CLEANUP AROUND AN OLD WASTE SITE
A SUCCESS STORY

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ABSTRACT

42,500 m^3 of contaminated soil were removed from off-site areas around an old, low-level radioactive waste site near Port Hope, Ontario. The cleanup was done by means of conventional excavation equipment to criteria developed by Eldorado specific to the land use around the Company's waste management facility. These cleanup criteria were based on exposure analyses carried out for critical receptors in two different scenarios. The excavated soils, involving eight different landowners, were placed on the original burial area of the waste management facility. Measures were also undertaken to stabilize the soils brought on-site and to ensure that there would be no subsequent recontamination of the off-site areas.

INTRODUCTION

The Welcome Waste Management Facility is located four kilometers from the town of Port Hope, Ontario. Between 1948 and 1955, Eldorado placed approximately 17,000 tonnes of low-level radioactive wastes in a five hectare burial area inside the overall 36 hectare site. These wastes, primarily chemical precipitates and residues from the processing of ores for the recovery of radium and uranium, also contain other metals naturally present in the ore such as arsenic, iron, cobalt, nickle, and manganese. They were placed on the ground surface of the burial area to a depth of about one meter or buried in trenches up to five meters deep in the sand and gravel deposit which forms the burial area.

The site was closed prematurely in 1955 because erosion and leaching of the waste materials was resulting in contamination of streams draining the burial area. In 1956, water collection ponds were excavated and a pumphouse was constructed for the pumping of contaminated effluent from the site through a 2500 m pipeline to Lake Ontario. In 1978, a chemical treatment system was put in place to remove radium and arsenic from the water prior to being discharged to the lake. Substantial quantities of the wastes were removed from the site during the period 1956 to 1960 for metal recovery or burial elsewhere. Other than the above, however, the site was left largely as it was at the time of closure up to the 1980's - with wastes exposed at surface and no definite idea on the extent to which contaminants had spread from the burial area. The facility was secured by chain-link fence and there was general evidence that the site was not resulting in any obvious environmental or health impacts. Gamma radiation levels at the facility fenceline were typically about 2 µSv/h, or less (on the waste burial site, gamma radiation levels were in the range 5 to 500 µSv/h), radon concentrations at the nearest residences were within levels of normal background for North America, drinking water supply wells around the site showed no evidence of being influenced by contaminants from the site, and the water reporting to the treatment plant typically contained 10 ppM arsenic, 1 to 2 ppM uranium, and less than 1 Bq/L radium.

In 1982, Eldorado began to plan for a new waste disposal facility in the local area. Among other wastes, this new facility was to be designed for the disposal of the wastes and contaminated subsoils from and around the Welcome site, i.e., the Welcome site would be decommissioned and the wastes relocated to the new facility.

SITE INVESTIGATIONS

Detailed site investigations at Welcome were carried out during 1983 and 1984 by MacLaren Engineers Incorporated of Toronto, Ontario. This consisted of an extensive, drilling and sampling program to determine the areal extent and depths to which above background concentrations of arsenic, radium and uranium existed. The focus on arsenic, uranium and radium was based on historical monitoring around the site and on preliminary work done in 1982. It had been determined that these were the only elements which had migrated from the site in significant quantites and that the other metals associated with the waste were not present at unacceptable concentrations.

Early on in the investigation, it became evident that substantial quantities of contamination had spread beyond the Eldorado fenceline on to adjoining private properties. It was therefore decided to initiate a cleanup program for these off-site areas as soon as possible. This necessitated that the investigation had to be of sufficient detail to map the areas of contamination.

In addition, since there are in Canada no criteria or standards for concentrations of arsenic, radium or uranium in soil which would allow the properties to be designated as clean, a major part of the work consisted of getting regulatory agreement and approvals for criteria developed and proposed by Eldorado for the off-site cleanup.

Acceptable residual concentrations were established to allow unrestricted use of the cleaned up and restored properties. This was done by specifying two different land use scenarios and estimating the resulting impact of each scenario on persons using the land for a number of likely uses. The potential impacts examined were total gamma radiation exposure to the individual for radium and uranium and toxicity to farm crops for arsenic. The two land use scenarios considered were:

1) Open Field. Likely land uses are farming and rural residence.

