Diver

Occupational Analysis Report

April 2013

Commission
de la construction
du Québec

The purpose of this report is to describe as accurately as possible the occupation of diver as currently practiced in Québec's construction industry. It is a record of discussions held by a group of workers who met for the occasion after industry partners recommended them to the Commission de la construction du Québec for their expertise.

The occupational analysis is a first step in the definition of the competencies required for practicing the occupation. This report becomes one of the reference and decision-making tools used by the Commission for teaching and learning purposes.

This report does not bind the Commission in any way. It has no legal effect and is meant as a reflection of discussions held on the date of the analysis workshop.

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The masculine gender is used generically
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APPROVAL

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TABLE OF CONTENTS

List of Tables

INTRODUCTION

In early 2009, the Direction de la formation professionnelle of the Commission de la construction du Québec (CCQ) launched a large-scale operation to review the occupational analyses[1] of the construction industry's trades and specialized occupations.

The CCQ undertook this operation for many reasons, particularly the following:

- the project to reform the construction workforce apprenticeship and management system, and the eventual design of qualitative apprenticeship logbooks requiring a detailed description of each trade and specialized occupation;
- the fact that most construction occupational analyses[2] had been conducted between 1987 and 1991 and had not been reviewed since;
- updates to vocational qualification examination question banks;
- implementation of Chapter 7 of the Agreement on Internal Trade (AIT) and of the Québec-France Understanding on the Mutual Recognition of Professional Qualifications.

These factors demonstrate the necessity of updating the occupational analyses in order to obtain a current and complete provincial profile of the various trades and specialized occupations.

The occupational analysis of the diver occupation belongs to this context[3]. Its purpose is to describe this specialized occupation as currently practiced in the construction industry. This report was written in order to collate and organize the information gathered during the occupational analysis workshop held in Québec City on April 12 and 13, 2012.

This analysis draws a portrait of the occupation (tasks and operations) and its working conditions, and identifies the skills and behaviours required. The report of the occupational analysis workshop is an accurate reflection of the consensus reached by a group of divers. A special effort was made to include in this report all the data collected during the workshop and to ensure that the data accurately depict the realities of the occupation analysed.

1. The terms "profession" and "trade" are considered synonymous.
2. Called "work situation analyses" at the time.
3. This occupational analysis was conducted according to the *Cadre de référence et instrumentation pour l'analyse d'une profession* produced in 2007 by the ministère de l'Éducation, du Loisir et du Sport (Direction générale de la formation professionnelle et technique) and the Commission des partenaires du marché du travail, ministère de l'Emploi et de la Solidarité sociale.

1. GENERAL CHARACTERISTICS OF THE OCCUPATION

1.1 DEFINITION OF THE OCCUPATION

According to the construction industry's Civil Engineering and Roadwork Sector Collective Agreement, the term "diver" means:

> "Anyone who, wearing a diving suit or equipped with breathing apparatus, performs construction, repair, installation, demolition or inspection work on equipment or structures underwater."

The participants consider this definition representative of their work but incomplete. Indeed, the definition mentions none of the tasks performed above water (assisting the diver who is underwater, planning, preparing parts, maintaining equipment, etc.). The diver also performs (under or above water) tasks without wearing a diving suit; this is also absent from the definition. In fact, the latter corresponds solely to a diver's underwater work (the participants estimate that 25 to 30% of their work time is spent underwater), but does not take into account the operational assistance and management roles of divers.

Moreover, the participants consider the expression "wearing a diving equipment" to be inappropriate because the diving equipment includes the system enabling the diver to breathe, which cannot be considered as clothing. So it would be more accurate to say "equipped with a diving suit."

Lastly, it should be noted that the expression "equipped with breathing apparatus" refers exclusively to surface-supplied breathing apparatus (with a support team).

1.2 JOB TITLES

On construction sites, the job titles "diver" and "commercial diver" are most frequent in designating divers. The job title "diver," found in the construction industry's collective agreements, will be used in the present report.

