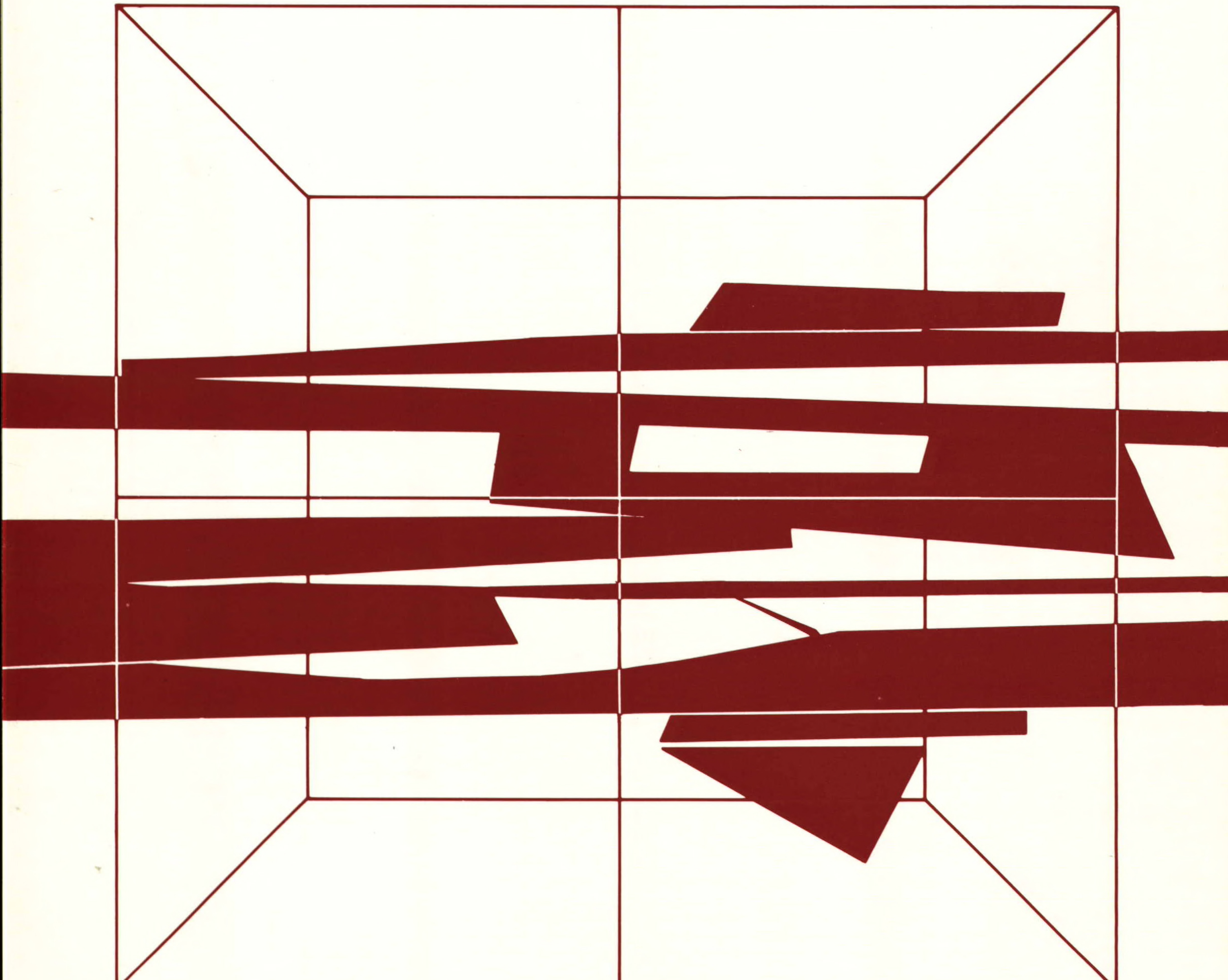
Environmental Codes of Practice for Steam Electric Power Generation

Construction Phase

Report EPS 1/PG/3
August 1989



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ENVIRONMENTAL CODES OF PRACTICE FOR STEAM ELECTRIC POWER GENERATION

CONSTRUCTION PHASE

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ABSTRACT

The Environmental Code of Practice for Steam Electric Power Generation - Construction Phase, is one of a series of documents being developed for the steam electric power generation (SEPG) industry under the provisions of the Canadian Environmental Protection Act. This industry includes fossil-fuelled stations (gas, oil and coal-fired boilers), and nuclear-powered stations (CANDU heavy water reactors). In this document environmental concerns associated with construction activities at SEPG stations are discussed. Practices are recommended for the protection of terrestrial and aquatic life, for the preservation of archeological and historical resources, for erosion and siltation control, for the control of wastewater discharges and spills, for the management of solid wastes, for the control of air pollution and noise, and for environmental auditing, monitoring, and reporting. These practices are intended to mitigate or eliminate adverse environmental effects due to construction or modification of steam electric power stations. The SEPG Codes are being developed by working groups of a federal-provincial-industry task force, and are intended as environmental standards for governments, industry and the public.

RÉSUMÉ

Le Code de recommandations techniques pour la protection de l'environnement applicable aux centrales à vapeur - étape de la construction, fait partie d'une série de documents élaborés pour l'industrie des centrales à vapeurs aux termes de la Loi canadienne sur la protection de l'environnement. Cette industrie comprend les centrales alimentées aux combustibles fossiles (chaudières au gaz, au mazout et au charbon) et les centrales nucléaires (réacteurs à eau lourde CANDU). Ce document traite des problèmes d'environnement liés à la construction de centrales. Des pratiques sont recommandées pour la protection de la vie terrestre et aquatique, la préservation des ressources archéologiques et historiques, le contrôle de l'érosion et de l'envasement, le contrôle de l'évacuation et du déversement des eaux usées, la gestion des déchets solides, du contrôle de la pollution de l'air et de la pollution par le bruit; on y aborde également la vérification de l'observation des directives, la surveillance, et la préparation de rapports. Ces pratiques ont pour but d'atténuer ou d'éliminer les effets néfastes pour l'environnement de la construction de centrales à vapeur ou de travaux d'aménagement dans ces centrales. Les codes applicables aux centrales à vapeur sont élaborés par des groupes de travail formés de représentants des gouvernements fédéral et provinciaux, et de l'industrie; ils serviront de normes relatives à l'environnement aux différents paliers de gouvernement, à l'industrie et au public.

NOTICE

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1 INTRODUCTION

1.1 Scope

The Environmental Codes of Practice for Steam Electric Power Generation (SEPG) consist of a series of documents which identify good environmental protection practices for various phases of a steam electric power project. The steam electric power industry includes facilities that utilize a steam cycle to produce electrical energy. The industry, therefore, includes both fossil-fuelled (coal, oil or gas) and nuclear-powered (CANDU) stations. The Codes of Practice encompass the siting, design, construction, operation and decommissioning phases of a project (1,2), and deal with multi-media (air, water, land) considerations. However, the Design Phase Code (1) deals only with water and land considerations, with air emission guidelines for new fossil-fuelled stations (3) appended to the document.

The Environmental Codes of Practice describe environmental concerns and alternative methods, technologies, designs, practices and procedures that will minimize or eliminate the adverse environmental effects of steam electric generating stations. The Codes also contain recommendations which are judged to be reasonable and practical measures that can be taken to preserve the quality of the environment affected by these stations. These environmental protection standards may be used by the electricity generation industry, federal, provincial and municipal government agencies, and the public as sources of technical advice and guidance in establishing environmental protection practices, requirements and regulations.

The Codes are being developed under the objectives, guidelines and codes of practice provisions of Part I, Section 8, of the Canadian Environmental Protection Act (4), and will help to achieve the objective of the Act, namely the protection of Canada's natural environment. However, compliance with these Codes does not remove obligations to meet federal, provincial and other legal requirements.

1.2 Development

The Construction Phase Code has been developed in collaboration with a federal-provincial-industry task force established by Environment Canada. This Code was produced by a working group of the task force with members selected to provide appropriate expertise on SEPG construction activities and environmental protection practices. A list of members of the Construction Phase Working Group is presented in the appendix.

1.3 Code Structure and Application

The Construction Phase Code describes construction activities (Section 2) and related environmental concerns (Section 3). These concerns include erosion and siltation, wastewater discharges and spills, solid waste disposal, air pollution, noise, effects on terrestrial and aquatic life, and damage to archeological and historic resources. Within the discussions of each area of concern specific recommendations are made to mitigate environmental effects (Section 4). Examples of possible applications of the recommendations are also provided. The recommendations are summarized in Section 5.

The Construction Phase Code applies to all on-site activities and facilities associated with power plant construction, including access roads, rail lines, fuel unloading and storage facilities, offshore intake and discharge structures, remote facilities for the impoundment and conveyance of cooling water, cofferdams, dykes and groins, waste disposal areas, and construction camps. The Code does not address off-site power transmission or coal mining facilities which may be associated with the site. The Code applies to construction at new stations and at existing stations that are undergoing major modifications. Modifications would include expansion (including replacement of obsolete generating capacity), conversion from one fuel type to another (e.g., from oil to coal), conversion from one major combustion method to another (e.g., from a pulverized coal-fired boiler to a fluidized bed combustion boiler), and the addition of any major new station system (e.g., a flue gas desulphurization system retrofitted to an existing coal-fuelled station).

For this Code, the construction phase is defined as beginning with the first on-site activities related to the installation of permanent facilities and proceeding until the station's commercial date.

While the Code recommendations are intended to be clear and specific with regard to the expected results, they have been formulated so that alternative methods may be used to achieve an equivalent or better level of environmental preservation. Continuing research, development and demonstration of improved environmental protection practices is encouraged.

While this Code was developed for the steam electric power generation industry, many of the recommended practices can be used for other major construction projects.

2 CONSTRUCTION ACTIVITIES

This section briefly describes the major activities involved in the construction of steam electric power generation facilities. Although a range of construction activities and alternative techniques are used, not all activities and techniques will be applicable at all stations. Also, the activities described do not necessarily constitute environmentally preferrable or recommended methods of construction but are presented here to identify the nature and scope of activities addressed in this Code. Emphasis has been placed on activities that relate to environmental concerns and mitigative measures discussed in subsequent sections of this document.

Typical site plans for fossil-fuelled and nuclear power stations are shown in Figures 1 and 2. These illustrate the large scale of these projects, involving more than one square kilometre of land. Typical examples of construction schedules for an oil-to-coal-fired station conversion, a single unit of a coal-fired station and a multi-unit CANDU (CANadian Deuterium Uranium) nuclear station are shown in Figures 3, 4, and 5, respectively. These indicate approximate construction periods, which vary from 2.5 years for an oil-to-coal conversion to 12 years for a large multi-unit nuclear generating station. Figures 1 to 5 were derived from documentation for steam electric power projects (5,6,7,8,9).

2.1 Clearing

Clearing consists of the removal of trees, shrubs, brush and other foliage. Selective clearing involves the retention of trees that are not obstacles to the development. Normally, trees are cut so that a sufficient stump remains to facilitate grubbing. Where grubbing will not be carried out, such as in swamps and future earth fill areas, stumps are often cut close to the ground (close cut clearing) (10).

Felling is accomplished using chain saws or large scale mobile equipment. Debris is then removed using winches and cable, trucks, bulldozers or skidders. Salvageable timber may be sold. Other debris must be disposed of (see Section 2.14).

2.2 Grubbing

Grubbing consists of the removal of stumps, roots, embedded logs and debris. This is accomplished using winches and cable, bulldozers, front end loaders, trucks and occasionally by blasting. As in clearing, grubbing produces large quantities of debris which must be disposed of (see Section 2.14).