2) Creek Channel. Likely land uses are occasional visitors, primarily for recreational use, and use of stream water for irrigation of crops and watering of livestock.

The various exposure pathways considered for the two land use scenarios are shown in Figures 1 and 2. For scenario 1, two individuals were considered; the full-time farmer, living elsewhere, and the full-time on-site resident. The derived cleanup criteria, based on the exposure pathways analysis are shown in Table 1.

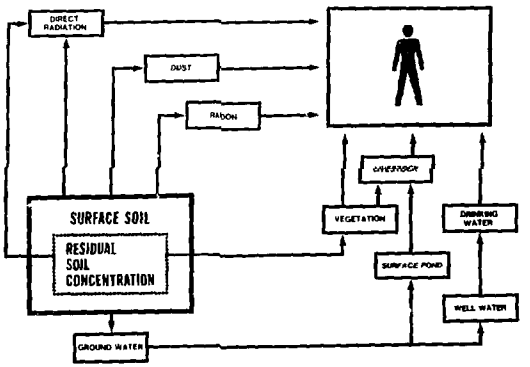

FIGURE 1. EXPOSURE PATHWAYS - FIELD.

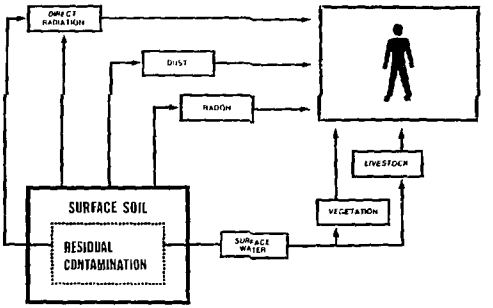

FIGURE 2. EXPOSURE PATHWAYS - CREEK.

Table 1. Criteria for off-site cleanup.

Scenario	Criteria		Total Dose µSv/annum
1. Field	*Ra-226: 0.2 Bq/g**	*Full time Farmer:*	*90*
	Uranium: 35 µg/g	Full time Resident:	300
	Arsenic: 50 µg/g		
2. Stream	Ra-226: 0.8 Bq/g*		
	Uranium: 100 µg/g	Typical Receptor:	90
	Arsenic: 150 µg/g		

*Above background

The overall investigation was conducted in several stages, with the level of detail and distance from the source increasing with each successive stage. The three phases of the investigation primarily concentrated on:

- the original waste burial area,
- the remaining areas of the Welcome site, and
- the off-site areas neighboring the Eldorado facility.

For each area, a gamma radiation survey was first carried out (using Eberline PRM-7 "Micro-R Meter") to direct the drilling and sampling program. By the time the investigation was completed, 57, 15 cm diameter boreholes, one to eight meters deep, had been drilled (primarily on the waste burial area) with a track-mounted drill rig and more than 1000 holes were drilled with a portable 75 cm diameter power auger and/or a 50 cm diameter hand auger to depths ranging from 15 to 280 cm. In addition, a small number of holes were excavated for sampling by a backhoe in areas too stoney to use augers.

All holes were sampled at 15 cm intervals, resulting in a total of about 5000 soil samples. The gamma activity of each sample was counted with a low-background scintillation counter (Eberline PRS-1 Portable Rate Meter/Scaler with SPA-3 Gamma Probe). In order to minimize analytical requirements, a correlation was sought between the net counts/minute (cpm) and radium concentration. Although a fair amount of variability was encountered, the resultant correlation, shown in Figure 3 was used to indicate the extent of radioactive contamination in the field. The net gamma activity

corresponding to the two cleanup criteria for radium (Table 1) were 75 cpm (field) and 160 cpm (creek). In addition to the gamma counting, selected soil samples were analyzed chemically for radium (about 200), uranium (about 2000) and arsenic (about 500).

