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GEOMEMBRANE USE IN A LANDFILL CAP REHABILITATION

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ABSTRACT: In 1992, leachate seepage was discovered at the base of an old landfill site on the banks of the North Saskatchewan river in Edmonton, AB. The landfill site, which had stopped accepting waste in 1978, had been developed into a public park. Initially a leachate recovery system was installed, however a permanent solution was sought. The City of Edmonton commissioned a hydrogeological investigation which recommended improvements to the clay cap and vegetated cover to prevent infiltration from precipitation and ponded water at the top of the landfill.

Initial construction to increase the thickness of the clay cap led to a small landslide. A revised plan involved expansion of an existing swale on top of the landfill to improve drainage and remove ponding water. Excavation revealed the top of the waste and a geomembrane was added to the design to prevent water infiltration in the swale area. The PVC geomembrane provided a light-weight, low-cost impermeable channel which allowed for a cost effective retrofit to an existing landfill drainage problem. Due to limitations in the stability of the landfill slope, the geomembrane was a key component in controlling precipitation and runoff without incurring additional instability in the landfill.

RÉSUMÉ : En 1992, une fuite de lixiviat a été observée au pied d'un site d'enfouissement localisé en bordure de la rivière, à Edmonton, en Alberta. Ce site, fermé depuis 1978, avait depuis lors été converti en parc récréatif. Un système de collection des lixiviats a tout d'abord été mis en place au niveau de la fuite, mais une solution permanente se devait d'être installée. Suite à une analyse hydro-géologique commandée par la municipalité d'Edmonton, il fut décidé de réduire l'infiltration et de supprimer l'accumulation d'eau de pluie au dessus de la couverture en retravaillant l'argile et la couche de sol végétalisé de la couverture.

La mise en œuvre de l'argile se solda par un petit glissement de terrain qui survint pendant la construction. La conception fut alors révisée pour améliorer la géométrie d'une rigole existant sur le dessus du site, afin de permettre une évacuation de l'eau stagnant au dessus des déchets et d'améliorer la qualité du drainage. Lors de la mise en œuvre de ce cours d'eau, les déchets furent mis à jour, ce qui nécessita l'ajout d'une géomembrane PVC destinée à réduire l'infiltration de l'eau de pluie au niveau du cours d'eau.

La géomembrane PVC se révéla être une barrière étanche légère et peu onéreuse, qui permit de réajuster à peu de frais le problème de drainage identifié. Du fait des limitations inhérentes à la stabilité des pentes du site, l'utilisation de la géomembrane s'avéra être un élément clé du système de contrôle de l'écoulement de l'eau sur le site, sans-porter préjudice à la stabilité générale du site.

1. INTRODUCTION

Seepage was discovered at the base of an old landfill site situated on the banks of the North Saskatchewan river in northeast Edmonton, AB. The landfill stopped accepting waste in 1978 and was capped with clay, vegetated and built into a park, now called the Strathcona Science Park.

In 1995 the City of Edmonton began to look at ways to manage the surface water that was infiltrating the clay capped landfill. The object was to minimize the generation of leachate that would have to be collected and treated. Various schemes to minimize infiltration were examined.

2. HISTORY OF THE SITE

The Strathcona Science Park is located in the northeast area of Edmonton, Alberta. The site had been used for various industrial applications since the turn of the 20th Century. Prior to 1900, the site was used by the Black