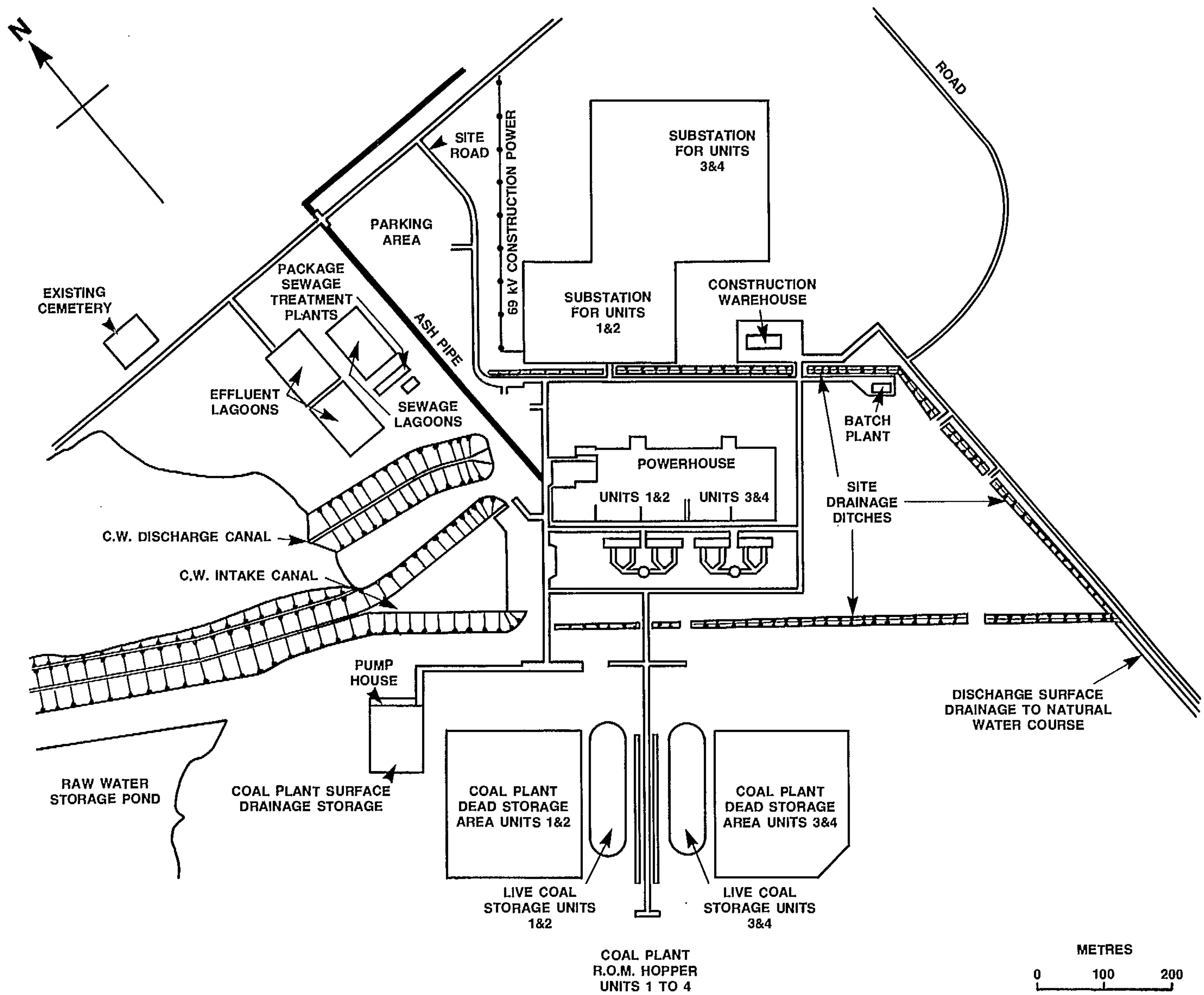

FIGURE 1 TYPICAL SITE PLAN FOR A FOSSIL-FUELLED POWER STATION (derived from reference 5)

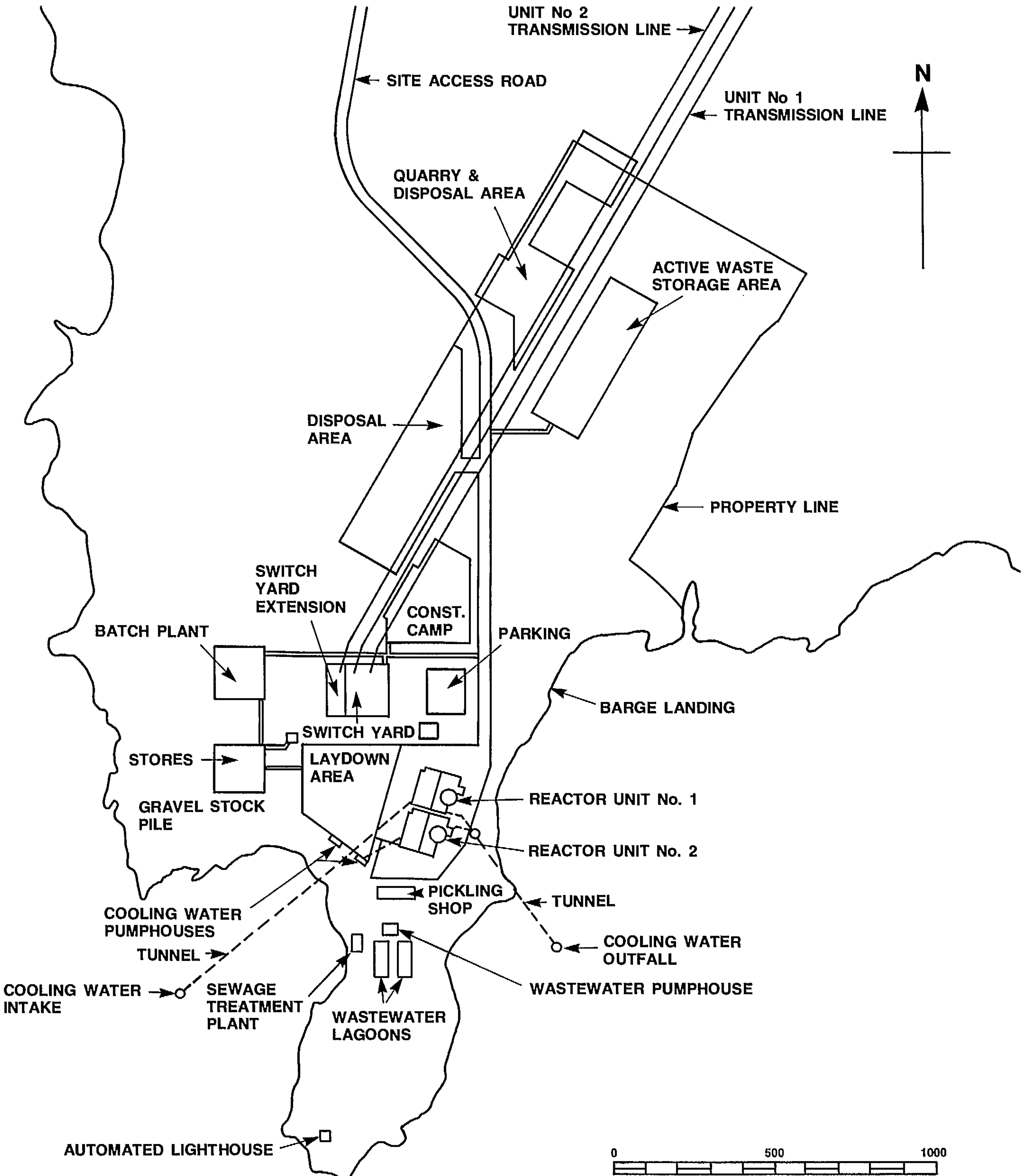

FIGURE 2 TYPICAL SITE PLAN FOR A NUCLEAR POWER STATION (derived from reference 6)

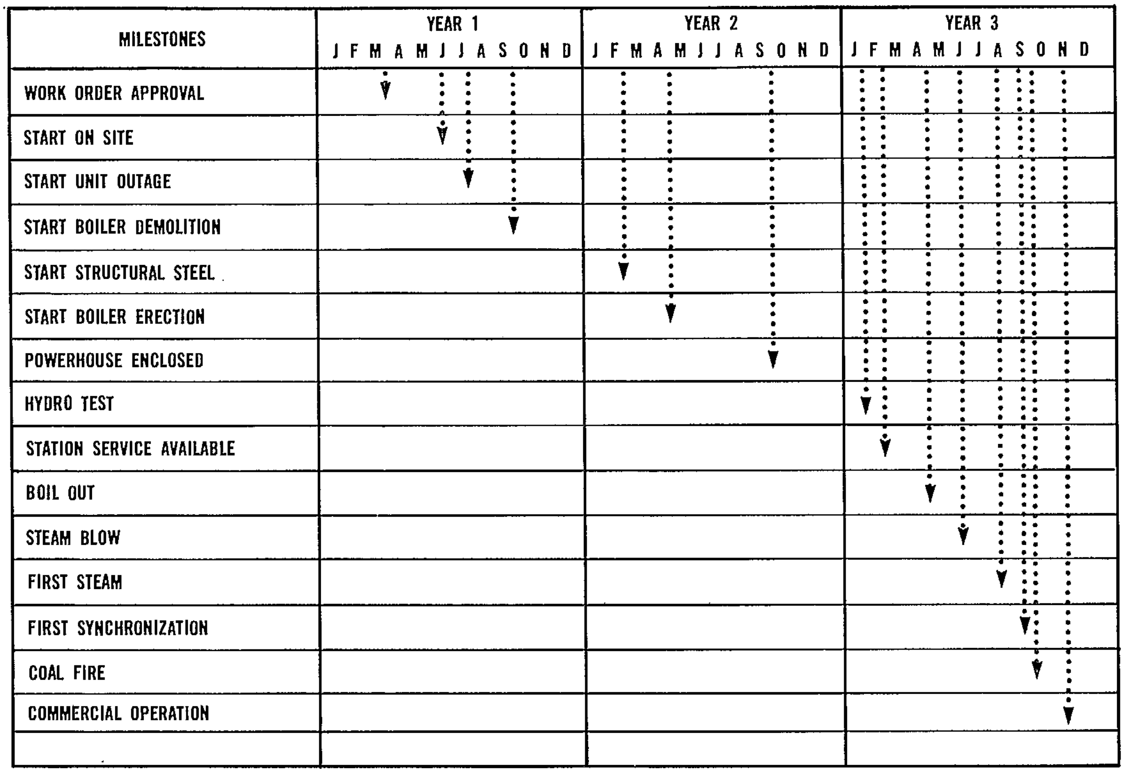

FIGURE 3 CONSTRUCTION SCHEDULE FOR AN OIL- TO COAL-FIRED STATION CONVERSION (derived from reference 7)

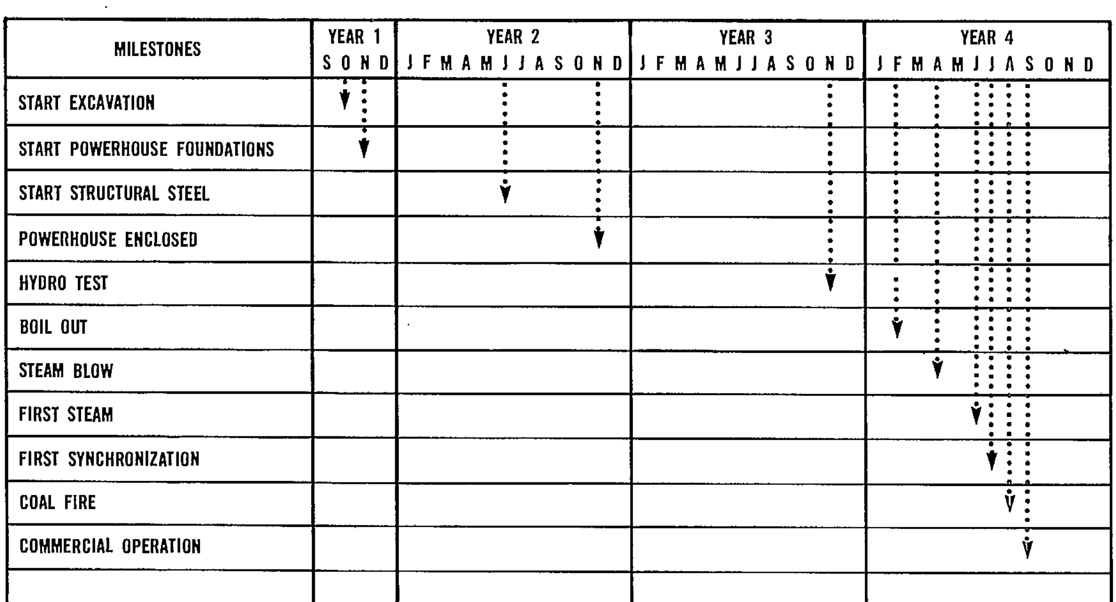

FIGURE 4 CONSTRUCTION SCHEDULE FOR A SINGLE UNIT OF A COAL-FIRED STATION (derived from reference 8)

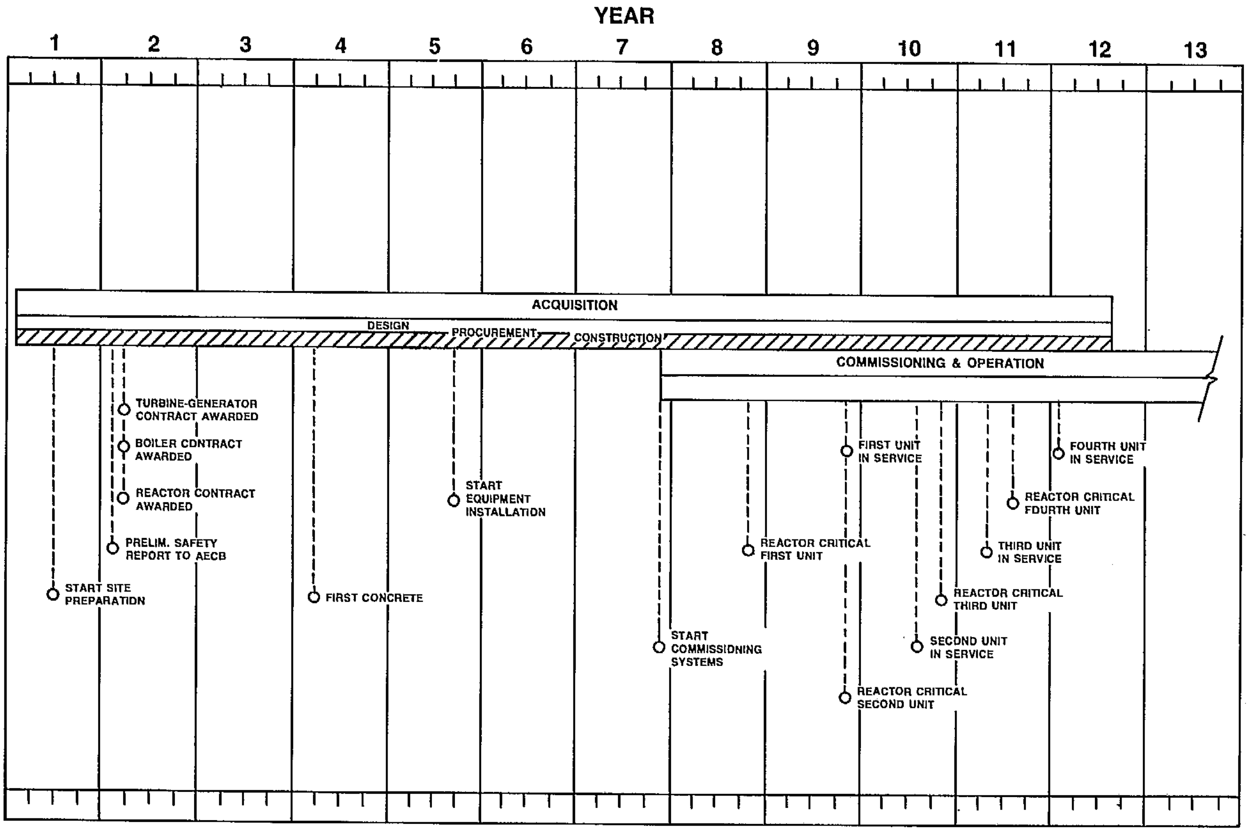

FIGURE 5 CONSTRUCTION SCHEDULE FOR A MULTI-UNIT CANDU NUCLEAR STATION (derived from reference 9)

2.3 Roadbuilding

Roadbuilding consists of the provision of access routes for vehicles to the various work areas on the site. The procedures used depend on topography, ground cover, and the intended use and lifetime of the road. Little-used roads may consist of the tracks worn by the vehicles which use them. Normally, however, clearing, grubbing, and stripping of topsoil are carried out and the roadway excavated or filled to establish a suitable grade. Granular sub-base is used followed by application of the road base and road surface. Permanent and heavily used roads are often surfaced with asphalt.

