPV	$0	Investment	$0
Discount Rate	4%	Rate	0%
Inflation Rate	2%	Periods (Years)	0

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
SUB-TOTAL		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Surplus (or Deficit)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

CBA Scenario Analysis

The remaining section looks at three possible CBA scenarios that may help RMs in their decision making. The three scenarios are:

1. Lease vs. Buy Land
2. Chemical Innovation vs. Status Quo
3. Trucking Tender vs. Truck Purchase

Scenario #1: Lease vs. Buy Land

The following section considers a strategic decision for a RM to secure aggregate through the lease of land compared to the option to purchase land.

The first table looks at a situation where there is a lease agreement in place and an RM pays a fee for each yard that is extracted. Some of the key assumptions in this scenario are that there is a $3/yard royalty due to the landowner and that there needs to be 15,000 yards extracted per year. These assumptions were based on a sample of costing data from RMs. Based on those assumptions, there is a $45,000 royalty fee in Year 1, which grows at a constant inflation rate of 2% per year based on a notional annual increase in price. Note that for financial analysis, the lease approach would be similar to conducting annual tenders for gravel supply.

Table 1.a: Lease

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$865,308	Investment	$0
Discount Rate	4%	Rate	0%
Inflation	2%	Periods (Years)	0

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Royalty Fees	$3 / yard (15K yards)	$ 45,000	$ 45,900	$ 46,818	$ 47,754	$ 48,709	$ 49,684	$ 50,677	$ 51,691	$ 52,725	$ 53,779
SUB-TOTAL		**$ 45,000**	**$ 45,900**	**$ 46,818**	**$ 47,754**	**$ 48,709**	**$ 49,684**	**$ 50,677**	**$ 51,691**	**$ 52,725**	**$ 53,779**
Surplus (or Deficit)		**$ (45,000)**	**$ (45,900)**	**$ (46,818)**	**$ (47,754)**	**$ (48,709)**	**$ (49,684)**	**$ (50,677)**	**$ (51,691)**	**$ (52,725)**	**$ (53,779)**

The second table looks at the alternative "buy" scenario where an RM would invest in purchasing the land. In this scenario, the RM would have total control over the land and be able to extract aggregate free of charge. In this scenario, it is assumed that 50 acres of land can be purchased for $20,000 per acre. These costs will largely vary due to a variety of different factors, including local marketing conditions, timing and seller, among others.

Table 1.b: Buy

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$1,000,000	Investment	$ 1,000,000
Discount Rate	4%	Rate	4%
Inflation	2%	Periods (Years)	25

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Debt	50 acres at $20K	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012	$ 64,012
SUB-TOTAL		**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**	**$ 64,012**
Surplus (or Deficit)		**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**	**$ (64,012)**

Thus, in any scenario where the need is 15,000 acres per year at a $3 per yard royalty, it is more beneficial over 25 years to lease land if the purchase value is more than the NPV for the lease option ($865,000). There are also many risks associated with this analysis. For example, many stakeholders note that the cost of aggregate is wildly variable year-to-year, which adds considerable risk to the lease model. There is additional risk that a land owner could sell the leased land and that the new land owner would seek to change the terms of the agreement.

A Sensitivity Analysis has been developed for this analysis that considers a volatile annual lease model that is similar to pricing issues RMs have faced in the past decade. The theoretical price evolution follows the scenario outlined below and notes that the annual increases are cumulative so multiple year-over-year increases make costs significantly higher than initial year estimates:

Year	Change
Year 1	-
Year 2	+ 5%
Year 3	+10%
Year 4	+20%
Year 5	+30%
Year 6	+ 5%
Year 7	-25%
Year 8	0%
Year 9 – 25	+2%

Table 1.c: Lease Sensitivity

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$1,053,870	Investment	$0
Discount Rate	4%	Rate	0%
Inflation	2%	Periods (Years)	0

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Royalty Fees	$3 / yard (15K yards	$ 45,000	$ 45,000	$ 47,250	$ 51,975	$ 62,370	$ 81,081	$ 85,135	$ 63,851	$ 63,851	$ 65,128
SUB-TOTAL		**$ 45,000**	**$ 45,000**	**$ 47,250**	**$ 51,975**	**$ 62,370**	**$ 81,081**	**$ 85,135**	**$ 63,851**	**$ 63,851**	**$ 65,128**
Surplus (or Deficit)		**$ (45,000)**	**$ (45,000)**	**$ (47,250)**	**$ (51,975)**	**$ (62,370)**	**$ (81,081)**	**$ (85,135)**	**$ (63,851)**	**$ (63,851)**	**$ (65,128)**

If these variations were to occur, the RM would be slightly worse off. Plus, also consider that the RM would have 50 acres as an asset under the 'Buy' scenario that could be re-sold, which could also be factored into the analysis.