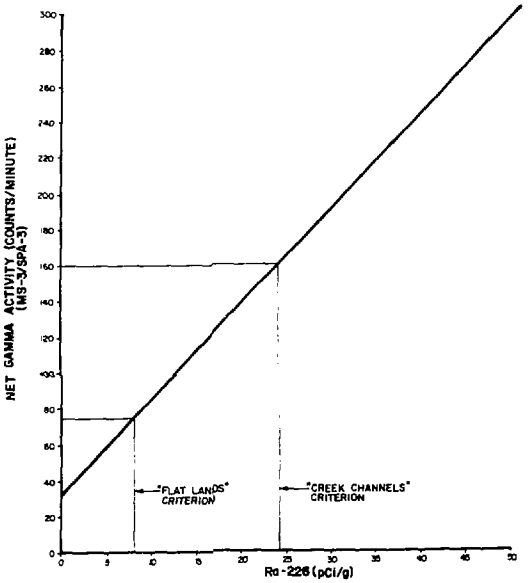

FIGURE 3. NET GAMMA ACTIVITY VS RADIUM CONCENTRATION IN SOIL SAMPLES.

At the outset of the investigation, it was decided to do sufficient sampling so that the volumes and areas of contamination could be calculated to a level of detail to allow the actual cleanup to be carried out simply from these design specifications. That is, no further soil sampling or analyses would be done to guide the cleanup process.

In the off-site areas, approximately 750 boreholes were required to delineate the areas of contamination and to calculate the total volume of soil to be removed.

Because the majority of boreholes and samples from the off-site areas were concerned with determining the distant limits to which contamination had spread, it was not possible to derive average concentrations of contaminants in the soil within these areas. However, some typical, maximum values for contaminant concentrations encountered in the off-site areas are shown below:

Net Gamma Activity	160-2577 cpm
Radium	1-2 Bq/g
Uranium	50-350 ppM
Arsenic	100-800 ppM

While these data indicate that contaminant concentrations did indeed exceed the respective cleanup criteria, they were not in the range of being an immediate health hazard. It was therefore considered possible to employ standard excavation procedures for the removal and transport of the contaminated soils and only minimal precautions were required for the protection of workers.

On the basis of the established cleanup criteria, and the results of the field investigations, it was possible to calculate the volume of contaminated soil and to map the extent of contaminant spread in the affected areas. The field investigations revealed a total of about 200,000 m^3 of surface and subsoils which had become contaminated to levels above the respective area criteria. Approximately 15% (31,000 m^3) of this was found outside the fenceline of the Welcome site. This was therefore the amount targetted for cleanup. Figure 4 shows the areas of off-site contamination in relation to the Welcome facility.

The distribution of contamination in the off-site areas further revealed the mechanism by which the contaminants were transported off-site. The burial area of the Welcome site is near a local topographic high point exposed to predominantly westerly winds. Run off from the burial area is in the westerly direction towards a creek channel about 1500 m away. The resulting pattern of contamination spread off-site to the north, east, and south was fairly uniform, covering a broad area (126,000 m^2) up to about 335 m from the site boundary indicating areal deposition of wind eroded wastes. Furthermore, the contamination in these areas was found to occur in the near surface zone, ranging in depth from about 15 to 30 cm.

To the west, contamination was generally restricted to drainage channels, occuring in narrow bands 5-30 m wide, and up to about 1000 m from the fenceline indicating water transport and deposition. Contamination was generally deeper (up to 1 m), suggesting more active movement of contaminants by the surface streams.

CLEANUP

Off-site contamination surrounding the Welcome site included the properties of eight private landowners, and road allowances belonging to the Township of Hope and the Ontario Ministry of Transportation and Communications. Eldorado contacted each landowner and negotiated an agreement for cleanup and restoration of the respective properties. These agreements specified the extent - area and depth - to which the properties would be cleaned up, the cleanup objectives, the type of restoration work which would be done, and compensation provisions. Compensation was made for specific quantifiable items such as loss of trees, soil or fill removal and loss of farm crops during the period of cleanup and restoration.

