Assessment of Long-Haul Transportation Options: Port Hope to Deep River*

D.M. Gorber, M.W. Davis
SENES Consultants Ltd.

D. Moffett
Acres International Ltd.

Over one million cubic metres of low-level radioactive wastes (LLRW) are currently stored at several locations in the vicinity of the Town of Port Hope, Ontario, approximately 100 km (60 miles) east of Toronto. The wastes, from operations dating back almost 60 years, contain radioactivity from the uranium and thorium series and toxic metals such as arsenic and cadmium. The Siting Task Force on LLRW was an independent group appointed by the Canadian federal government to implement a co-operative siting process to find one or more sites for long-term management of these historic wastes. The siting process used a consultative and voluntary siting approach designed to ensure that there was public acceptance of the recommended site(s).

As part of this novel study, an assessment of long-haul transportation options was undertaken to determine a preferred mode and route for transporting LLRW from the temporary storage sites to the potential volunteer community of Deep River, Ontario, a distance of approximately 400 km (250 miles).

MATERIAL TO BE TRANSPORTED

Materials to be transported were classified as either primary wastes or contaminated soils/sediments. Primary wastes refer to materials that were produced directly in the processing operations at the Port Hope plant between 1932 and 1988. They include both the chemical residues and the industrial refuse generated in the plant. The quantity and composition of the primary wastes are known and were used to estimate contaminant concentrations. Contaminated soils/sediments resulted from the spread of contamination from the primary wastes through leaching, wind dispersion and physical mixing over the past 50 years. Of the total of approximately one million cubic metres, primary wastes comprise 15% and soils/sediments comprise the remaining 85%.

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Primary wastes have higher concentrations of radionuclides and metals than soils/sediments. For example, some of the older radium wastes contain upwards of 10% by weight arsenic, while many of the contaminated soils have arsenic concentrations in the range of a few hundred parts per million or less. Measurements have also shown that some segments of the waste may contain radium-226, uranium-238, and thorium-230 at concentrations up to 680, 900, and 5,000 Bq/g, respectively.

Throughout all of the waste, the average concentrations of the major contaminants, radium-226, arsenic, and uranium-238 were estimated to be 32 Bq/g, 2,600 ppm, and 7.3 Bq/g, respectively. The average concentrations of thorium-232 and thorium-230 were estimated at 1.7 and 100 Bq/g, respectively.

In summary, the total quantity of material to be transported is 1,767,000 tonnes. The material can generally be described as **low specific activity** as defined by the Canadian Transport Packaging of Radioactive Materials regulations. This implies that the material may be transported in bulk, exclusive-use vehicles, or containers, with certain safeguards to ensure there is no external contamination. Waste analysis and laboratory test work are required to classify the wastes for transportation purposes other than radioactivity.

DESCRIPTION OF TRANSPORT MODES AND ROUTES

Available Road, Rail and Water Routes

Since there are no navigable waterways linking Port Hope and Deep River, road and rail transport were the only modes considered in this assessment. The number of potential rail routes to Deep River from Port Hope is limited to two, the CN (Canadian National) line and the CP (Canadian Pacific) line. In contrast, the road network between the two points is extensive and consists of 11 potential routing options. To simplify the evaluation process, the road network was broken down into three broad corridors and the optimum route, among road segments within each corridor, was evaluated using the following decision rules:

- use only provincial highways;
- minimize the travel distance between Port Hope and Deep River;
- maximize the use of multilane highways, where possible;
- minimize the number of communities potentially affected;
- avoid use of a single lane highway between two points if a multilane highway is available; and
- use bypasses around communities, where available.

The preferred routes within each corridor were carried forward to the evaluation of the preferred route and mode which compared three road and two rail routes.

Available Transport Methods

For **bulk** rail transport, gondola cars with rigid fibreglass covers to provide some measure of containment mainly from wind and weather, were investigated. Gondola cars could reasonably carry about 70 tonnes of waste, or about 42 m^3 assuming a density of 1.65 tonnes/m^3. Depending on waste characteristics, bulk transport of some of the chemical wastes may not be acceptable.