Scenario #2 – Innovation

The second scenario uses the same format as the first, comparing two different scenarios both aimed towards similar end goals. In this scenario, the lifetime cost of maintaining a road is being compared when either a) investing in a chemical innovation and b) using the 'status quo'. This analysis is based off of the case study of a road in Montana that is outlined in the Chemical Products section. It is also included below:

Montana Case Study

In 1998 the United State Forest Service re-graveled a road in Northern Montana that led access to a hiking trail, a lake for fishing and a camp site. The road is heavily used and in the late spring throughout summer it can carry up to 300 vehicles a day. When re-graveling, they incorporated a magnesium chloride product, compacted and shaped it, and then did nothing to it for the rest of the season. The winter conditions were poor, as the road does not get plowed during the winter. In the spring they did a reshape and added about ¼ to 1/3 of the magnesium chloride product that was initially added. Since then, the US Forestry Service has not had to add any gravel onto the road, a road that has very rough conditions and that, under typical circumstances might need to be re-graveled each three to four years.

This case example provides a real-world example of some savings that can be realized when looking towards the long-term investment in treatments to extend the life-cycle of an unpaved road.

The first table has several assumptions when analyzing the chemical innovation. First, the cost of the chemical has been labelled the "innovation". Anecdotally, it has been communicated that these can cost approximately $11,250 per kilometer ($7,000 per mile) and that has been used for the initial application. Since the initial road building would occur regardless, no additional costs have been carried for the application of the chemical treatment. The "additional innovation" value has been set at $3,750 or 1/3 of the full scale application. An estimated value of $15,000 has been used for the reshaping of the road. It has also been assumed that the cost of this work would be financed. Thus the total investment is $285,850 (the sum of all costs per mile multiplied by 10 kilometres).

Table 2.a: Using Innovation

Aggregate Resource Manual

Cost Benefit Analysis

25 Year NPV	-$285,850	Investment	$ 285,850
Discount Rate	4%	Rate	4%
Inflation	2%	Periods (Years)	7

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Debt	$28,585 / km (10 km)	$ 47,625	$ 47,625	$ 47,625	$ 47,625	$ 47,625	$ 47,625	$ 47,625			
SUB-TOTAL		**$ 47,625**	**$ 47,625**	**$ 47,625**	**$ 47,625**	**$ 47,625**	**$ 47,625**	**$ 47,625**	**$ -**	**$ -**	**$ -**
Surplus (or Deficit)		**$ (47,625)**	**$ (47,625)**	**$ (47,625)**	**$ (47,625)**	**$ (47,625)**	**$ (47,625)**	**$ (47,625)**	**$ -**	**$ -**	**$ -**

The second table looks at the 'status quo' or 'no innovation' option. In this scenario it has been estimated that the road has needed to be re-graveled every three or four years, as heard in the case example. For the 25 years in the financial model, it has been assumed that the re-graveling would occur every four years, followed by three, followed by four and so on and so forth. Based on expert opinions, a number of 160 yards per kilometer

(100 yards per mile) of graveling at $15 per yard have been used. Additionally, a cost of $8,000 per kilometre has been used to account for the equipment, people and other resources required performing the graveling.

Table 2.b: No Innovation

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$558,828	Investment	$0
Discount Rate	4%	Rate	0%
Inflation	2%	Periods (Years)	0

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Regravelling Costs	$8,000 / km				$ 84,897			$ 90,093			
Gravel Costs	$2,400 / km				$ 25,469			$ 27,028			
SUB-TOTAL		$ -	$ -	$ -	**$ 110,366**	$ -	$ -	**$ 117,121**	$ -	$ -	$ -
Surplus (or Deficit)		$ -	$ -	$ -	**$ (110,366)**	$ -	$ -	**$ (117,121)**	$ -	$ -	$ -

In this scenario, it can be seen that the incorporation of the chemical innovation at the construction of the road has decreased the cost of the 25 year design/operation life of the road by nearly 50%. Assumptions would need to be updated by the RM to account for their estimated re-graveling costs, although in this scenario looks like the additional upfront investment looks as though it is more promising (less negative) than the alternative. There are additional risks to this as well, as there may be political risks involved. It may be difficult to justify to rate payers why such a large investment is required when the alternative includes no additional costs to the road until Year 4.