2.4 Stripping, Grading and Excavation

Stripping involves the removal of topsoil and other organic materials. This is accomplished using scrapers and bulldozers. Material suitable for use as topsoil is stockpiled.

Grading and excavation consists of removal of material below the topsoil layer to the lines and grades specified in the design (10). Where fill is required, suitable excavated material or borrow material is placed and compacted. This is accomplished using bulldozers, scrapers, backhoes, shovels and trucks. Where rock is to be excavated blasting is generally used. Excess excavated material is stockpiled or used directly as fill in other areas.

2.5 Drainage

Drainage refers to the removal of surficial or impounded water from construction areas such as ponds, cofferdams and diked enclosures. Where water will not drain by gravity, pumps are used. Drainage containing high sediment levels is routed to settling ponds where suspended sediments are removed. In areas with porous foundations, wellpoints have been connected to suction pumps to dewater the area (10).

2.6 Marine Construction

2.6.1 Dredging. Dredging refers to the excavation of material from the bottom of a water body. This can be accomplished mechanically, using a backhoe, clamshell or dragline, or hydraulically, using a suction pump. In some cases dredged spoils are disposed of in open water. Where this is not the case, spoils are transferred to on-shore disposal areas or in some cases used as a resource (construction fill material, beach nourishment, etc.). On-shore disposal areas normally include basins where suspended sediments can settle out prior to the water being returned to the water body. Where rock is to be excavated underwater blasting is required.

2.6.2 Dyking. Dyking is the construction of a solid barrier to the movement of surface water. Although dykes are sometimes porous they are generally impervious and are used to allow dry construction techniques in an area previously covered by water. Temporary dykes used in this way are usually referred to as cofferdams. Dyking is also used to impound water for a cooling or ash lagoon or to direct water for canals. Generally the surface of dykes exposed to water are armoured with coarse rock and the interior is constructed of finer, less permeable material.

2.6.3 Shoreline Reclamation. Shoreline reclamation involves the placement of fill in such a manner that usable land is formed in an area once covered by a water body. This is accomplished by dumping fill directly into the water body or by first dyking the perimeter of the area to be reclaimed and then placing fill within the dyke.

2.6.4 Offshore Intake and Discharge Construction. Offshore intakes or discharges are usually constructed in one of two fashions.

The first method involves tunnelling by drilling and blasting or the use of a tunnel-boring machine. Braces are commonly installed and, depending on the rock type, a concrete liner may be placed. The tunnel is extended to a pre-determined point under the water body. In the case of the intake, the work is then continued upwards until only a wedge of bedrock separates the water body from the tunnel. Immediately under this wedge, a sump is dug. Material from the wedge that is blasted away to connect the tunnel to the water body falls into this sump. Prior to this final blast, all surficial silt and soil from the lake or ocean bottom is dredged down to the bedrock and deposited elsewhere. The intake structure is assembled onshore and then floated out to the water inlet, where it is lowered into place after the wedge has been blasted away (10).

The second method of constructing offshore intakes or discharges is commonly referred to as cut-and-cover. As its name suggests, this method involves excavation followed by backfilling. First, the overlying layer of sediment is dredged with barges equipped with rock grabs or clam shells. Then spud-legged barges are floated into place to commence drilling operations. These barges are equipped with legs, enabling them to lift themselves out of the water to escape wave action. When drilling is completed, blasting is used to break the rock that is to be excavated. The blast rubble is then cleared by the same method used to dredge the lake sediments. Next, a bedding of sand or gravel is laid on the trench floor using hoses from barges. Once this has been completed, the pipe comprising the intake or discharge is laid. Crushed rock from the initial blast can then be used to cover the pipe and fill the remainder of the trench. Near the shore, armour stone must be placed to protect the trench and pipe from the forces of wave pressure and erosion. Finally, if applicable to the design, the intake cap is lowered into place by barge (10).

2.7 Drilling and Blasting

Drilling is used to collect soil and rock samples for study, to position charges for blasting, and to facilitate grouting in rock. Blasting is used to loosen or break up rock areas which must be removed. Powder holes are drilled using pneumatic, hydraulic or mechanical rock drills. After the holes have been completed to the predetermined pattern and depth, explosive, a detonator and packing are placed, and the explosive is detonated. After blasting, loose rock is excavated (10).

2.8 Borrowing

Borrowing refers to the procurement of fill materials other than those already available from site excavation. This normally involves the creation of borrow pits. Material may include gravel, sand, clay, weathered shale, rock or other material of suitable properties. To obtain borrow material it may be necessary to clear, grub and strip areas outside the area to be occupied by the power plant, and to transport material to the site. Equipment used is the same as that used for excavation.

2.9 Concrete Work

Large quantities of concrete and reinforcing steel are used in the construction of footings, piers, abutments, floors, walls, tunnels and basins for the power plant.

Hand crews, assisted by cranes, construct the formwork (timber or steel) needed to support the concrete. Reinforcing steel is placed within the formwork followed by concrete supplied from commercial or on-site concrete mixing plants. The concrete is delivered to the forms by ready-mix trucks, conveyor belts, pumps, buggies or cranes with concrete buckets and placed within the formwork. After the concrete has cured, the formwork is removed. In some cases the concrete surface is washed with high pressure jets (10). The majority of the formwork is generally reused but some amount will be disposed of. Off-specification or surplus batches of concrete may also require disposal.

2.10 Equipment Washing

Mixing trucks, conveyors, chutes, buckets and shovels which have come in contact with wet concrete have to be washed. Other equipment is washed to remove accumulations of mud, dust, oil and grease. Trucks and other equipment used for handling of coal and ash require regular washing. These activities generate washwater contaminated with suspended solids, lime, oil and grease, coal and ash.

2.11 Equipment Maintenance

Equipment maintenance involves the draining and replacement of lubricating oil, hydraulic oil and fuel, flushing of cooling systems, degreasing of parts, machining, welding and painting. These activities lead to the presence of waste oils and fuel, contaminated wastewaters, waste cutting fluids, scrap metal and empty containers.

2.12 Oil, Fuel and Chemical Handling and Storage

On large projects significant quantities of oil, fuel and chemicals are handled and stored on the construction site. These materials include oil for firing of boilers, lubricating and hydraulic oils, gasoline for fueling vehicles, solvents, acids and alkalis used for metal cleaning, and process chemicals. These materials are contained in centrally located bulk storage facilities, in mobile equipment used for the transfer of material to the point of use, or in small depots throughout the site. Handling and storage facilities are also required for used materials such as waste lubricating oils or used chemical solutions.

2.13 Construction Camp Activities

Where the site is in a remote location the construction camp usually includes living quarters, a cafeteria, offices, lavatories, potable water supply, and sewage treatment facilities. Electricity is supplied by portable diesel generators or by a transmission line to the site. Where the site is close to an urban centre the construction camp will be much smaller and will generally not include living quarters. Potable water and sewage treatment can be provided by connection to the nearby municipal system.

The area for the construction camp often requires clearing, grubbing stripping and grading. Additional area is sometimes cleared and graded to facilitate insect control or to provide recreation facilities. Facilities are housed in portable trailers, temporary buildings or permanent buildings which will become part of the generating station.

Where domestic sewage is to be treated on-site a biological treatment system is normally constructed. This consists of a large lagoon or set of lagoons, or a smaller "package" treatment system consisting of tanks, aeration equipment, clarifiers, and chlorination equipment. The construction of a lagoon may involve the placement of a low-permeability liner to limit seepage from the lagoon to groundwater.

2.14 Solid Waste Disposal

Construction activities generate considerable quantities of solid wastes. Some of this waste may be handled by off-site disposal firms, particularly where the construction site is near urban areas. However, significant quantities of wastes are commonly disposed of on-site. Slash and debris from clearing, and stumps from grubbing operations are common examples.

On-site disposal of solid waste generally involves landfilling, usually variations on either trench and fill or area fill procedures. In both cases, wastes are usually covered by a layer of earth. Domestic solid waste disposal requires particular attention because of the potential for sites to attract nuisance animals and predators.

2.15 Metal Cleaning and Surface Preparation

For fossil-fuelled projects, metal cleaning and surface preparation are normally done off-site except for the final, in-place, preoperational cleaning which takes place over a relatively short period of time. Preoperational cleaning of boiler waterside surfaces and associated piping is necessary to remove iron oxide which forms on the surfaces during the manufacture and assembly of the boiler. It also removes oil, grease and construction debris. Preoperational cleaning of the water side typically consists of the following steps (11):

- alkaline boilout followed by drain and rinse,
- acid clean followed by drain and rinse,
- alkaline boilout to neutralize trapped acid, and
- passivation rinse (may be combined with alkaline boilout in one step).

Preoperational cleaning of the steam path is usually accomplished by blowing steam through the piping and exhausting the entrained debris, oxides etc. to the atmosphere.

Spent cleaning solutions and rinses from preoperational cleaning may contain caustic, sulphuric, formic, and hydroxyacetic acids, citrates, ammonia, ethylenediaminetetraacetic acid (EDTA), silicates, sulphites, phosphates and metal ions, notably iron, from the metal surfaces cleaned (12).

For nuclear plant construction there is a requirement for cleaning and surface preparation during the fabrication of metallic components. Degreasing agents, solvents, etching or pickling solutions, and rinses may be used. In some cases sandblasting is also used. Facilities are usually provided on-site for immersing parts in cleaning solutions or for spraying and recovering solutions. Spent cleaning solutions and rinses require disposal. The need for metal cleaning facilities and disposal of the associated waste solutions can exist for several years during the construction of nuclear facilities.

For nuclear stations preoperational cleaning involves flushing the circuits with demineralized water to remove construction debris, and then flushing with hydrazine and amine treated demineralized water.

Pickling, and/or high velocity oil flushing may be done on turbine oil piping and equipment at both fossil and nuclear stations.

2.16 Commissioning

Commissioning refers to the process whereby individual plant systems are tested and brought on-line, culminating in the commercial production of electric power.

Prior to commercial operation of a fossil-fuelled power plant the following activities take place:

i) Plant process water supply and treatment systems, including the boiler feedwater treatment system, are started up.

ii) Preoperational boiler cleaning takes place.

iii) Fuel oil or gas for start-up or firing of the boiler is made available.

iv) Coal is stockpiled at coal-fired stations.

v) Condenser and auxiliary cooling water systems are made operable.

vi) The boiler and turbine are brought on line and checked out during a period of pre-commercial operation.

vii) Procedures are implemented for the management of:

- water treatment plant wastewaters and sludges,
- boiler blowdown,
- ash, and
- other wastes.

Commissioning of a CANDU nuclear power station takes place in the following four phases (13):

Phase A: Pre-critical stage

Phase B: First approach to criticality and reactor physics measurements stage

Phase C: Power ascension stage

Phase D: Power shakedown stage

During these phases extensive inspection, testing, and calibration of safety and safety support systems and procedures is carried out under the authority of the Atomic Energy Control Board. Activities relating directly to pollution control that take place during this period include:

- alkaline washing of the piping system (phase A);
- placing in service of the process water and feedwater treatment systems and the condenser cooling water system (phase A);
- placing in service of the fuel and radioactive waste storage and handling systems (phase A); and
- testing of monitoring systems used for detecting reactor coolant leaks, effluent release, fuel failure, and for planned and accidental emission of radioactivity (phase C).

3 ENVIRONMENTAL CONCERNS

Environmental concerns associated with steam electric power plant construction are outlined in this section. Specific concerns are discussed in greater detail in Section 4.

Because steam electric facilities use large quantities of water for cooling condensers and other equipment, they are generally situated adjacent to large water bodies or on reservoirs created by impounding smaller rivers or streams. The proximity to water means that there is a high potential for construction activity to affect the water body.