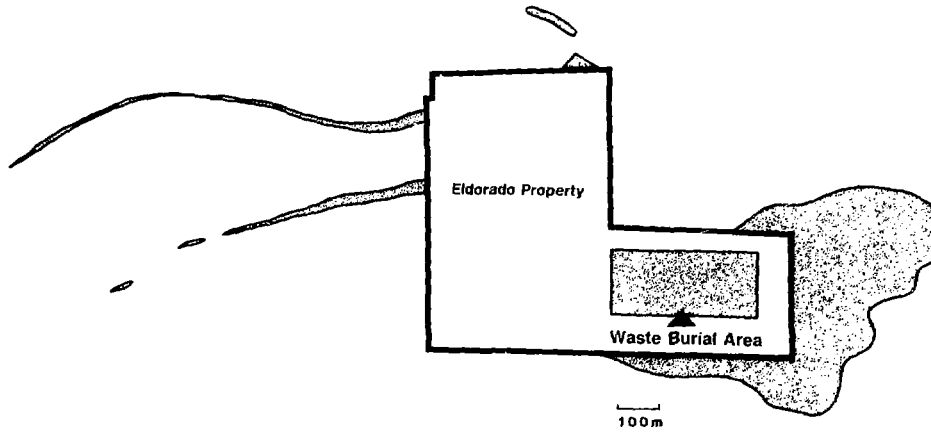

FIGURE 4. AREAS OF OFF-SITE CONTAMINATION.

One of the unique aspects of the cleanup program was that the restoration of the various properties was tailored to the particular type of land which was being cleaned up and also to the landowner's particular desires. In general, areas which were formerly wooded or non-productive were restored with sand fill. Stream channels were restored by shaping and grading alone. In this case, the landowners were compensated for the volume of soil or fill excavated. Agricultural fields were restored by replacing the top soil. In most cases, the cleaned up fields were parts of larger agricultural fields and agreement was made with the landowners that a thin layer of top soil from the areas adjacent to the cleanup area would be "borrowed" to restore the cleaned up area. The owners were paid at the going market rate for the borrowed top soil. Most areas were seeded with grass to complete the restoration.

In addition to the landowner agreements, Eldorado also required the approval of the federal regulatory authority - the Atomic Energy Control Board and its advisors, Environment Canada and the Ontario Ministry of the Environment. This was required because it was intended that all of the contaminated soil and fill removed from the affected areas would be transported back to the burial area of the Welcome facility. As part of the approval process, the AECB, also agreed to act as the auditor for the cleanup. This audit included inspection of the cleanup work in progress, establishment of a compliance sampling protocol, supervising the compliance sampling and conducting independent analyses of these samples. The AECB also provided Eldorado with a letter of certification once each landowner's property had been cleaned up satsifactorily.

The cleanup of the off-site contamination around the Welcome Waste Management Facility took place over four construction seasons (April through November) starting in 1984 and finishing in 1987. Removal of the contaminated soils was done by conventional excavation equipment; a backhoe with 1.8 m straight edge (ditching) bucket and tandem axle, 10 m^3 capacity, dump trucks. Excavation of contaminated soil was "design driven". This meant that the perimeters of the areas of contamination were surveyed and marked on-site with stakes and within these areas, the excavation depths were strictly controlled to that specified for the particular area. There were to be no field determined conditions, i.e., gamma radiation levels, used to direct the excavation. In this way, the amount of soil actually excavated should be very close to that calculated. Only if subsequent compliance sampling showed that unacceptable amounts of contaminated soil remained, additional excavation would be carried out. This approach was selected because other remedial projects, relying on "field driven" criteria, often result in the excavation of soil volumes that greatly exceed the amount of material predicted.

The "design driven" approach is immune to minor variations in the distribution of contaminants but still ensures that, overall, the cleanup will be successful. In practice, however, it was not always possible to stick to the design depth of excavation. In some cases it was physically difficult to maintain a specified depth, in other cases, compliance sampling results dictated that additional excavation was indeed required. Although most of the contamination occured at shallow depths requiring excavations of 15 to 30 cm, and on fairly level terrain, much of the area requiring cleanup was quite thickly wooded and/or littered with numerous boulders (up to 2 m diameter). This complicated the removal process somewhat in that the excavation of the tree stumps (after cutting and removing all the trees) and boulders made it difficult to maintain an even 15 cm soil removal depth. In these areas,

the actual excavation depth more often was at about 30-40 cm, thereby increasing the volume of soil removed.