Scenario #3 – Trucking Tender vs. Purchase

The third scenario analyzed looked at the hauling aspect of aggregate operations. In this scenario, the two options for hauling are to either haul aggregate using a per yard/kilometre cost or to purchase a truck to perform the hauling 'in-house'.

The scenario uses several assumptions that are critical to the CBA and the associated NPVs. In scenario one, it has been assumed that the cost per yard/km is $0.226 ($0.365 per yard/mile) from a hauling company. It has also been assumed that the yearly gravel requirement is 15,000 yards and that the average haul distance is 15 kilometres. With that, a total cost per year can be calculated.

Table 3.a: Trucking Tender

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$794,383	Investment	$0
Discount Rate	4%	Rate	0%
Inflation	2%	Periods (Years)	0

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Tendering Price	$0.226/yard/km (15K yards, 15 km)	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850	$ 50,850
SUB-TOTAL		**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**	**$ 50,850**
Surplus (or Deficit)		**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**	**$ (50,850)**

The second table looks at the NPV of purchasing a truck and performing the hauling 'in-house'. Along with this situation, there are also many assumptions made, such as the purchase price of a truck $50,000 and that it would need replacement on average every

10 years. Other assumptions have been made for the maintenance, fuel and employee costs as well. If an RM were to undertake this scenario, they would want to update, of course, with their historical data to have a better individualized look at the trade-offs between purchasing and tendering for trucking.

Table 3.b.: Truck Purchase

Aggregate Resource Manual
Cost Benefit Analysis

25 Year NPV	-$1,214,786	Investment	$50,000
Discount Rate	4%	Rate	4%
Inflation	2%	Periods (Years)	7

Item	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Maintenance, Insurance, Other	10% of cap cost	$ 5,000	$ 5,100	$ 5,202	$ 5,306	$ 5,412	$ 5,520	$ 5,631	$ 5,743	$ 5,858	$ 5,975
Fuel		$ 2,125	$ 2,168	$ 2,211	$ 2,255	$ 2,300	$ 2,346	$ 2,393	$ 2,441	$ 2,490	$ 2,540
Employee	$50,000 / year	$ 50,000	$ 51,000	$ 52,020	$ 53,060	$ 54,122	$ 55,204	$ 56,308	$ 57,434	$ 58,583	$ 59,755
Debt	Cost of Truck	$ 8,330	$ 8,330	$ 8,330	$ 8,330	$ 8,330	$ 8,330	$ 8,330			
SUB-TOTAL		**$ 65,455**	**$ 66,598**	**$ 67,763**	**$ 68,952**	**$ 70,164**	**$ 71,401**	**$ 72,663**	**$ 65,619**	**$ 66,931**	**$ 68,270**
Surplus (or Deficit)		**$ (65,455)**	**$ (66,598)**	**$ (67,763)**	**$ (68,952)**	**$ (70,164)**	**$ (71,401)**	**$ (72,663)**	**$ (65,619)**	**$ (66,931)**	**$ (68,270)**

Based on the assumptions made in this analysis, tendering for trucking was the cheaper alternative, even after debt repayment on the truck was retired. However, sensitivity analysis highlighted that longer hauling distances made the outsourced model comparatively more expensive with a break-even distance of 23.25 kilometres where the 25 NVP in both scenarios is near ($1,232,000). An RM would have to input its own assumptions in the CBA model, but this illustrative scenario provides an overview of what the results might look like. Additionally, RMs could test the option of partnering with neighbouring RMs using the CBA tool and may find that sharing costs for a truck and an employee make that option more affordable.

6. TOOLS & TEMPLATES

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[xi] "Restoration of Saskatchewan's Agricultural Crown Rangelands" Reviewed May 2012. Guidelines and Procedures for Developers.