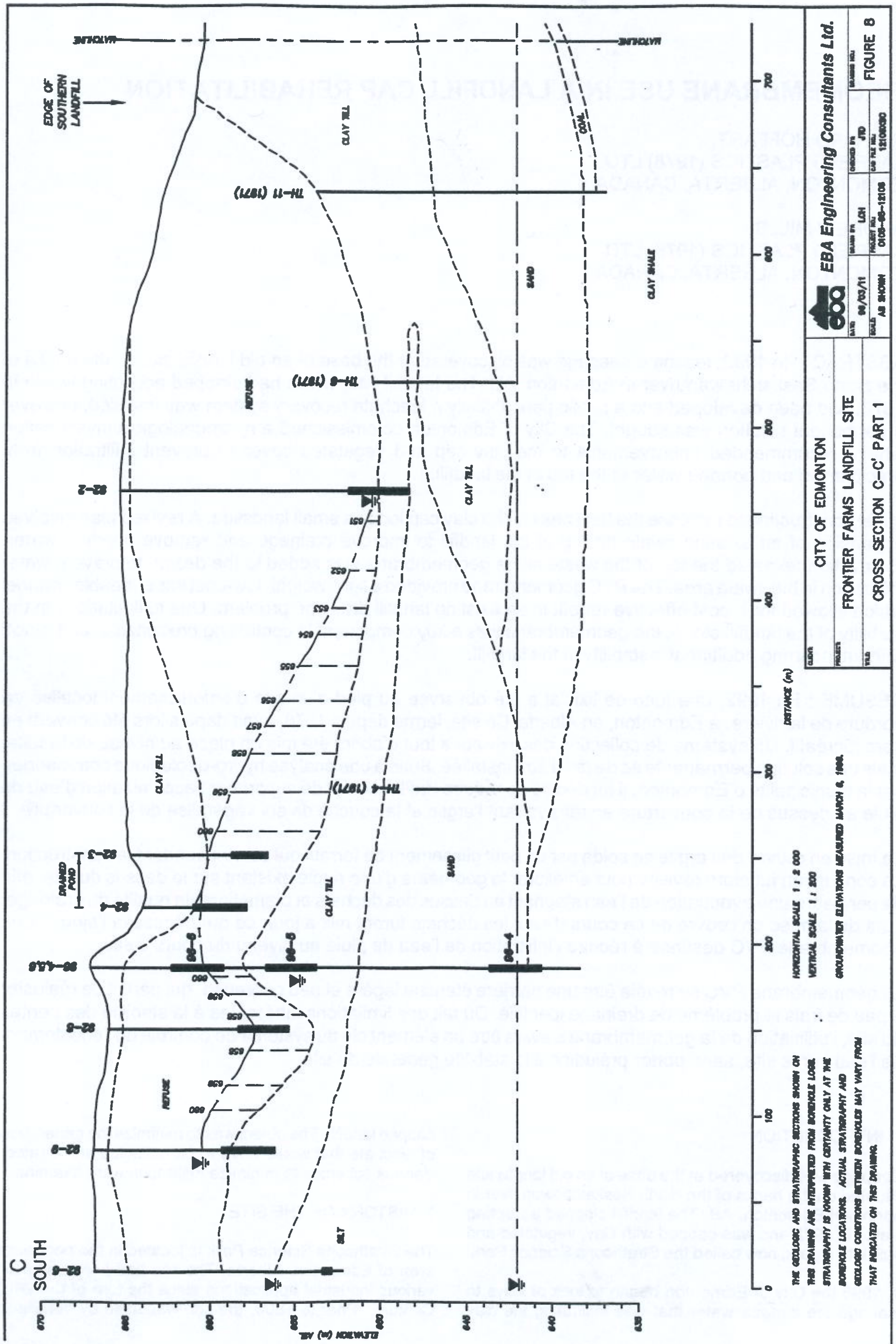

Figure 1 Cross Section C - C' through the South Frontier Farms Landfill.

Diamond Coal Mine. In 1903, the operation of the coal mine was taken over by the Great West Coal Company. A spur railway line was built at the site which made the coal mining more commercially viable. During this time more than 3 million tons of coal was mined at the site, which accounts for more than 22% of all the coal ever mined in Edmonton.

In 1952 the site was taken over by Glacier Sand & Gravel Ltd. Sands and gravels were extracted from the site until 1972. The sands and gravels were used to supply aggregate material to two companies, Apex Ready Mix Concrete and Du-Al Blocks Ltd. both of which were located in the current area of the current Strathcona Science Centre. They did not begin excavating the southernmost pit until sometime between 1962 and 1967. There were at least two major excavations left open at the end of their operations. Excavation for gravel had now occurred on both the north and south parcels of land.

In 1972 the site was divided into the North Frontier Farms Landfill and the South Frontier Farms Landfill. The South Frontier Farms Landfill was opened on December 1, 1972 and was officially closed on September 14, 1975. The North Frontier Farms Landfill operated from May 1, 1975 to December 22, 1977.