For **containerized** rail transport, standard flatbed cars capable of carrying four 20-tonne ISO-type (International Standards Organization-type) containers would be provided.

For **bulk** transportation by road, conventional tipper-type trailers were proposed, either a single large trailer, or a **road train** twin trailer configuration enabling loads in the order of 33 to 36 tonnes to be carried. A fabric-type cover, as required by the Ministry of Transportation of Ontario (MTO), would protect the load from wind and rain but it would offer no containment in the event of a roll-over. As for rail, bulk shipment by road might not be acceptable for some of the chemical wastes.

For **containerized** transportation, the use of flatbed trailers, commonly referred to as chassis trailers, was investigated. Unlike rail, where there are strict limitations on the type of container that can be carried, road haulers can choose from ISO-type containers and others such as lugger boxes. Both were considered in this study. Removable steel covers would be made for open boxes to completely contain the waste.

Haul Frequency and Duration

The frequency of train/truck movements and duration of the haul operation were determined assuming the removal of a total of 1,767,000 tonnes at an excavation rate of 1,260 tonnes/d (760 m^3/d), and working a 5-day week for 8 months of the year.

The duration of the haul operation was calculated to last approximately 8 years. During operation, the frequency of vehicle movements (one way) was estimated at one train per day (18 cars bulk or 16 cars of containers) or 35 to 38 trucks per day for bulk and 32 to 34 trucks per day for containers.

Short List of Route Alternatives

Two rail and three road networks suitable for hauling wastes from the Port Hope area to Deep River were identified for detailed study. It was assumed that the rail head would be located at the rail yards to the west of Port Hope and the rail terminus would be located in Pembroke at the closest common junction to the Deep River site. For road transport, it was assumed that the nearest major highway intersection at Port Hope marked the beginning of the road network and the entrance to the proposed property marked the end of the road network.

METHODOLOGY

Basis of Comparison

Evaluation of the preferred mode and route of transport was carried out by identifying five broad **categories**: environment, radiation, accidents, cost, and road characteristics. The first four categories were common to both road and rail and the fifth was applied to road transport only. Within each category, **criteria** were identified that were considered essential to the evaluation of potential impacts. For example, the potential aquatic impacts criterion was set as one of three criteria within the environment category. At the next level, each criterion was expressed as a set of **indicators** which were quantifiable measures of potential impact. For example, the number of stream crossings was one of three indicators comprising the aquatic criterion.

Environment

Three criteria were used to compare alternative routes and modes from an environmental perspective: the **potential effects on the aquatic environment** were measured by the number of stream crossings, the linear extent of water bodies, and the linear extent of wetlands; the **potential effects on the terrestrial environment** were measured by the linear extent of forest and the linear extent of agricultural lands; and the **potential effects on the socio-economic environment** were measured by the number of socio-economic features in rural areas and the linear extent of urban lands.

Table 1. Potential Environmental Effects

Criteria/Indicators		Road Route 1	Road Route 2	Road Route 3	Rail CN	Rail CP
Aquatic Environment						
- Number of Stream Crossings		148	168	179	292	147
- Linear Extent of Open Water	(m)	1,225	1,675	2,825	4,100	3,250
- Linear Extent of Wetlands	(m)	20,850	41,600	13,900	55,950	28,200
Terrestrial Environment						
- Linear Extent of Forest	(m)	261,400	212,600	12,600	*	*
- Linear Extent of Agriculture	(m)	152,850	110,700	97,300	*	*
Socio-Economic Environment						
- Number of Residences		1,314	837	238	*	*
- Number of Businesses		215	112	36	*	*
- Number of Institutional, Community and Recreational Features		51	26	4	*	*
- Linear Extent of Urban Lands	(m)	8,000	3,800	26,650	13,100	14,800

* Not required for rail routes.