The building of the power plant itself, fuel unloading and storage facilities, switch yards, waste disposal facilities and construction camps may involve the clearing of large areas of land. A major concern is erosion of the disturbed soil and siltation of the adjacent water body. Another potential cause of siltation is construction activity which takes place in the water body itself. Large intake and discharge structures, for cooling water, may extend more than one kilometre from the shoreline. Their construction can disturb large quantities of bottom sediments. The need for bulk fuel (coal, oil) and major equipment (nuclear reactors) unloading facilities may involve the construction of docks and breakwaters and the dredging of nearshore areas. This may result in shoreline disturbances, changes in littoral drift patterns, and suspension of bottom sediments. Portions of the water body may be reclaimed to accommodate some of the power plant facilities, and the reclamation process may result in additional sediment loadings to the water body.

Another area of environmental concern during construction is contamination of the water body by wastewater discharges and spilled materials. On large projects many activities that might normally be done off-site, may be located on-site. For example, metal cleaning and surface preparation work, which is commonly done in metal fabrication or surface finishing plants, may be done at on-site facilities for nuclear power plants. The resultant wastewaters, consisting of cleaning solutions, spent pickling liquor, and rinses will be a concern. Concrete-making and handling facilities may also be located on-site and contaminated equipment washwater could also be a concern. Discharge of wastewaters associated with routine generating station operation will commence during startup and commissioning. Commissioning will also result in the generation of non-routine wastes such as those from testing of equipment and preoperational cleaning. Relatively large quantities of liquid fuel, oils and chemicals are also used and stored on the construction site. Leaks and spills of these materials to surface water, soils, or groundwater are of concern.

Solid waste disposal is of concern because of potential effects on surface water, groundwater, soils, air quality, aesthetics and land use. Some of the solid wastes encountered during construction may require special consideration during disposal.

Construction activities may also have an impact on local groundwater levels. Dewatering of construction areas has in some cases drawn down nearby domestic wells.

Local air quality can be impaired by dust from drilling, sandblasting, blasting, excavating and the movement of heavy equipment. Emissions from internal combustion engines, construction boilers, and other combustion sources, will also affect air quality. Noise from drilling, blasting, steam blows, pile driving, and heavy equipment may be of concern, particularly in nearby residential areas.

Terrestrial and aquatic life can be directly affected by the construction of a large power generation facility. In-water construction activities can interfere with fish spawning and underwater blasting can kill fish. Wildlife may be disturbed by construction noise and site activity. Terrestrial and aquatic habitats can be temporarily or permanently degraded.

Protection of archeological and historic resources is a consideration in most large construction projects. Because steam electric facilities are normally located adjacent to water bodies, the land to be developed lies in areas which are also likely to contain sites of archeological or historic significance.

These environmental concerns can be reduced, remediated, or eliminated by appropriate environmental protection measures taken during the construction phase.

4 RECOMMENDED ENVIRONMENTAL PROTECTION PRACTICES

This section is organized by areas of environmental concern. Following a description of a specific concern, mitigative measures are recommended which can be applied to various relevant activities. The rationale is provided for each recommendation, as well as examples of possible applications. These examples have been taken from the literature on general construction practices, from reports concerning Canadian power plants, from federal and provincial regulations, guidelines or codes, and from the experiences of the Construction Phase Code Working Group. The examples are not expected to be relevant to all steam electric power construction projects but are included to assist in interpretation of the Code.

Application of the recommendations to specific projects may involve practices which are not mentioned in this Code but which achieve equivalent or better results in terms of environmental protection. Also, where more stringent provincial and/or legal requirements exist, these must be taken into account and satisfied. Federal and provincial requirements applicable to the electric power industry have been summarized in "A Reference Guide to Environmental Legislation in Canada" (14). A number of relevant federal and provincial documents are also cited as references in this Code.

The previously published Design Phase Code (1) presented three series of recommendations numbered 100, 200, and 300. The construction phase recommendations presented in this Code comprise series 400.

4.1 Erosion and Siltation Control

Many of the initial activities in power plant construction alter the natural vegetative cover of the land. Any disturbance to the vegetative cover makes the soil more susceptible to wind and water erosion by exposing the soil directly to the elements, removing the soil holding properties of roots and organic material, decreasing water infiltration, increasing water runoff, and changing the pattern and speed of runoff.

Silt laden runoff entering water bodies has a number of undesirable effects (15, 16). Increased turbidity will decrease the penetration of sunlight, resulting in decreased primary productivity in the water body. Bottom dwelling organisms and their habitat can be destroyed by severe sediment deposition. Suspended sediment can interfere with respiration in adult fish and sediment deposition can damage fish spawning areas. Increased sediment loadings can degrade the quality of water for municipal and industrial use and decrease the aesthetic value of recreational waters.

Activities during power plant construction which may lead to increased erosion and siltation include clearing, grubbing, trenching, excavation, dredging and roadbuilding. Mitigation measures that apply to these activities are addressed in recommendations 401 to 407.

4.1.1 Scheduling of Construction.

RECOMMENDATION 401. Where practicable the use of high bearing pressure equipment should be restricted during periods when the terrain is susceptible to damage because of low bearing capacity.

Rationale. The use of high bearing pressure equipment on water-saturated ground will create ruts which increase the potential for erosion.

Examples of Possible Applications.

i) Since terrestrial effects of construction are usually greatest in the spring when the ground is moist and soft, and least in the winter when it is frozen or in the summer when it is dry and hard, construction can be scheduled accordingly.

ii) When work must be done when the ground is soft, low bearing pressure equipment can be used.

4.1.2 Clearing.

RECOMMENDATION 402. Clearing should be carried out in such a way that:

i) the area cleared is minimized;

ii) buffer zones of natural vegetative cover are retained wherever possible between cleared areas and adjacent bodies of water;

iii) the time between clearing of an area and subsequent development is minimized.

Rationale. The natural vegetation of a site is frequently the most effective and least costly protection against erosion. Vegetation along a shoreline is particularly important because it protects against shoreline erosion and also reduces the potential for sediment generated on the construction site to enter a water body. Once an area is cleared, the potential for erosion increases with time until it is suitably developed. A desire to minimize mobilization costs for clearing equipment and crews and a lack of thorough planning may result in areas being cleared unnecessarily or too early in the project. The objective of minimizing the area cleared and/or the duration of exposure of cleared areas is a common component of guidelines and recommendations for erosion control during construction activity (10, 16, 17, 18, 19, 20, 21).

Examples of Possible Applications.

i) Clearing boundaries can be clearly identified on construction drawings and at the construction site before clearing begins, and it can be stipulated that no trees or vegetation are to be cut outside the clearing boundaries (17,18).

ii) Areas within the site which are to be protected can be fenced to prevent inadvertent clearing or use of the areas in a manner that would destroy the natural vegetation (10,19).

iii) Clearing can be staged in increments coinciding as much as possible with the development of specific areas of the site (19).

iv) Where it is necessary to clear areas adjacent to a water body, this can be scheduled as late as possible during development.

4.1.3 Grubbing.

RECOMMENDATION 403. Stumps should not be grubbed in areas where grubbing would disturb standing timber.

Rationale. Grubbing of stumps will disturb the root systems of nearby standing timber, weakening the trees generally and leaving them more susceptible to being blown down. This in turn will reduce the capacity of the vegetation to control erosion.

Examples of Possible Applications. A buffer zone where stumps are not to be grubbed can be identified on drawings and at the site to protect adjacent standing timber. Buffer zones would encompass the root zones of standing timber or extend a minimum of 2 m from the base of a tree.

4.1.4 Roadbuilding.

RECOMMENDATION 404. To control erosion from access roads:

i) where possible buffer zones should be provided between access roads and water bodies,

ii) road grades and ditches should be designed to limit the potential for erosion.

Rationale. Access roads are not as amenable to erosion control as other areas of the construction site. Because surface compaction reduces soil infiltration capacity and encourages runoff, there is a need to locate and construct roads in a manner that will minimize problems related to erosion.

Examples of Possible Applications. Although the location and construction of roads is constrained by site-specific features, the following practices are suggested for implementation where it is practical to do so.

i) Where roads must be constructed close to a water body a non-erodable surface such as paving can be used. Where roads are not otherwise protected a buffer strip of at least 100 m can be provided between a road and a water body (17).

ii) Avoidance of access road grades exceeding 10 percent to 12 percent will, under normal circumstances, reduce the potential for erosion (17, 19).

iii) Where access roads are close to water bodies, grades not exceeding 5 percent will reduce the potential for erosion (17).

iv) Where slopes on access roads exceed 50 m in length a shallow berm can be laid across the road to direct longitudinal flow into roadside swales (19).

4.1.5 Stripping, Grading and Excavation.

RECOMMENDATION 405. To minimize erosion on areas that have been stripped, graded or excavated:

i) the extent and duration of exposure of these areas should be kept to a minimum;

ii) where practicable, topsoil from stripped areas should be segregated and conserved for subsequent application to areas requiring vegetation;

iii) all exposed areas and particularly slopes should be developed as soon as practically possible in accordance with accepted procedures for erosion control.

Rationale. Areas that have been stripped of topsoil and the associated vegetative mats of roots, etc., are generally the areas most sensitive to erosion. Timely and effective measures to protect these areas are essential to an overall erosion and sedimentation control program, and can eliminate the need for costly and time-consuming remedial measures for severely eroded areas.

Examples of Possible Applications.

i) The extent and duration of exposure of stripped, graded or excavated areas can be minimized by phasing construction activities. Although this may entail higher mobilization costs for earthmoving equipment, costs may be reduced by eliminating the need to handle the same material twice. For example, as an alternative to stockpiling topsoil, the topsoil removed from one area can be respread immediately on another area that is ready for final contouring (19).

ii) The application of topsoil to finished contours to allow revegetation, is fundamental to many long-term erosion control programs (17, 19, 22, 23, 24). If topsoil is segregated during stripping operations it may be spread directly on other areas ready for final contouring or stockpiled for later use. However, storage of topsoil for long periods of time can impair its properties, as can overhandling and compaction.

iii) The erosion control measures appropriate for any site will depend on whether temporary or permanent protection is required, the erosion potential of the site, climatic conditions, availability of materials and cost. The erosion potential of the site is a function of the slope gradients, slope lengths and the erodibility class of the soils (20). Erosion control measures should take these factors into account. Examples (iv), (v) and (vi) describe various erosion control measures. Some combination of these measures can be employed to protect areas which have been stripped, graded or excavated.

iv) Where surfaces must remain exposed, temporary control of erosion can be achieved by controlling runoff. This can be achieved in the following ways.

  a) Reduction of slope gradients will reduce erosion by reducing runoff velocity (20).
  b) Constructing terraces or benches reduces runoff velocity by reducing the effective slope length (20).
  c) Diversion ditches or berms can redirect water away from highly erodible soils and steep slopes (20).
  d) Roughening or cultivation of soil increases its permeability, decreasing runoff (19). Runoff velocity is also decreased (20).
  e) Cultivation along contour lines or "tracking" by a bulldozer creates ridges perpendicular to the slope which act as diversion channels and also impound water (19, 25).

v) Long-term erosion control can be achieved by protecting exposed surfaces. The following are examples of vegetative protection (20).

  a) Seeding of annual or perennial plants such as grasses or legumes is effective in the long term although protection is not immediate.
  b) Mulching is the application of organic material or other substances to the soil surface. Mulching provides immediate protection and is effective in the short and long term.

c) Hydroseeding refers to the spraying of seed, fertilizer, mulch, soil adhesives and water in one application. It is advantageous where steep or rocky slopes make protection by other methods difficult.

d) Sodding is advantageous where complete vegetative protection must be established immediately. It is generally much more expensive than seeding.

vi) The following are examples of non-vegetative methods of achieving long-term erosion control (20).

a) Rip-rap is a protective soil cover made up of large, loose angular stones.

b) Aggregate cover is the direct application of crushed stone or gravel to the soil surface.

c) Chemical stabilization is the use of chemicals which change the properties of the soil surface, generally by aggregating the finer soil particles. Chemical stabilization may be used alone or as temporary protection while vegetative cover is developing.

d) Nets and matting may be used separately or in conjunction with mulches and/or developing vegetation. Nets may be applied to steep slopes and stapled in place.

e) A layer of geofabric may be held in place by a layer of crushed or natural rock.

4.1.6 Surface Drainage Management

RECOMMENDATION 406. To control site surface drainage and the associated erosion and sedimentation:

i) Prior to construction, a site erosion and sediment control plan should be prepared by trained and experienced personnel in consultation with appropriate agencies.

ii) Site drainage should be diverted from cleared, graded, or excavated areas.

iii) All runoff from erodible areas should be directed to a siltation basin(s) prior to discharge to a watercourse.

iv) Where possible, site drainage facilities and siltation basins should be in place and operational before other site construction activity begins.

v) The sizing and design of siltation facilities (including chemical addition if necessary) should be such that:

a) the facility will contain the accumulated precipitation of a 20-year return period, 24-hour precipitation event for each year that the drainage area *remains exposed to erosion, up to a maximum of the precipitation from a 100-year return period event, and*

b) *the quality of the effluent from the siltation basins does not exceed 25 mg/L suspended solids (based on average weekly composite samples) and does not adversely affect local fish populations or their habitat.*

Rationale. Measures to protect areas that have been cleared, graded or excavated will minimize but not eliminate erosion and sedimentation. Effective control of erosion and sedimentation requires a comprehensive program for the entire site which combines protection of vulnerable areas, control of stormwater and treatment of silt-laden runoff.