From June 1961, a company called East Side Disposal Ltd. used a 10 acre parcel (one of the former gravel pits) as a waste disposal site. This site was located immediately north of the present park entrance. During this time, two large commerial manufacturing companies used this parcel to dispose of solid and liquid wastes. Aerial photographs of the East Side Disposal site indicates that it ceased its operations sometime between 1971 and 1974.

In January of 1971, the City of Edmonton entered an agreement with the County of Strathcona to use the site as a sanitary landfill. During the same month, Edmonton Regional Planning Commission also agreed to use the site as a landfill. The objective was to infill the gravel pits to restore the site to its original contours.

The landfill site was divided into north and south portions. The southern portion started landfilling operations first and was officially closed in September 1975. Between 1972 and 1978, a total of 1.86 million metric tonnes of waste was deposited in the two Frontier Farms Landfills. In December 1977, the final load of waste was received at the north site.

Between 1976 and 1979/80, the site was known as the Capital City Park. During this period, the ownership of both landfills was transferred to the Province of Alberta. The City leased the site until 1979, constructed the final cover, and completed the site reclamation. Since 1979/80, the site has been known as the Strathcona Science Park. By 1980, most of the current buildings and roads were completed.

3. DESCRIPTION OF THE LANDFILLS

Both the north and south landfills used a cell construction method, that isolated individual sections of the landfill using berms. These cells were filled one at a time similar to modern landfill waste placement methods, however, the technique of placing a daily cover was not used. Additional liquid due to precipitation is expected to have accumulated in the cells during landfilling. The north landfill accepted some 608,375 tonnes of waste of which 3.5% were liquid wastes. The south landfill accepted 1,254,000 tonnes of waste of which 6% were liquid wastes.

4. SITE GEOLOGY

The geology of the site was determined from borehole logs taken in 1971, 86, 92, and 96. The boreholes in 1971 were drilled before landfilling began, while subsequent boreholes were drilled to determine the landfill's performance.

The 1996 site report stated that, " the site is underlain by postglacial drift, overlying a thick layer of glacial till. These strata lie on top of pre-glacial drift, known as the Saskatchewan Sands and Gravels. Beneath this is the bedrock formation of the Horseshoe Canyon Formation."

Most of the post glacial sands and gravels were removed by gravel mining operations. The clay till layer is classified as very stiff, brown to grey, and highly plastic. The till layer varies from as much as 20 metres thick under the south landfill to almost nothing under parts of the north landfill.

The pre-glacial sand and gravel layers under the glacial till consist of basal gravels and channel sands. These channel deposits vary across the site, but are not present under the north landfill.

The bedrock formation consists of interbedded clay shale, sandstone, and coal beds. The 1 metre thick coal seam at approximately 55 metres below surface level was the site of extensive coal mining activity.

The geology undeneath the north landfill is significantly different from that of the south landfill. The north landfill area is underlain by the glacial till layer, directly on top of bedrock. The bedrock is as shallow as 7 metres under the north landfill. The water table in the north landfill is in the bedrock layer and the landfill itself is dry. There is no significant leachate reported in the base of the north landfill.

The south landfill (Figure 1) is underlain by the glacial till layer which is on top of the pre-glacial channel deposits of sands and gravel. The bedrock under the south landfill is as deep as 27 metres. The water table under the south landfill is in the pre-glacial channel sands deposit. A perched water table exists on top of the glacial till in the refuse of the south landfill. This perched water table consists of the leachate that has been formed in the base of south landfill. At one point under the south landfill the refuse may be interconnected with the channel sands