Radiation Doses

The potential collective and individual (critical group) radiation doses to workers and members of the public during long-haul transport of the LLRW were considered important aspects in the selection of the preferred mode and route of transport. People who may be exposed to increased radiation during transport of the waste include truck drivers and railway engineers, other on-link users (e.g. commuters who travel behind loaded trucks), off-link individuals (e.g. members of the public who live or work beside transport routes), and rest stop employees who work at a preferred truck stop frequented by the waste haulers.

Based on the potential exposure scenarios applicable to haulage of LLRW, two criteria were used to compare alternative routes and modes: the **potential doses during incident-free transport** were measured by the total collective dose to all members of the public and transport workers, and the maximum individual doses to critical group members in the public and transport workers; and the **potential doses following transport accidents** were measured by the total collective dose to all members of the public and transport workers, and the maximum individual doses to critical group members in the public.

Table 2. Potential Radiation Doses

Criteria/Indicators		Road Route 1	Road Route 2	Road Route 3	Rail CN	Rail CP
Potential Doses During Incident-Free Transport						
- Collective Dose	(person-mSv)	59	53	78	1.8	1.9
- Critical Group Dose						
Worker	(μSv/y)	180	180	180	3.5	3.5
Public	(μSv/y)	25	25	25	1	1
Potential Doses Following Transport Accidents						
- Collective Dose						
Collisions	(person-μSv)	27	20	35	93	98
Roll-Overs	(person-μSv)	170	27	85	1,900	8,300
- Critical Group Dose						
Collisions	(μSv)	0.34	0.34	0.34	14	14
Roll-Overs	(μSv)	25	25	25	610	610

Accidents

Routes or modes (road/rail) with higher probabilities of accidents are obviously less desirable than those having lower probabilities. Three criteria were considered: the **number of crashes** likely to occur; the **number of roll-over or derailment accidents** that could cause a release of material to the environment; and the **number of fatalities** that might be expected during the haul period. These were classified in order of increasing severity as follows: collisions, roll-over/spill-type accidents, and fatalities.

Table 3. Accident Statistics for Long-Haul Routes

Criteria	Road Route 1	Road Route 2	Road Route 3	Rail CN	Rail CP
- Number of Collisions	27.2	19.4	34.9	0.78	0.82
- Number of Roll-Overs/Spill Derailments	1.32	0.21	0.65	0.18	0.78
- Number of Fatalities	1.76	2.19	3.11	0.35	0.17

Costs

Consideration was given to the haul costs and also to the indirect costs of transporting the waste to Deep River. Haul costs include the supply of equipment, operators, fuel, maintenance, and associated licences and taxes; they do not include local material handling at either end of the route.

Indirect costs include such items as mitigation measures, and local material handling at either end of the long haul, that are difficult to quantify, or, in the case of local materials handling, fall outside the scope of study, and as such have been assessed on a qualitative basis only.

Table 4. Long-Haul Costs

Transportation Method		Road Route 1	Road Route 2	Road Route 3	Rail CN	Rail CP
- Bulk Shipment	(1993$ x 10^6)	42.4	42.4	58.3	65.4	42.4
- Containerized Shipment						
ISO Container	(1993$ x 10^6)	45.8	45.8	61.6	59.8	50.1
Lugger Box	(1993$ x 10^6)	46.7	46.7	62.7	*	*

* Not considered for rail routes.

Road Characteristics

Features of the road routes, such as gradients, pavement widths, number of lanes, passing opportunities were used to compare potential road routes. A similar study was not required for the rail routes because rail lines are more uniform than roads in terms of physical features such as gradients.