Examples of Possible Applications. Potential candidates for inclusion in an erosion and sediment control plan are the following (17):

a) location of critical features such as streams and groundwater recharge zones, soil types, topography, water table, and vegetative cover types;
b) areas where ground cover will be altered;
c) sites for borrow pits, material stockpiles and spoil areas;
d) location of temporary and permanent stream crossings and areas where stream modifications such as straightening will be carried out;
e) location of erosion and sediment control structures, along with pertinent design information and a description of areas to be stabilized;
f) location of monitoring stations;
g) procedures for maintenance of erosion and sediment control structures including plans for the disposal of materials from such structures;
h) land drainage maps;
i) maps of streams to indicate pattern and speed of channel migration; and
j) scheduling for terrain disturbance and rehabilitation measures, e.g., terrain is disturbed only when construction is to proceed at stream crossings, etc. Rehabilitation measures are taken immediately after the construction work has been completed.

With such a plan, drainage ditches and siltation basins can be incorporated during the earliest stages of construction so that they are effective in controlling siltation resulting from all subsequent activity. Siltation ponds are designed to retain runoff for a period sufficient to allow sediment to settle out. If adequate retention time is provided, the decanted water will generally meet the 25 mg/L suspended solids discharge criterion and will not affect local fish populations. Where necessary, appropriate chemicals may be added to the basin to promote settling of the solids and improve the quality of the water discharged. The size of the siltation basin will also be determined by the volume of runoff that must be contained. The sizing of the basin for a one-in-20-years, 24-hour precipitation event for each year that the drainage area remains exposed to erosion means that, if the area is to remain exposed for two years, the siltation facility would be sized for a one-in-40-year event. The maximum size of a facility would be based on a one-in-100-year event, which is consistent with containment sizing recommended in the Design Phase Code of Practice for Steam Electric Power Generation (1) for permanent facilities.

4.1.7 Dredging and in-water construction.

RECOMMENDATION 407. To minimize sedimentation and impairment of water quality:

i) the duration of dredging and in-water construction should be kept to a minimum;

ii) dredging and construction methods and associated mitigation measures should be selected to minimize the mixing of bottom sediments and fill materials with the water column;

iii) tunneling rather than cut and cover methods should be used for offshore intakes and discharges, where practicable;

iv) at on-shore dredge spoil disposal areas and in areas where the shoreline will be altered, mitigative measures should be taken prior to construction and as quickly as possible during construction; and

v) at stream crossings the timing, duration, and methods of construction, and design of structures should be selected to minimize the suspension of sediments.

Rationale. Experience with in-water construction of pipeline stream crossings has indicated that grain size and settling time are as important as suspended sediment levels in their effect on fish. The primary concern is the possibility that benthic organisms may be smothered, and this is best determined by considering the grain size and settling time of solids input, duration and time of year, and total sediment load (15). Effects can be minimized by limiting the duration of in-water activities and by taking other precautions to prevent unnecessary disturbance of sediments when working in water (15, 17).

The wide range of dredging and in-water construction practices have a corresponding range of severity of disturbance of bottom sediments. Careful selection of dredging and in-water construction practices represents an opportunity to control sedimentation. On-shore dredged spoil disposal areas and areas where the shoreline has been changed are particularly susceptible to erosion.

Examples of Possible Applications.

i) Methods that have been recommended for minimizing the duration of in-water construction during the laying of pipe in a trench include the following (17).

   a) assembly of all materials and equipment on shore before any excavation begins;
   b) installation of pipe immediately after the trench has been excavated; and
   c) termination of land excavations at least 5 to 15 m from water crossings, leaving an adequate plug of undisturbed material at each bank. Plugs can be left in place to contain sediment until the excavation in the streambed is completed and only removed when absolutely necessary. The disturbed stream bank is stabilized upon completion of local construction.

ii) In the construction of offshore intake and discharge structures, tunneling is recommended as an alternative to burying a pipe by the cut-and-cover method. Tunneling physically isolates the construction activity from the watercourse, eliminating the disturbance of bottom sediments which would be experienced with the cut and cover method. At one site, tunneling was found to be not only environmentally more appropriate but also much less expensive than the cut-and-over method (26).

iii) In reclaiming shoreline areas it may be preferrable to dyke the perimeter of the area to be reclaimed before adding fill (10, 27). The exposed surfaces of dykes can be constructed of clean rock fragments that will not cause sedimentation problems and will limit contact between the water body and the finer fill materials within the dyke. At one site an area was reclaimed by first dyking and then dewatering. In addition to being environmentally preferrable to unconfined dumping of fill, this was operationally preferrable because it allowed use of dry construction techniques (26).

iv) Where significant disturbance of the bottom sediments is inevitable, silt curtains or covered clam shells may be used to limit the spread of sediments (10, 27). A silt curtain can be formed by suspending material between the water surface and the bottom to create an enclosure within which the water column is relatively still. A cover on a clam shell is used to prevent water from washing sediments through the clam shell bucket while it is being raised. In waters affected by tides, dredging at certain periods of the tidal cycle may reduce sediment exchange in the water column.

v) Where pipes must be laid in a trench, excavated material should be placed to one side of the trench and used as backfill. Unless the sediments are contaminated and require special handling they should not be brought to the surface and used for backfill because this will increase mixing of sediments in the water column (27).

vi) For fine-grained sediments mechanical dredging is preferrable to hydraulic dredging because it minimizes contact between sediments and water. Mechanically dredged spoils are more readily dewatered in on-shore disposal areas and the disposal areas are more readily reclaimed than is the case with hydraulically dredged spoils (27).

vii) Open water disposal of dredged spoils is regulated by the Canadian Environmental Protection Act (Part VI, Ocean Dumping) (28), Navigable Waters Protection Act, and Fisheries Act, and by provincial legislation. Also, under the Federal Environmental Assessment and Review Process (EARP) the potential effects of any proposed dredged spoil disposal must be addressed. On-shore disposal of spoils may be advantageous because it allows a high degree of separation of sediment and water. Potential disadvantages of on-shore disposal are possible increased leaching of contaminants in an aerobic environment, and the costs of constructing and maintaining a confined disposal area. The separation of sediment and water can be accomplished during on-shore disposal by discharging spoils into a settling basin from which clarified supernatant is discharged. It may be necessary to add chemical coagulants to meet supernatant quality objectives. It has been suggested that the best use of a site's initial settling capacity will be made by dredging the poorest quality material first and capping it with better quality material. This practice will also minimize the need for a covering layer of clean fill to prevent biological uptake in plants and contaminant losses through surface erosion (27). As an alternative to discharge of clarified supernatant, water may be discharged from the spoil containment area by allowing it to pass through a porous dyke which will retain sediment particles.

viii) The following practices will help to protect on-shore spoil disposal areas from erosion.

   a) Surface runoff from adjacent land can be diverted around spoil disposal areas.

   b) Spoil can be dewatered to a physically stable state. If necessary, stabilizing agents can be mixed with the spoil or the area can be capped with more stable material.

   c) Spoil disposal areas can be revegetated or otherwise provided with an erosion resistant surface.

ix) Stream crossing will generally involve fording, bridging, or culvert construction. Disturbance to sediments can be minimized by selecting the most appropriate method for the specific circumstances. For each method opportunities exist to minimize impacts.

   a) Repeated fording can be confined to one location equipped with an armoured ford (16). An armoured ford can be created by lining a stream or river bottom with rock or other material to prevent the disturbance of sediments by vehicles using the ford.
   b) The use of instream or nearstream substructures in bridge designs can be minimized (16).
   c) Culverts can be designed to minimize upstream and downstream effects by incorporating adequate inlet and outlet erosion protection, wherever necessary, and including energy dissipation measures to prevent increased downstream velocities. The invert elevation should provide a sufficient depth of water for the passage of fish at low flows while avoiding backwater effects at peak flows. The culvert diameter should accommodate anticipated discharge fluctuations, including those resulting from ice damming or other blockages (16).

x) Stream crossings can normally be completed with least disruption during the low streamflow (usually summer) period (16).

xi) The use of heavy equipment on stream beds or banks can be minimized (16).

xii) Rechannelling of watercourses (flow diversion) can be minimized (16).

4.2 Wastewater Discharges and Spills

Many of the activities for a large project such as a steam electric power station will generate wastewaters. These include aggregate washing, equipment cleaning and washdown, and metal cleaning. Domestic wastewaters will also be produced within the construction camp. Also, power plant process wastewaters are produced during commissioning, which is addressed here as part of the construction phase.

In addition to the routine discharge of wastewaters, contaminants may be discharged as a result of spills. Materials used and stored on-site during construction and which could be spilled include:

- fuel oil used to power stationary and mobile equipment and for firing or startup of oil or coal-fired boilers;
- gasoline used to power mobile equipment;

- lubricating oil used in stationary and mobile equipment, including waste oil from equipment maintenance;
- hydraulic oil used in mobile equipment;
- various solvents and degreasing agents used in equipment cleaning and maintenance, paint thinning and laboratory work;
- acids and alkalis used in metal cleaning and surface preparation, in construction boilers and their water treatment plants; and
- brine, various amines and polyelectrolytes used in construction boilers and their water treatment plants.

Materials discharged in wastewaters, or as a result of spills, may be toxic to fish or other aquatic organisms, or they may impair the quality of surface water for other uses such as domestic water supply, industrial use, animal watering, irrigation or recreation. Section 36 of the Federal Fisheries Act (formerly section 33), prohibits or limits the deposit, or actions permitting the deposit of deleterious substances in water frequented by fish (29). Spilled material may also contaminate soil and groundwater.

The following recommendations relate to the control of wastewater discharges and spills.

4.2.1 Wastewater minimization.

RECOMMENDATION 408. Wherever practicable, water use should be minimized and wastewater should be reused and recycled to minimize wastewater production.

Rationale. Reduction of water use, and wastewater reuse and recycling are normally the first and least costly steps in a program to control wastewater discharges. Smaller volumes of wastewater can be treated more easily in on-site facilities, or shipped for off-site treatment.

Examples of Possible Applications.

i) Water use can be reduced by using high-pressure, low-volume jets for equipment washing, and automatic shutoff valves on equipment washing hoses.

ii) Wastewater may in some cases be recycled after receiving minimal treatment. For example, recycled sedimentation pond water may be used for dust control sprays (26).

iii) Wastewater can be "cascaded", i.e., reused in processes that have progressively lower water quality requirements.

4.2.2 Wastewater treatment.

RECOMMENDATION 409.

i) *All wastewaters, including process and commissioning wastewaters, and wastewaters resulting from aggregate washing, equipment cleaning and washdown, and metal cleaning should not exceed the following effluent quality criteria prior to discharge to cooling water, to a municipal sewer, or to a receiving water:*

Parameters and Elements	*Recommended Effluent Quality*
pH	*6.5 to 9.5*
Iron (total)	*≤ 1.0 mg/L*
Chromium (total)	*≤ 0.5 mg/L*
Chromium (hexavalent)	*≤ 0.05 mg/L*
Copper (total)	*≤ 0.5 mg/L*
Nickel (total)	*≤ 0.5 mg/L*
Zinc (total)	*≤ 0.5 mg/L*
Total Suspended Solids (TSS)	*≤ 25.0 mg/L*
Oil and Grease	*≤ 15.0 mg/L*
Total Residual Chlorine (TRC)	*≤ 0.2 mg/L*

Notes: 1) *Metal concentrations are for total dissolved and undissolved solids.*
2) *Values apply to average weekly composite samples.*

ii) *Sanitary wastewaters should be given secondary biological treatment prior to discharge or should be directed to a municipal sewage treatment system.*

iii) *Hazardous wastewaters which cannot be treated in on-site facilities should be treated off-site at a licensed disposal facility.*

Rationale. The startup and commissioning stages of power plant construction may be times of particularly high wastewater pollutant loading because of a high level of equipment cleaning and surface preparation, more frequent plant upsets, lack of experience with plant systems, lack of opportunity to implement wastewater minimization programs, and poorly installed equipment. It is therefore particularly important that wastewater discharges be controlled at this time.

Generally, technologies capable of achieving the recommended limits have been demonstrated, or have been judged to be technically feasible. Although limits for all parameters and elements of environmental concern have not been prescribed, it is believed that the application of operating practices and technologies to meet the specified effluent quality criteria will also reduce other contaminants of concern. Other contaminants of environmental concern may also be specified on a site-specific basis (e.g., arsenic, boron, selenium, mercury, etc.).

Examples of Possible Applications.

i) As recommended in the Design Phase Code of Practice, wastewaters discharged from new steam electric power plants should not exceed the above criteria for pH, total suspended solids and various metals, and secondary biological treatment should be provided for sanitary wastewaters (1). For most fossil-fuelled plants this will mean that treatment facilities will be specified at the design phase for wastewaters routinely produced during operation of the plant. These facilities may be installed and operated early in the construction phase. At fossil-fuelled plants, systems designed to treat normal operational wastewaters should be capable of providing adequate treatment for most construction phase wastewaters. This may not be true for nuclear stations because much of the wastewater produced during normal operations (which may be radioactive) will be different from construction phase wastewater (with the exception of domestic sewage, some commissioning wastewaters, boiler blowdown, and boiler feedwater systems wastewater). Treatment of some construction phase wastewaters may require separate treatment systems or the wastewaters may have to be treated off-site. For example, at one station commissioning wastewaters composed mainly of fluorescein dye and hydrazine/ammonia were treated in a two-lagoon treatment system prior to discharge (26). Spent pickling fluids at this and other nuclear generating stations were taken away by a licenced disposal firm (26).

ii) The domestic sewage treatment system may require a much higher capacity during the construction phase than that needed during the operations phase because of the large numbers of workers on-site. One approach to this problem has been to use a modular biological treatment system (26). During the operations phase the number of modules used can be reduced because of the lower loads on the system.

iii) At one station a biodegradable solvent was chosen for degreasing operations. Degreasing waste was stored in a lagoon and was pumped at a controlled rate into a sewage treatment system (26).