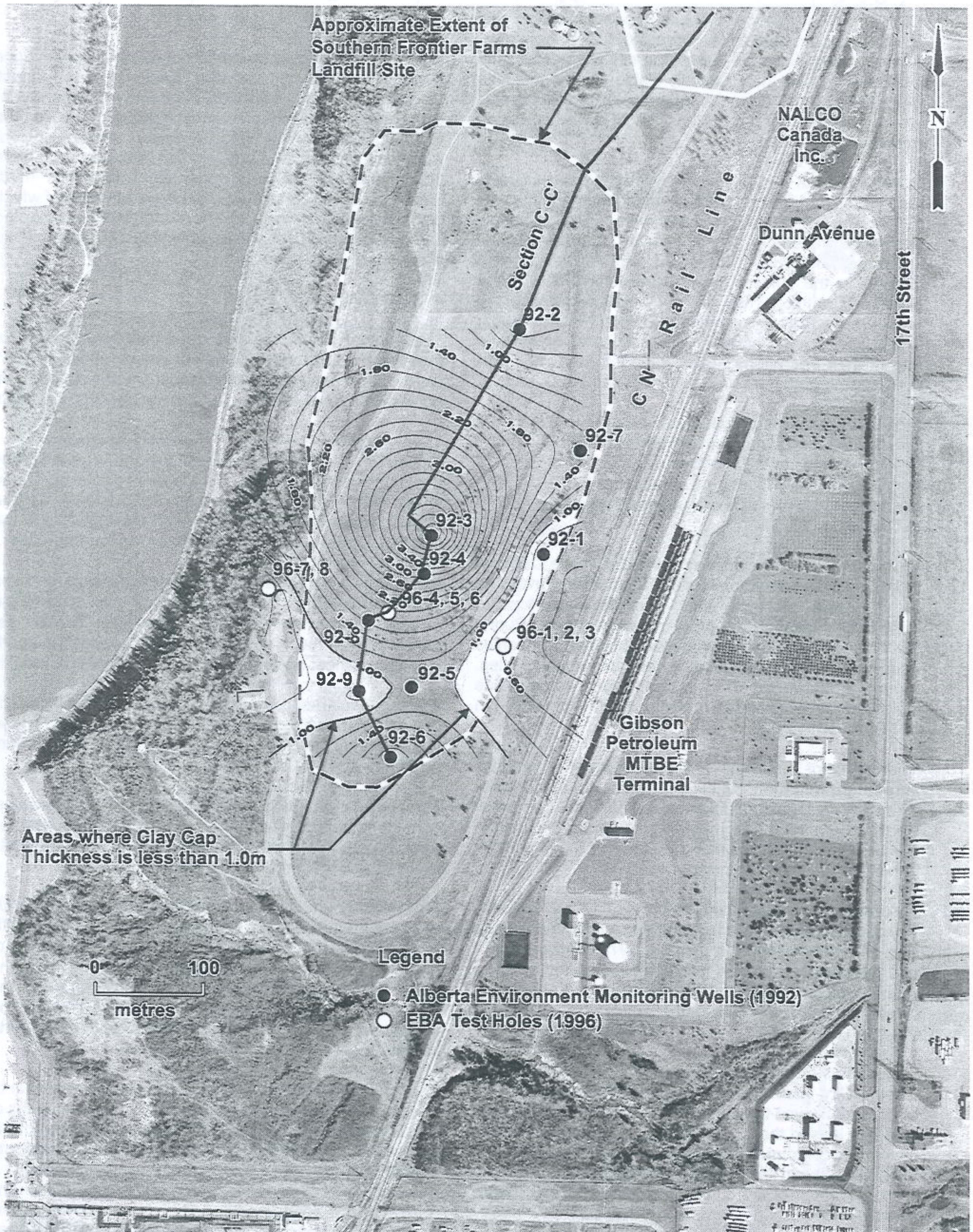

Figure 2 A general layout of the Frontier Farms south landfill site showing the extent of the landfill. The isobars show the thickness of the clay cap. Seepage was occurring near the borehole marked 96-7, 8.

deposit. The leachate level in this cell is much lower than the other cells, however the inter-cell berms have limited the loss of leachate from this area.

Investigation of the groundwater flow from the channel sands deposit where it intersects with the river valley has not shown any leachate contamination. The observed leachate appears to be coming from the south landfill at an elevation that corresponds to the top of the clay till layer.

5. THE PROBLEM

In April of 1992, an odorous groundwater seep was noticed near the Indian Artifact Archaeological site of the Strathcona Science park site. The Province conducted tests on the seepage and determined that the water was affected by leachate.

The Province hired a Contractor to construct an interceptor trench and install some collection tanks. The affected groundwater was collected and pumped from the trench to be stored in a holding tank. The affected groundwater was then run through a carbon filter system and stored in a second tank before disposal. The whole process of collecting, testing, and treating the groundwater was done within the confines of the park.

In 1995, Alberta Environmental Protection approached the City to take over the existing contract to collect, store, treat, and dispose of the affected groundwater. The City took over the contract with the understanding that both parties come to an agreement that the problem of the seepage was to be looked at as a long term environmental management issue and not a contaminated site issue.