Table 5. Road Characteristics

Road Route	Segment	Road Type	Grades	Passing Opportunities
1	A	4-lane divided	Minor	Good
	B	2-lane	Moderate/minor	Fair
	C	2-lane	Steep	Fair
Total Distance:	D	2-lane	Steep	Poor
379 km	E	2-lane	Steep	Poor
	F	2-lane	Moderate	Fair
	G	2-lane	Minor	Fair
	H	2-lane	Minor	Fair (passing lanes)
2	A	4-lane divided	Minor	Good
	B	2-lane	Moderate/steep	Fair/poor
	C	2-lane	Moderate/steep	Fair/poor
Total Distance:	D	2-lane	Minor	Fair
353 km	E	2-lane	Minor	Fair
3	A	4-lane divided	Minor	Good
	B	2-lane	Minor	Fair
Total Distance:	C	4-lane divided	Minor	Good
528 km	D	2-lane	Minor	Fair (passing lanes)
	E	2-lane	Minor	Fair (passing lanes)

Assigning Relative Importance to Evaluation Factors

Weights were assigned to indicators, criteria, and evaluation categories to reflect their varying levels of importance. Weights were assigned to categories (i.e. environment, radiation, accidents, and cost) based on the following rationale. The **environment** and **accidents** categories were each assigned a weight of 0.35 to reflect the high level of importance placed on these two categories. **Cost** was assigned a weight of 0.2 to reflect the increased level of importance placed on the other categories. Typically, the public is willing to pay more for an activity to achieve lower risk and consequence. **Radiation** was assigned the lowest weight of 0.1 because the potential radiation dose received is strongly influenced by other indicators such as the linear extent of urban lands and the accident probabilities. Furthermore, collective and individual dose levels were calculated to be low.

SELECTION OF PREFERRED MODE AND ROUTE

First, the road and rail routes were compared independently. Then a comparison of the preferred road haul route and rail haul route was made to select the overall preferred mode and route.

The three road haul routes were compared to determine the overall preferred road haul route. The preferred route was the shortest of the three and it was preferred in the environment, radiation, and accident categories and was tied with another route in the cost category. Additional review demonstrated that no road characteristics associated with the preferred route would render it unsuitable for road haul.

The two rail haul routes were compared to determine the preferred rail route. The preferred rail haul route was the shorter of the two and it was preferred in the environment, accident and cost categories. Significantly lower costs for the preferred route were directly attributable to its shorter length.

Comparison of the preferred rail and preferred road routes resulted in rail transport being marginally preferred over road transport. The rail option was preferred in the accident criterion and was tied with the road option in the radiation and cost criteria. The preference for rail transport was reinforced by the public generally preferring rail over road because they perceive it to be more isolated and causing fewer accidents.

In comparing bulk versus containerized methods, containerized transport was considered preferred largely on the basis of local transportation and materials handling considerations in the Port Hope area and at Deep River.

LOCAL TRANSPORTATION STUDIES

The long-haul transportation study determined that containerized rail transport was the preferred method of transporting waste from the rail head in the Port Hope area to the terminus in the Deep River area. Once this was determined, it was necessary to carry out separate local transportation studies at both of these locations.

The local transportation of waste in the Port Hope area from the various waste sites to the rail head was evaluated for two options: the construction of one central rail siding with road transport of waste from each waste site to the central siding (integrated option); and the construction of rail sidings at each of the waste sites (go-it-alone option). The integrated option was found to be preferred with the construction of a rail siding near one of the centrally located waste sites.

The local transportation of waste at Deep River was evaluated for two options: construction of a terminus along the existing rail line and road transport of waste from the terminus to the site; and construction of a spur line to facilitate rail transport directly to a terminus on-site. The preferred option was construction of a spur line which provided direct access of the long-haul trains to the site.

WHERE WE ARE NOW

The current status of the Co-operative Siting Process is marked by two recent achievements. The Siting Task Force successfully negotiated a Community Agreement-in-Principal with Deep River in which the terms and conditions for hosting a LLRW disposal facility were specified and a referendum addressing continued participation in the process was held. The heavy turnout of registered voters (60%) strongly supported the siting of a LLRW facility with 72% of participants voting in favour. The Canadian government is currently investigating options and financial commitments before deciding how to proceed.