4.2.3 Spill Control Planning and Procedures.

RECOMMENDATION 410. Site management should designate a person or persons who will be responsible for ensuring that oil, fuel and chemicals used or stored on the site do not contaminate the environment. Responsibilities should include:

i) developing procedures for the handling and storage of oil, fuel and chemicals on the site;
ii) developing a detailed spill response plan;
iii) maintaining awareness among contractors that adherence to spill control procedures is a condition of employment at the site;
vi) routinely inspecting oil, fuel and chemical handling and storage facilities and contractor's equipment, and checking adherence to spill and leak control procedures;
v) training personnel in response to a spill;
vi) maintaining access to up-to-date equipment for dealing with spills; and
vii) acting as the first point of contact in the event of a leak or spill.

Rationale. The potential for spills or leaks of oil, fuel or chemicals may be particularly high during construction because:

i) work may be performed by a large number of separate contractors and subcontractors whose primary responsibilities are not in environmental control;
ii) it may be economically more attractive for a contractor to add lubricating or hydraulic oil to leaking, poorly maintained equipment than to repair the equipment;
iii) fuel, oil and chemicals may be stored in many small containers dispersed throughout the construction site, and these containers may not be built to the same standards as permanent storage facilities, or equipped with instrumentation that would signal a spill or leak;
iv) contractor's personnel may not be properly trained in the storage, handling and disposal of fuels, oils and chemicals.

When spills or leaks do occur, contractor's personnel may not have the equipment or training to respond in an environmentally appropriate manner. The assignment of specific responsibility for spill control resolves many of the above problems.

Examples of Possible Applications.

i) Firefighting and occupational health and safety personnel may have expertise relating to spill control and may be candidates for spill control responsibilities.

ii) Contractor's responsibilities regarding spill and leak control can be identified in the tendering and contract documents (See Recommendation 426).

iii) Designated persons with spill control responsibilities reporting to the site construction manager could help to ensure compliance with spill control procedures.

iv) Well developed spill response procedures and trained personnel will facilitate prompt and appropriate action in the event of a spill.

v) Where equipment for dealing with spills cannot be maintained on-site, a knowledge of the location and capabilities of off-site spill control equipment or services will facilitate access during emergencies.

4.2.4 Oil, Fuel and Chemical Storage.

RECOMMENDATION 411. Specific sites should be designated for the bulk storage and transfer of oil, fuel and chemicals. These areas should be:

i) located on material of low permeability (high clay content soil, asphalt or concrete);

ii) constructed to contain the maximum probable spill;

iii) located so as to minimize the possibility that a spill could under any circumstances enter a watercourse; and

iv) protected from physical damage.

Rationale. Proper provisions for the bulk storage and transfer of oil, fuel and chemicals are needed to prevent the discharge of these materials into the environment under normal circumstances and during an emergency.

Examples of Possible Applications.

i) The permeability specified in the Design Phase Code for material between oil storage facilities and groundwater is equivalent to a 1-metre thickness of 1×10^{-5} cm/s material (1). Naturally occurring soils of equivalent or lower permeability can be found in many regions of Canada .

ii) Provincial regulations governing the storage of oil generally specify minimum containment volumes for dyked areas. For other materials in storage, determining the maximum probable spill will require a site-specific assessment. As a general guide it is suggested that dykes or other containment facilities be sized according to the National Fire Code of Canada criterion, which states that: "the diked area shall be of sufficient size to contain a volume of liquid at least equal to the volume of the largest tank plus 10 per cent of the aggregate volume of all the other tanks, or 10 per cent greater than the volume of the largest tank, whichever is greater" (30).

iii) Drums containing oil, fuel, or chemicals can be stored on metal gratings underlain by metal catch trays and sheltered from precipitation (24). This will provide containment for spills occurring during transfer to or from the containers, or resulting from leaking containers. Such facilities are inexpensive and can be relocated as necessary.

iv) Provisions can be made for the controlled regular discharge of rainwater from dykes or other containments. Rainwater should be sampled prior to discharge to ensure that it is not contaminated.

4.2.5 Refuelling.

RECOMMENDATION 412. Refuelling of equipment should be conducted in a manner that will minimize the possibility of a spill entering a watercourse.

Rationale. In many cases it is impractical to refuel equipment at a site designated and properly designed for the storage and transfer of fuel. In these cases the equipment is refuelled where it sits and special precautions are necessary to prevent the entry of any spilled fuel into a watercourse.

Examples of Possible Applications.

i) Equipment operating in or near a watercourse can be moved as far away from the watercourse as possible prior to refueling.

ii) Where it is necessary to refuel equipment in or near a watercourse, provisions can be made to contain possible spills, e.g., drip trays on equipment platforms and oil booms to contain floating oil.

4.3 Waste Containment and Disposal

Wastes produced, contained and disposed of on the construction site may include:

- slash and stumps from clearing and grubbing;
- dredged spoil;
- waste construction material such as forms, concrete, pipe, wire, paint cans and crating materials;

- waste from equipment maintenance activities such as scrap metal, oil rags, empty drums of chemicals, lubricants, etc.;
- process wastewaters, and water and wastewater treatment sludges from startup and commissioning;
- domestic garbage;
- coal ash;
- ash and residues from burning of combustible wastes;
- absorbents used to clean up spills; and
- waste batches of concrete.

Environmental concerns associated with containment and disposal of these wastes include the effect of seepage and leachates on groundwater and surface waters, long-term land use and reclamation implications, aesthetics, odour and pests.

4.3.1 Management of Solid Wastes

RECOMMENDATION 413. Solid wastes other than dredge spoils and clean fill used for shoreline reclamation should not be placed in a water body and should be prevented from coming into contact with a water body.

Rationale. Slash and debris from clearing and grubbing may clog a water body, interfere with aquatic organisms or impair the shoreline. Decaying debris contributes to biochemical oxygen demand (BOD) in the water body. Other solid wastes may release chemical contaminants upon contact with the water. Relatively inert wastes such as rock or broken concrete may interfere with benthic organisms or create undesirable fish habitat if placed in inappropriate locations.

Examples of Possible Applications.

i) In locating solid waste storage sites, flood plains and locations where wastes may be washed into a water body can be avoided.

ii) All solid wastes can be placed in disposal sites that are located, constructed, and operated in a manner that minimizes environmental degradation.

4.3.2 Location and construction of disposal sites.

RECOMMENDATION 414. In locating and constructing solid waste disposal sites it should be ensured that:

i) the location of solid waste disposal sites is clearly identified on the site plan;

ii) *solid waste storage and disposal areas are located a minimum of 100 metres from a watercourse unless measures are taken to provide an equivalent degree of protection to the watercourse;*

iii) *site drainage is diverted around the landfill area;*

iv) *the sites are hidden from view by fences, earth berms, or buffer zones of dense trees between the landfill sites and adjacent roads, trails or watercourses; and*

v) *consideration is given to beneficial uses of the site after closure.*

Rationale. Incorporation of solid waste disposal into the site plan is a first step in ensuring comprehensive and effective management of solid waste disposal. The identification of disposal sites on the site plan also provides an historical record of sites which could be of value if remedial work were later required. Separation of disposal sites from water courses and diversion of runoff will reduce the probability of contamination of water by seepage or runoff from the disposal site. Earth berms and buffer zones of vegetation will further reduce the probability of runoff contaminating the watercourse, and will provide an aesthetically desirable visual screening between the disposal site and the surrounding area. Early consideration of the final use of the site will facilitate ultimate reclamation.

Examples of Possible Applications. An "equivalent degree of protection" for sites located less than 100 m from a watercourse depends on site-specific considerations. Measures can be provided to increase protection of the watercourse from surface runoff, seepage, and windblown debris. These may include more extensive use of drainage diversion ditches or berms, more stringent seepage control, and more effective wind breaks.

4.3.3 Seepage Control Criteria.

RECOMMENDATION 415. Solid waste disposal or storage, and wastewater treatment and containment facilities should be constructed with seepage control barriers that meet the following minimum conditions with respect to material thickness and maximum water permeability, measured over the entire depth from the bottom of the disposal or containment site to the aquifer.

i) *The equivalent of 1 m of 1×10^{-7} cm/s material for wastewaters from construction, startup and commissioning, and sludges from water and wastewater treatment.*

ii) *The equivalent of 1 m of 5×10^{-7} cm/s material for:*

   a) *dredged spoil not suitable for open water disposal,*

   b) *ash and flue gas desulphurization (FGD) waste lagoons.*

iii) The equivalent of 1 m of 1 x 10^{-6} cm/s material for:

a) dry or dewatered ash disposal sites,*

b) dry or dewatered flue gas desulphurization waste disposal sites.

iv) The equivalent of 1 m of 1 x 10^{-5} cm/s for:

a) domestic refuse,

b) other solid construction wastes.

v) No specific permeability criteria for:

a) inert material,

b) spoil material from grubbing, stripping and excavation.

Rationale. The contamination of groundwater aquifers by seepage and leachate from waste disposal and containment sites is reduced by the presence of seepage control barriers between the sites and aquifers. Seepage control criteria depend, in part, on the environmental concern associated with the material in the site.

Examples of Possible Applications.

i) The Design Phase Code of Practice recommends seepage control criteria for material underlying disposal or containment areas for various wastes (1). Waste disposal or containment sites meeting these criteria can be constructed and operational in time to be used for construction phase wastes.

ii) Some provincial requirements for the landfilling of industrial wastes contain more stringent criteria for seepage control (31).

iii) A hydrogeological study will indicate whether naturally occurring surficial deposits meet the permeability criteria. If not, imported clay or synthetic liners can be constructed.

iv) Uncontaminated dredge spoils are often disposed of in open water but can also be placed on shore for use as construction fill in a manner similar to that used for earth fill or other excavated material. However, if contaminated dredge spoils are placed on shore, leaching of the contaminants to groundwater is a concern. The seepage control criteria recommended here are intended as baseline measures to mitigate potential effects of leachate from contaminated dredge spoils on groundwater. Depending on the site and the severity of contamination, more stringent criteria for disposal may apply.

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* Seepage control recommendations for coal mine disposal of ashes are deferred. "Ash" includes combustion wastes from conventional boilers, fluidized bed combustors, and other combustion devices.

v) Sludges from water and wastewater treatment include lime softener sludges from water treatment, and chemical precipitation sludges from treatment of preoperational cleaning wastewaters and process wastewaters.

vi) Wastewater containment and treatment facilities which require seepage control provisions include lagoons for preoperational cleaning wastewater, process wastewaters, and for domestic sewage.

4.3.4 Management of Disposal Sites.

RECOMMENDATION 416. The following practices should be adopted for the management of solid waste disposal sites:

i) Liquid wastes, and hazardous wastes should be disposed of only in facilities specifically designed, approved, and licensed for that purpose.

ii) Solid wastes should be segregated before and during landfilling and recycling practiced where practicable.

iii) Landfill sites should be developed in modules or cells which are compacted and covered when full, and contoured and capped to minimize infiltration.

Rationale. The above practices will minimize the volume of disposal sites and the potential for adverse effects on the surrounding environment.

Examples of Possible Applications.

i) Liquid or hazardous wastes may be recycled, treated in on-site treatment systems, or shipped for off-site disposal at an approved and licensed facility. If on-site facilities are to be used for the disposal of hazardous wastes, they will generally be required to meet more stringent design criteria than facilities discussed in this document.

ii) Scrap metals (steel, iron, copper, aluminum, etc.) from construction sites can be sold and recycled.

iii) Segregation of wastes and landfilling of similar wastes in distinct areas will facilitate future cleanup and restoration of sites if necessary.

iv) The segregation of domestic wastes from other wastes will discourage rodents.

v) Wood from clearing operations can be marketed or made available for firewood.

vi) Where local regulations permit, slash and stumps from site clearing and grubbing can be burned to reduce volumes of solid waste.

vii) Topsoil removed during construction of the disposal site can be stockpiled and used for covering and contouring of cells.

RECOMMENDATION 417. Waste disposal sites should be managed in such a manner that:

i) access to solid waste landfill sites is controlled and all disposal activities are supervised by personnel familiar with proper waste disposal procedures;

ii) records are kept of the types and approximate amounts of wastes disposed of;

iii) wildlife, birds, rodents, and pests are kept out of solid waste disposal sites or otherwise controlled; and

iv) drainage from disposal sites is monitored and treated where appropriate.

Rationale. Control of access to disposal sites will eliminate inadvertent disposal of inappropriate materials and permit reliable records to be kept of the materials disposed of. Such records will facilitate any future cleanup and restoration of sites or provide evidence that site cleanup is not required. Pests, if uncontrolled, can lead to problems both on- and off-site. Monitoring will indicate any developing problems with disposal site operation.

Examples of Possible Applications.

i) Disposal sites can be fenced off from other construction areas and from public access, and gates controlled or locked at all times.

ii) Personnel can be assigned to maintain records of wastes disposed of. Records should include the location and content of completed sections of the disposal site on the site plan.

iii) Pests can be discouraged by regular covering of domestic refuse.

iv) Covering and contouring of the disposal site can reduce the contact between waste and site drainage, reducing treatment needs. Drainage can be collected in perimeter ditches.