On April 1, 1996, the City took over the existing contract for the collection and disposal of the seepage coming out of the bank of the Strathcona Science Park. The City immediately commissioned EBA Engineering Consultants Ltd. (the Consultant) to take a look at the entire site. The Consultant conducted a hydrogeological study and presented recommendations on what the City could do on a long term basis to manage the leachate.

6. FIRST TRY

Investigation of the two landfills on the site indicated that the southern landfill (Figure 2) had a perched water table of leachate within the waste that was affecting local groundwater. The northern landfill appeared to be dry.

Using a water balance model, the consultant determined that the souce of the liquid forming the leachate was ether from the initial liquid content of the landfill, or from excess infiltration of precipitation. Some 48,100m^3 of liquid had been disposed of with waste and 1,244m^3 had been collected at the seep. A preliminary water balance estimated that 50,000m^3 of liquid was still stored in the waste.

The Consultant used a hydrogeologic modelling program to determine the critical factors in reducing leachate production. The model estimated that 17% of precipitation could infiltrate the vegetative and clay cover. It further estimated that 8.4% of incident precipitation would exit the base of the landfill as leachate. In the current state the level of leachate in the south Frontier Farms landfill was increasing due to precipitation infiltration.

The investigation also showed that the thickness of the vegetative cover was the key element in preventing additional infiltration. Increasing the clay cap was not as effective as increasing the thickness of the topsoil cover with a 50 cm thick topsoil layer being determined as the optimum amount.

The Consultant found that parts of the south landfill had less than the 1.0 metre clay cap that had been recommended for the final closure. They recommended that the south landfill be regraded to improve surface drainage and eliminate ponding water. They also recommended that the cover system be reconstructed in the deficient areas to bring the clay cap to a 1.0 metre thickness and the topsoil layer to a 25 to 50 cm thickness.

An additional recommendation was to install a series of pumping wells to immediately reduce the volume of leachate within the landfill. The City accepted these recommendations.

Leachate pumping wells were installed first in 1996. Site grading began later that year. In the fall a small landslide occurred at one of the locations that was to be re-capped with additional clays. This event caused the City to cease work until the cause fo the landslide could be determined.

It was felt that the addition of clay and topsoil to the existing site was adding too much weight which was causing instability in the landfill. An alternative rehabilitation method was needed.

The City had budgeted approximately $200,000 to complete this portion of re-grading and re-capping. A review of the costs was done and it was determined that to continue under the circumstances would require an additional $300,000 (for a project cost of $500,000). This was well over budget and so the problem was looked at one more time.

7.SECOND TRY

In the spring of 1997 the City visited the site to try and come up with an alternative to continuing with the earthworks proposal. As they toured the site, it was noticed that a shallow drainage swale (or channel) had naturally developed on top of the south landfill. This swale was approximately 5 meters wide and ran 250 metres from north to south, curling to the west and eventually draining into the river.

The swale offered an opportunity to improve site drainage and to eliminate standing water. Further investigation showed that with only minimal grading the swale could accomplish most of the regrading objectives recommended by the Consultant.

The swale area appeared to run through much of the area identified by the Consultant as having insufficient clay cover. Standing water and poor drainage were occurring in the same location as the thinnest sections of the landfill cap. There was a concern that this situation promoted infiltration rather than minimizing it.

The City's intention was to excavate the swale to a lower grade to accomplish positive drainage from the top of the landfill. This existing low point would be regraded using on-site soils to eliminate adding extra weight to the top of the landfill. The reduced scope of earthworks fell well within the original project budget.

A geomembrane was specified in order to ensure the impermeability of this new channel. The geomembrane allowed the construction of an impermeable channel without adding significantly to the weight on top of the landfill.

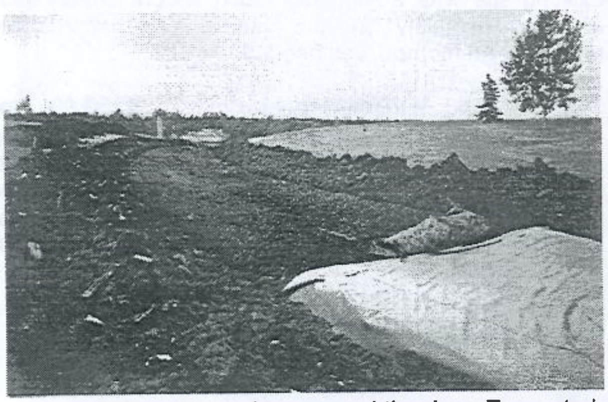

Figure 4 Channel looking toward the river. Excavated waste is visible along the left side of the channel.