Excavation of the contaminated soils from the various creek channels also provided some special challenges. Because the areas to be excavated were mostly narrow bands along the bottom of drainage channels which had heavily wooded banks, access to the areas of excavation was limited. Rather than removing all the trees from the creek banks (which were not contaminated), it was found that the contaminated soil could be removed by multiple handling of the soils by the backhoe towards specific access points spaced along the drainage channels. Furthermore, during the excavation of contaminated soils from the creek channels, it was occasionally found necessary (after compliance sampling) to go back and excavate additional soil from some areas. The water deposition of the contaminants is thought to have resulted in a more uneven distribution in these areas.

All of the affected areas were successfully cleaned up and restored to the respective owners' satisfaction. A total of approximately 42,500 m^3 of contaminated soil (about 37% greater than the design) was removed and transported to the burial area on the Welcome facility. This material was graded into a set of gently contoured mounds over the entire burial area so that all previously exposed wastes received a fill cover at least 1 meter thick. These mounds were stabilized against erosion by a planting of grass seed.

In order to protect the cleaned up areas from possibly getting re-contaminated by material transport from the Welcome site in the future, major on-site works were constructed for the containment of materials on-site. As mentioned, the contaminated soils brought on-site were seeded to provide a vegetative cover for protection against erosion by wind.

A perimeter ditch system was constructed around the waste facility to convey all site runoff toward water collection ponds for treatment. New ponds were constructed which are of sufficient capacity to contain all the runoff from the site in all but the most extreme circumstances.

ENVIRONMENTAL AND HEALTH CONCERNS

Prior to starting the cleanup program, environmental and health concerns were identified in relation to handling and working with contaminated soils. These consisted of:

- gamma radiation exposure to workers on the waste burial area,
- beta or gamma radiation exposure to workers by contact with contaminated soils, and
- dusting of contaminants to the general environment during construction.

As a result, workers were issued with thermoluminescent dosimeters (TLD) and checked regularly with a contamination meter. High volume air samplers were set up at convenient locations near the construction areas. This monitoring indicated that the only concern with measurable impact was gamma radiation exposure while working on or near parts of the burial area in which waste materials were still exposed at the surface. Once all these areas were covered with the incoming fill, gamma radiation levels were not found to result in any measurable exposure. Contaminant levels in the off-site soils were generally low enough so that no criteria for exposure were exceeded in the monitoring of personnel or equipment. Similarly, while the high volume air sampling did indicate general dusting from the cleanup operations, analysis of the filter papers indicated extremely low levels of airborne contaminants. The monitoring program was therefore reduced substantially during the latter phases of the cleanup program.

SUMMARY

When the extent of contamination spread on properties around Eldorado's Welcome Waste Management Facility had been determined, the Company decided to cleanup and restore these properties immediately so that unrestricted use of the properties could be assured, even though there was not yet any prospect of a new, low level, radioactive waste disposal facility being made available. As a result, all of the contamination is now isolated and contained within Eldorado's property limits.

The level of contaminants were not causing any immediate environmental or health impact. The cleanup was required to ensure that there would be no such impacts in the long-term.

Because the levels of contamination were relatively low, standard excavation and transportation procedures were employed. Specialized containment of the wastes or protection of workers (other than exposure monitoring and contamination checking) were not required.

The total cost of the cleanup operations and associated on-site remedial measures was approximately $1.1 million, or about $26/$m^3$ of contaminated soil excavated.

The cleanup was considered a success for a number of reasons:

1. The contaminated soils on the off-site properties were all satisfactorily removed, i.e. the cleanup criteria were met and certification for each was given by the AECB.

2. All affected properties were restored to the satisfaction of the respective landowners.

3. The cleanup of low-level radioactive material was carried out with no complaints or protests from the owners or other local residents.

4. A high degree of cooperation was demonstrated between Eldorado, the regulatory agencies, consultants, analytical labs and the public.

5. The "design driven" approach was successful in meeting the cleanup objectives, and keeping costs under control.

6. Improvements in the environmental impact of the waste site itself were also realized. The covering of the waste site with fill has reduced on-site and fenceline gamma radiation levels and has also decreased the quantity of contaminants leaching from the site requiring treatment. Effluent discharges from the facility have been steadily improving in quality since the completion of the cleanup program.