4.4 Air Pollution Control

Air pollution concerns associated with construction include:

- particulate emissions from the burning of slash during clearing activities;
- dust from vehicle traffic;
- dust from drilling, blasting and excavating;
- dusting from coal piles and coal transfer facilities;
- dust from coal ash disposal activities;

- odours from domestic garbage;
- vehicle emissions; and
- emissions from construction boilers, diesel generators, etc.

Power plant stack emissions of particulates, nitrogen oxides and sulphur dioxide are covered in the Federal Clean Air Act Guidelines (3) and various provincial regulations, and are not addressed here.

Environmental concerns relating to these emissions include nuisance or health effects on neighbouring communities, the health of site workers, and effects on local vegetation and the aquatic environment.

4.4.1 Dust.

RECOMMENDATION 418. All reasonable measures should be taken to control fugitive dust from:

i) vehicle traffic in unpaved areas;
ii) drilling, blasting and excavating;
iii) coal transfer and storage facilities;
iv) coal ash handling and disposal facilities; and
v) other significant sources of fugitive dust.

Rationale. This recommendation calls for the control of the major sources of fugitive dust at a construction site. Appropriate measures may be selected on a site-specific basis from a range of measures available.

Examples of Possible Applications.

i) A general method for dust control is to preserve natural vegetation around the site to act as a wind break.
ii) Activities that generate large quantities of fugitive dust can be avoided during high winds.
iii) The following methods can be used for dust control on roads:
    a) Roads may be sprayed with water. An advantage to this technique is that it allows reuse of low quality wastewater such as sedimentation pond water and thus reduces wastewater discharge. However, water spraying may be a problem because it must be repeated frequently and may contribute to erosion.
    b) A variety of commercial products are available which can be mixed with water to improve dust suppressing performance.

c) If the site is developed according to a long-range site plan, main roads may be paved early in the construction phase.

iv) Dust generated during rock drilling can be suppressed by sprays of water or water-based mixtures (32). Dust can be suppressed during blasting by using shock absorbing covering mats.

v) Coal transfer and storage facilities normally employ a variety of measures to suppress or collect dust during the operation phase. Measures for coal dust suppression and collection at transfer and storage facilities include (33):

a) application of water sprays, oil or oil emulsion sprays or surface crusting agents to coal piles;
b) application of water sprays or other dust suppressants during stacking or reclaiming;
c) enclosure of transfer points on coal conveyors;
d) collection and filtering or scrubbing of air from enclosed coal conveyors and transfer points;
e) wind guards on non-enclosed conveyors;
f) minimization of the height of coal drop during stacking; and
g) contouring of the pile.

Although practices and facilities at individual sites may vary, those practices and facilities selected for a site should be operational when coal is first delivered to the site.

vi) During coal ash handling and disposal, dust can be suppressed by adding a small amount of water (usually about 10 percent) to the ash as it exits the ash silos. At the ash disposal site water sprays, chemical dust suppressants, ash compaction, modular disposal techniques and covering of completed cells will minimize dusting. The site can be developed taking into account natural topography and wind exposure and by adding or leaving natural wind breaks, fences, trees, berms etc. Where the ash is handled dry, "dustless" unloaders at the discharge of ash silos and covered ash transport vehicles can be used.

vii) Air filtration systems have been used to collect dust from sandblasting operations during construction (26).

viii) Vegetated top soil has been applied to a "dead" coal storage pile for dust control.

ix) Covering ash disposal sites with artificial snow has been suggested as a method of dust control during winter.

4.4.2 Emissions From Combustion Sources.

RECOMMENDATION 419. The siting, design, operation, and maintenance of combustion sources of emissions should be managed to ensure compliance with federal, provincial, and local air emission and air quality requirements and to minimize on-site and off-site air pollution.

Rationale. Emissions can emanate from a large number of combustion sources on a site. Individually or collectively these may result in air pollution on- and off-site. Compliance with applicable requirements is a key step in mitigating these concerns. In addition, or where no applicable requirements exist, attention to siting, operation and maintenance of equipment will minimize air pollution.

Examples of Possible Applications.

i) Internal combustion equipment can be shut off when not required.

ii) Regular inspections and maintenance can be carried out on all combustion sources and associated emission control equipment.

iii) Possible on-site and off-site receptors of air emissions can be considered when siting stationary sources such as construction boilers, diesel generators, standby generators, etc.

iv) Where burning of domestic wastes and other combustible materials is permitted, possible on-site and off-site receptors of air emissions can be considered when siting facilities.

v) Air emissions from fossil-fuelled boilers for steam electric power generation are addressed in federal guidelines (3), and various provincial regulations.

4.4.3 Odours.

RECOMMENDATION 420. Domestic garbage pickup and disposal should be scheduled regularly so that garbage is sent off-site or buried on-site without causing nuisance odours.

Rationale. Domestic garbage generally contains discarded food, food wastes and wrappings. If improperly managed this material can produce odours which will be objectionable to adjacent communities and may attact undesirable animal pests.

Examples of Possible Applications.

i) Off-site disposal of domestic garbage be handled by a contractor.

ii) Domestic garbage disposed of in on-site landfills can be placed in cells that are covered promptly with fill materials.

4.5 Noise Control

Noise is produced during construction by equipment driven by internal combustion engines, pneumatic drills and impact equipment (pile drivers), blasting, traffic entering and leaving the construction area, and by steam blowing of piping. Noise may be a nuisance to communities adjacent to a construction site and may be a health hazard to site construction workers exposed to greater intensities of sound. Noise may disturb the normal activities of wildlife in the vicinity of construction.

Noise is defined here as unwanted sound. Sound is considered a contaminant and is regulated by environmental protection legislation in some provinces. Noise may also be regulated under municipal bylaws, or local regulations concerning construction practices or worker safety and health.

4.5.1 Intensity Limitations.

RECOMMENDATION 421. Measures should be taken to ensure that noise levels in residential areas adjacent to a construction site do not normally exceed:

Period	*Equivalent Sound Level (Leq), dBA*
Day (07:00 - 19:00)	*65*
Evening (19:00-23:00)	*60*
Night (23:00 - 07:00) and all day Sundays and Holidays	*55*

Rationale. Noise that is audible in adjacent residential areas will normally be maintained below disruptive levels. (Abnormal situations are addressed in Section 4.5.2). The noise level limitations in Recommendation 421 are based on noise criteria used by the Nova Scotia Department of the Environment (34). Criteria used in other jurisdictions may differ (35).

Examples of Possible Applications.

i) The equivalent sound level (Leq) is the value of the constant sound level that would result in exposure to the same total A-weighted energy as would the specified time varying sound, if the sound level persisted over an equal time interval (35). Standard procedures for assessing noise levels in adjacent communities are available (35). Appropriate instrumentation and trained personnel will be necessary. Computer modelling can be used before beginning construction to estimate noise levels in adjacent communities.

ii) If it is possible that new residences may be built closer to the plant boundary during the construction period, measures can be taken from the outset to control noise in all areas near the plant that are zoned residential. Total assurance could be gained by meeting the criteria at the plant fence.

iii) Internal combustion engines on construction equipment can be fitted with muffler systems designed and maintained to effectively reduce noise levels (10, 17, 24, 32). Some newer equipment has been designed to emit less noise (35).

iv) Noisy equipment may be located as far as practical from site boundaries or enclosed to suppress noise (10, 32).

v) Berms or other site features can be used to shield adjacent communities from noise.

vi) The routing and timing of transportation to and from the construction site can be planned to minimize traffic noise in adjacent communities (10, 17).

vii) Blasting or other sudden or loud noises can be avoided if wind or temperature inversions are likely to cause an increase in noise in adjacent residential areas or critical wildlife habitat (10, 17).

viii) Millisecond delays can be used to decrease the vibrations from blasting and the number of holes per shot can be limited using millisecond delays in series (10, 17).

4.5.2 Scheduling of Activities.

RECOMMENDATION 422. Wherever possible local residents should be informed of abnormal noise-causing construction activities, and these activities scheduled to cause minimum disruption.

Rationale. Unexpected noises from blasting, steam blows, and other activities may be of concern to local residents.

Examples of Possible Applications.

i) Particularly noisy activities such as blasting can be avoided during night time (10, 24, 26).

ii) Meetings with local residents can alleviate many concerns associated with unexpected noises.

4.6 Protection of Terrestrial and Aquatic Life

Many recommendations in this Code relate indirectly to protection of terrestrial and aquatic life, through measures which will protect terrestrial and aquatic environments. However, a large steam electric power construction project is likely to have very direct effects on terrestrial and aquatic life. For example, shock waves from underwater explosions can kill large numbers of fish. The following recommendations present practices that will reduce the direct effects of construction on terrestrial and aquatic life.

4.6.1 Terrestrial Life.

RECOMMENDATION 423. To protect wildlife during the construction phase:

i) activities should, where possible, be timed to avoid disturbing critical and sensitive wildlife migration and breeding activities;

ii) the use of firearms on-site should be prohibited except for approved predator control;

iii) procedures and devices used should not prevent normal migrations of wildlife and should not present an unnecessary risk to the life or the health of wildlife;

iv) disturbance to wetlands should be minimized by restricting access; and

v) disturbance to forested areas and hedgerows should be minimized and, wherever possible, trees should be left standing.

Rationale. Some disturbance of individuals within the wildlife population is inevitable during construction activities. However, disturbance during migration and breeding can have extensive and far-reaching implications and should be avoided. Because wetlands represent a productive but scarce habitat for many species, they are priority areas for preservation.

Examples of Possible Applications.

i) A wildlife survey of the site prior to construction will indicate wildlife species in the area that are sensitive to disturbance, and the times at which disturbance could be critical to these populations.

ii) Access roads can avoid wetlands.

4.6.2 Aquatic Life.

RECOMMENDATION 424. To protect aquatic life:

i) *wherever possible in-water construction including dredging should be scheduled to avoid periods of fish spawning, incubation and migration;*

ii) *modification to watercourses should not impede fish migration;*

iii) *the area around submerged intake structures should be cleared of spoil and debris and the original contours and substrates replaced;*

iv) *measures should be taken to avoid entraining fish in temporary water intakes;*

v) *before any blasting takes place in a water body, fisheries agencies should be consulted to evaluate and minimize the potential impact on fish and fish habitat;*

vi) *peak overpressures and rates of pressure change caused by underwater blasting should be controlled to reduce fish mortality;*

vii) *actual fish mortality resulting from underwater blasting should be monitored to confirm predictions and blasting practices should be modified if necessary.*

Rationale. Disturbances affecting spawning and migration can impair the viability of the affected population in the water body. The presence of spoil or bottom depressions around submerged intakes can create habitats that attract fish to the intake, increasing the chance of entrapment. Temporary water intakes for use during the construction period can entrain and destroy fish. Sudden pressure changes caused by blasting can be lethal to fish in the vicinity of the blast (27). The magnitude and rate of pressure change is influenced by a number of controllable factors.

Examples of Possible Applications.

i) The Federal Fisheries Act contains provisions for controlling disruptions to fish spawning areas and migration routes. A guide to the application of these provisions of the Act is contained in the "Policy for the Management of Fish Habitat", developed by the Federal Department of Fisheries and Oceans (36).

ii) Fish spawning periods have been successfully accommodated in the schedule for construction of offshore intake at a multi-unit nuclear generating station (26).

iii) Entrainment of fish in temporary water intakes can be avoided by use of fish screens on the intakes. When dewatering diked areas containing fish, fish pumps can be used to return fish to the watercourse without damage.

iv) A number of recommendations have been made regarding modifications to water courses that will not impede fish migration (17, 37, 38). Examples include:

a) bridge crossings as alternatives to culvert crossings (17),

b) blocking no more than one-third of the stream width during bridge or culvert construction (17, 38),

c) designing culverts to allow fish passage and avoiding drop falls at culvert outfalls (17, 37, 38).

v) While unwarranted underwater blasting is not encouraged, in certain instances there may be no alternative as a construction technique. Sections 32 and 35 (formerly sections 30 and 31) of the Federal Fisheries Act, and provincial fishery regulations made pursuant to the Fisheries Act, govern the use of explosives in water bodies and prescribe the manner in which fisheries agencies are to be notified of the intent to use explosives (39). Early notification of fisheries agencies will help to avoid delays in obtaining approval for blasting, pending the review of plans and development of mitigative measures. Other parties to be notified of intended underwater blasting could include the provincial environment and natural resources departments and the Federal Department of Transport.

vi) Since the rate of pressure change is determined by an explosive's characteristic detonation velocity, fish mortality can be influenced by the choice of explosive (27, 39).

vii) Peak overpressure from a blast is a function of the weight of explosive per delay period, the distance between the shot and the observation point, and site conditions (27, 39). Charges placed in a drilled hole lose most of their energy fracturing the rock and produce smaller pressure changes than unconfined charges (27, 39). Mortality from underwater explosions can be reduced by burying the charges as deep as possible in the substrate and detonating successive charges with sufficient time between firings to allow the shock wave to dissipate (10).

viii) Sequenced charges have been used for underwater blasting during the construction of a generating station (26). Monitoring during the blasting indicated that very few fish kills occurred (26).