Excavation of the swale started in July of 1997. Soon after construction began it was discovered that the site had much less clay cover than anticipated. During excavation of the swale, waste from the landfill began to show up along the entire length of the swale. This development reinforced the requirement for the geomembrane as a waterproofing membrane.

Figure 5 Deployment of the PVC geomembrane in the channel. View is looking north along swale.

8. THE GEOMEMBRANE

The City design used a geomembrane to improve the impermeability of the swale. After considering a number of materials from local suppliers the City chose 30 mil (0.75 mm) Polyvinyl Chloride (PVC) for this project.

PVC is a proven geomembrane material that has been extensively used in landfill cap applications. The main selection criteria for the PVC geomembrane included; material flexibility to accomodate differential settlement, the ability to prefabricate panels for rapid installation, high friction angle characteristics, and regulatory acceptance.

The geomembrane channel was designed with a small trench at either side to connect with the clay landfill cap. The design required that the liner be backfilled and that vegetation be established in the finished channel. This was an ideal application for the use of a PVC geomembrane.

In June 1997, Layfield Plastics (1978) Ltd. of Edmonton, AB. was awarded the contract to supply and assist with the installation of the PVC geomembrane.

The geomembrane was fabricated in Edmonton to a common width of 4.87 metres. Since the length of the swale was over 250 metres the geomembrane was made

Figure 3 The natural swale with grade stakes just prior to construction. This view is looking toward the river.

in multiple panels. The fabricated panel size was decided based on site requirements. Since the installation was to be done with a limited crew, the total panel weight was kept low to allow for hand placement. The channel liner was made into five 50 metre long panels. This final panel weight was 158 kg, well below the 1,800 kg size commonly used on large geomembrane installations.

The earthworks for the swale took considerably longer due to poor weather conditions in the months of July and

Figure 6 Welding panels of PVC together with solvent.

early August. Once the earthworks were completed, the PVC panels were shipped to the site. The City used a front end loader to off load the panels and to place them every 50 metres along the length of the excavated swale.

The City provided a labour crew to undertake the deployment and welding of the panels at site. Layfield Plastics supplied a field welding Technician to assist the City crew in deploying and welding the geomembrane.

The 30 mil PVC geomembrane was installed one panel at a time. The panels were unrolled and pulled into place. As the first two panels were placed, the Layfield Technician instructed the City staff on how to solvent weld a PVC geomembrane in the field. A seaming solvent called Tetrahydrofuran (THF) was used to make a permanent chemical weld between panels. The City crew quickly learned the chemical seaming process and were soon able to successfully seam panels without the assistance of the Layfield Technician.

After the geomembrane was installed it was immediately backfilled with a soil covering. The backfill was used to protect the material from UV exposure, cold temperatures, and mechanical damage. The backfill was first placed in the anchor trench on each side of the liner and then spread across the channel. By backfilling the anchor trench immediately, the danger of wind uplift was eliminated.

9. THE RESULT

The five 30 mil PVC geomembrane panels took less than eight hours to deploy, seam and backfill using a crew of five to six people. The City personnel installed over 1,200m^2 of 30 mil PVC geomembrane in only one day, reducing the time and cost associated with any field work. The use of a prefabricated geomembrane was an effective way of reducing the field installation time.

The City of Edmonton Waste Management Department addressed an environmental problem with the use of a geomembrane material in an unusual situation. The use of the geomembrane in the drainage swale will help to promote surface run-off thereby reducing the amount of water infiltrating into the landfill. The light weight geomembrane solution helped to avoid the potential for instability in a sensitive location. The geomembrane channel was also was a cost effective solution. The final cost for the geomembrane lined channel was under $100,000 which was well within the budget, and substantially less than the clay capping and regrading option.

Monitoring of leachate production from this landfill is ongoing and the success of this project will be measured in the years to come in reduced leachate production and operating costs.

REFERENCES

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