4.7 Protection of Archeological and Historical Resources

RECOMMENDATION 425. To protect archeological or historical resources:

i) a survey of site archeological resources should be carried out prior to construction under the direction of a qualified archeologist/historian,

ii) *important archeological resources within or adjacent to the construction site should be identified and protected from damage from construction activity, and*

iii) *where an artifact or feature is encountered during construction, work in the area should be stopped until the find is brought to the attention of a qualified archeologist/historian.*

Rationale. Sites for steam electric power development may contain significant archeological and historical resources, either observable or hidden. The construction phase can represent the last opportunity to recover or document the presence of these resources before they are lost or destroyed. In some provinces, such as Alberta, powerful legislation exists, requiring that an assessment be performed of the impact of any development on these resources and that appropriate mitigative measures be taken (40). Areas of concern include potential damage to known archeological and historical resources, or the loss or destruction of resources uncovered during construction.

Examples of Possible Applications.

i) Areas identified as being of archeological or historical significance can be fenced and signs posted to exclude construction personnel and equipment.

ii) A qualified archeologist can be identified who may be consulted on finds of potential significance. By facilitating this process, time lost during construction will be minimized.

4.8 Construction Contracts

RECOMMENDATION 426. For steam electric power generation projects, adherence to appropriate environmental protection practices should be specified as a requirement in construction contracts.

Rationale. Implementation of effective environmental protection measures during the construction phase will depend on the active cooperation of each of the many contractors on the site, and their awareness of appropriate environmental protection practices.

Examples of Possible Applications.

i) Adherence to the Environmental Codes of Practice for Steam Electric Power Generation - Construction Phase (1989), and other environmental documents, can be included as requirements in construction contracts.

ii) The five-page "Summary of Recommendations" from this Code is a concise list of environmental protection practices. Appropriate sections of the summary can be appended as requirements in contract documents.

iii) Clearly stated environmental requirements will lessen the possibility of misunderstanding between construction managers, contractors, and regulatory agencies.

4.9 Environmental Audits

RECOMMENDATION 427. During the construction phase, periodic internal environmental audits should be conducted to ensure compliance with all applicable regulations, licences, permits, policies, procedures and practices, and to anticipate and prevent possible future liabilities and environmental problems.

Rationale. Internal environmental audits will help the utility to ensure that all environmental protection requirements are being followed, that management is informed, and that appropriate corrective action can be identified and taken if necessary.

Examples of Possible Applications.

i) Environmental audits are usually undertaken by an individual or team independent of the site operations, e.g., a consultant or a central corporate team.

ii) All applicable environmental requirements are identified, and appropriate site personnel contacted.

iii) The audit team visits the site, interviews appropriate personnel, inspects facilities, and witnesses selected operations.

iv) An audit report with recommendations is discussed with the site management.

v) The site manager normally undertakes appropriate follow-up action, based on the recommendations of the environmental audit report.

4.10 Monitoring and Reporting.

RECOMMENDATION 428. Relevant environmental monitoring data and information should be documented for each project, and reported as agreed with appropriate regulatory agencies.

Rationale. Although well established and accepted environmental protection practices exist for construction projects, relatively little data are available on the effectiveness of these measures. The monitoring and reporting of environmental data will facilitate evaluation of existing practices and development of improved mitigative measures. It will permit the validation of predictions made during the environmental assessment process concerning the impacts of construction activities, and focus attention of site personnel on environmental issues and protection practices during construction.

Examples of Possible Applications. Data to be included in a program of environmental monitoring and reporting will depend on the scale of the construction project and potential areas of impact. Potential candidates for inclusion are:

i) suspended sediment loadings in adjacent water bodies;
ii) effluent quality and discharge rates from sedimentation basins and wastewater treatment systems;
iii) groundwater, runoff, and leachate quality in the vicinity of solid waste disposal sites;
iv) groundwater levels and quality in adjacent domestic wells;
v) nearby wildlife populations and diversity;
vi) nearby aquatic life populations and diversity;
vii) chemical spill incidents;
viii) volumes and types of liquid and hazardous waste shipped off-site for disposal;
ix) types and approximate quantities of solid waste disposed of on-site;
x) noise levels in adjacent communities;
xi) fugitive dust deposition rates on-site and in nearby areas;
xii) air pollutant emission rates for regulated combustion sources; and
xiii) in-water blasting effects on fish.

The scope and frequency of reporting can be negotiated with the appropriate regulatory agency. Minimal, if any, additional monitoring and reporting is anticipated for minor construction projects. However, more extensive and frequent reporting may be appropriate for large, long-term steam electric power construction projects.

4.11 General Implications of Recommendations

The intent of recommendations 401 to 426 is to mitigate or eliminate adverse environmental impacts during the construction of new or modified steam electric power stations. The intent of recommendations 427 and 428 is to verify the performance of mitigative measures and to provide data upon which improved practices may be based. All recommendations are judged to be reasonable and practical environmental protection measures which can be taken during the construction phase.

5 SUMMARY OF RECOMMENDATIONS

A summary of the Construction Phase Code recommendations is presented in Table 5.0 and is intended to provide an overview for the reader. The full text of the recommendations, presented in Section 4, should be consulted for greater detail.

TABLE 5.0 SUMMARY OF RECOMMENDATIONS

NUMBER	SUBJECT	SUMMARY OF RECOMMENDATION	SECTION
401	**Erosion and Siltation Control** - Scheduling of Construction	Where practicable, restrict use of high-bearing pressure equipment when the terrain has low bearing capacity.	4.1.1
402	**Erosion and Siltation Control** - Clearing Practices	i) Minimize cleared area. ii) Leave buffer zones between cleared areas and water bodies wherever possible. iii) Minimize time between clearing and development.	4.1.2
403	**Erosion and Siltation Control** - Grubbing Practices	Avoid grubbing near standing timber.	4.1.3
404	**Erosion and Siltation Control** - Roadbuilding	i) Where possible provide buffer zones between roads and water bodies. ii) Design road grades and ditches to limit erosion.	4.1.4
405	**Erosion and Siltation Control** - Stripping, Grading and Excavation	In areas that have been stripped, graded or excavated: i) minimize the extent and duration of exposure, ii) where practicable save topsoil for use on revegetated areas, and iii) as soon as practically possible apply erosion control measures to exposed areas.	4.1.5
406	**Erosion and Siltation Control** - Surface Drainage Management	i) Prepare a site erosion and sediment control plan prior to construction. ii) Divert drainage from cleared areas. iii) Direct runoff from erodible areas to siltation basins prior to discharge. iv) Where possible make drainage facilities operational before other construction begins. v) Provide siltation facilities: a) to contain precipitation from a 1 in 20 year, 24-h storm for each year that the drainage area remains exposed (up to a maximum 1 in 100-year storm) b) to have effluent quality less than 25 mg/L TSS.	4.1.6
407	**Erosion and Siltation Control** - Dredging and In-Water Construction	For dredging and in-water construction: i) minimize duration of activity; ii) minimize mixing of sediments with water column; iii) where practicable use tunnelling, not cut and cover for offshore intakes and discharges; iv) protect against sedimentation of water body at on-shore dredge spoil disposal areas and shoreline alterations; and v) minimize the suspension of sediments at stream crossings.	4.1.7
408	**Wastewater Discharges and Spills** - Wastewater Minimization	Minimize water use and practice wastewater reuse and recycling where practicable.	4.2.1

TABLE 5.0 SUMMARY OF RECOMMENDATIONS (Cont'd)

NUMBER	SUBJECT	SUMMARY OF RECOMMENDATION	SECTION
409	**Wastewater Discharges and Spills** - Wastewater Treatment	i) Manage all wastewater discharges so as not to exceed the following criteria prior to release to cooling water, a municipal sewer or receiving water: pH 6.5 to 9.5 Fe 1.0 mg/L Cr, Cu, Ni, Zn 0.5 mg/L Cr (hexa) 0.05 mg/L TSS 25.0 mg/L Oil and Grease 15.0 mg/L TRC 0.2 mg/L ii) Provide secondary biological treatment for sanitary wastewaters. iii) Treat hazardous wastewaters at licensed off-site facilities if they cannot be treated on site.	4.2.2
410	**Wastewater Discharges and Spills** - Spill Control Planning and Procedures	Formally assign responsibility to designated person(s) to: i) develop procedures for handling and storage of oil, fuel and chemicals ii) develop a spill response plan, iii) ensure that contractors are aware of spill control procedures, iv) inspect facilities and check adherence to spill control procedures, v) train personnel in response to spills, vi) maintain access to equipment for dealing with spill, and vii) act as point of contact in case of a spill.	4.2.3
411	**Wastewater Discharges and Spills** - Oil, Fuel, and Chemical Storage	Sites designated for the bulk storage and transfer of oil, fuel and chemicals should be: i) located on low permeability material ii) constructed to contain spills, iii) located to minimize possibility of spills entering a watercourse, and iv) protected from physical damage.	4.2.4
412	**Wastewater Discharges and Spills** - Refuelling	Refuel equipment so that the possibility of spills entering a watercourse is minimized.	4.2.5
413	**Waste Containment and Disposal** - Management of Solid Wastes	Solid wastes should not be placed in or come into contact with a water body.	4.3.1
414	**Waste Containment and Disposal** - Location and Construction of Disposal Sites	In locating and constructing solid waste disposal sites ensure that: i) disposal site locations are identified on the site plan, ii) sites are at least 100 m from a watercourse unless equivalent protection is provided, iii) site drainage is diverted around the landfill, iv) sites are hidden from view from roads, trails and watercourses, and v) sites are suitable for beneficial uses after closure.	4.3.2

TABLE 5.0 SUMMARY OF RECOMMENDATIONS (Cont'd)

NUMBER	SUBJECT	SUMMARY OF RECOMMENDATION	SECTION
415	**Waste Containment and Disposal** - Seepage Control Criteria	Solid waste disposal or storage and waste-water treatment and containment facilities should have barriers between the bottom of the disposal site and the underlying aquifer with minimum flow resistance equivalent to material 1 metre thick having the following permeabilities: i) 1×10^{-7} cm/s for wastewaters and sludges from water and wastewater treatment; ii) 5×10^{-7} cm/s for land-disposed dredged spoil, and ash and FGD waste lagoons; iii) 1×10^{-6} cm/s for dry ash and dry FGD waste; iv) 1×10^{-5} cm/s for domestic refuse and other solid wastes; and v) no specific permeability criteria for inert material and spoil from grubbing, stripping and excavation.	4.3.3
416	**Waste Containment and Disposal** - Management of Disposal Sites	Manage solid waste disposal sites so that: i) liquid and hazardous wastes are disposed of only in facilities designed, approved and licensed for that purpose, ii) solid wastes are segregated and recycled where practicable, and iii) landfill sites are developed in cells, compacted, covered, contoured and capped.	4.3.4
417	**Waste Containment and Disposal** - Management of Disposal Sites	Manage waste disposal sites so that: i) access is controlled and disposal activities supervised, ii) records are kept of types and amounts of wastes disposed, iii) rodents, birds, and pests are controlled, and iv) drainage is monitored and treated where appropriate.	4.3.4
418	**Air Pollution Control** - Dust	Take all reasonable measures to control fugitive dust from: i) vehicle traffic in unpaved areas, ii) drilling, blasting and excavating, iii) coal transfer and storage facilities, iv) coal ash handling and disposal facilities, and v) other significant sources of fugitive dust.	4.4.1
419	**Air Pollution Control** - Emissions from Combustion Sources	Ensure that combustion sources comply with applicable air emission and air quality requirements.	4.4.2
420	**Air Pollution Control** - Odours	Schedule domestic refuse pickup and disposal regularly to avoid odours.	4.4.3
421	**Noise Control** - Intensity Limitations	Noise levels in adjacent residential areas should not normally exceed: i) 65 dBA (Leq) during daytime, ii) 60 dBA (Leq) during the evening iii) 55 dBA (Leq) at night and on holidays.	4.5.1

TABLE 5.0 SUMMARY OF RECOMMENDATIONS (Cont'd)

NUMBER	SUBJECT	SUMMARY OF RECOMMENDATION	SECTION
422	**Noise Control** - Scheduling of Activities	Where possible inform local residents of abnormal noise-causing activities and schedule these to minimize disruption.	4.5.1
423	**Terrestrial and Aquatic Life Protection** - Terrestrial Life	To protect wildlife: i) schedule activities to avoid disturbing migration and breeding, ii) prohibit on-site use of firearms, iii) avoid procedures or devices which endanger wildlife or prevent migration, iv) restrict access to wetlands, and v) leave trees standing where possible.	4.6.1
424	**Terrestrial and Aquatic Life Protection** - Aquatic Life	To protect aquatic life: i) schedule in-water construction to avoid fish spawning and migration where possible, ii) do not impede fish migration by modification of water courses, iii) clear spoil and debris and replace original contours at submerged structures, iv) avoid entraining fish in temporary water intakes, v) consult fisheries agencies before in-water blasting, vi) control underwater blasting to reduce fish mortality, and vii) monitor fish mortality from underwater blasting.	4.6.2
425	**Archeological and Historical Resource Protection** - Surveys and Finds	To protect archeological or historical resources: i) conduct a survey of site archeological resources prior to construction, ii) identify and protect important resources within the site from damage, and iii) stop work and consult experts when artifacts or features are encountered.	
426	**Construction Contracts** - Environmental Requirements	Include appropriate environmental protection practices in construction contracts.	4.8
427	**Environmental Audits** - Utility Management Information	Conduct periodic internal environmental audits to ensure compliance with all applicable environmental protection requirements.	4.9
428	**Monitoring and Reporting** - Regulatory Agencies	Monitor and report relevant environmental data and information as agreed with appropriate regulatory agencies.	4.10

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APPENDIX

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