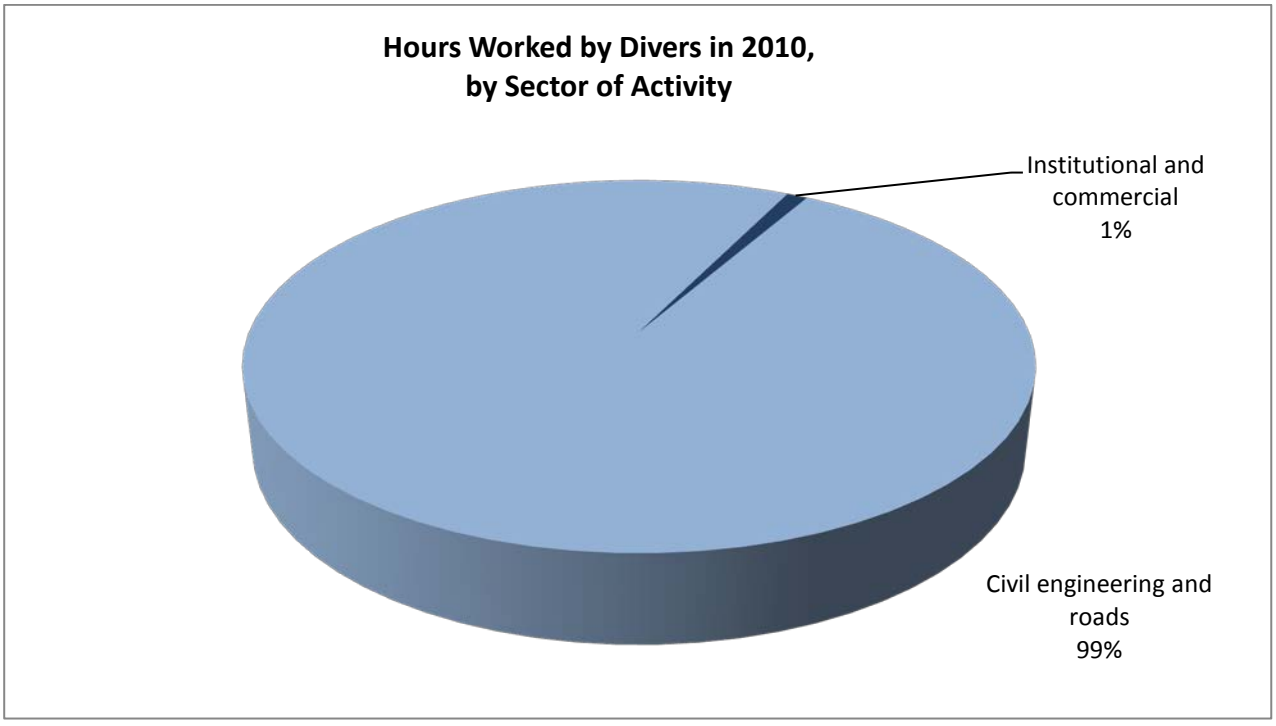
The nature of a diver's functions makes any confusion with other occupations or trades unlikely. However, some of the diver's tasks are identical to those of certain trades (for example, the carpenter-joiner's formwork tasks, the tinsmith's tasks in installing reinforcing steel, etc.), so that the work environment is what distinguishes the diver's tasks in such cases: underwater for divers and above water for those trades.

1.3 SECTORS OF ACTIVITY

Divers are active, to varying degrees, in two of the four construction industry sectors:

- the institutional and commercial sector;
- the civil engineering and roads sector.

The graphic below illustrates the distribution of hours worked by all divers in Quebec in 2010[4].



4. Commission de la construction du Québec, *Careers in Construction*, 2011-2012 edition.

After presenting the above graphic, we asked the participants about the sectors in which they practice their occupation. Of the 13 participants, 3 stated that the graphic corresponds to their work time, 8 work solely in the civil engineering and roads sector, and 2 estimated that they work slightly more than 1% of the time in the institutional and commercial sector.

1.4 FIELD OF PRACTICE

The occupation's field of practice is the construction industry. The Act respecting labour relations, vocational training, and workforce management in the construction industry (R.S.Q., c. R-20) defines construction as follows:

> […] the foundation, erection, maintenance, renewal, repair, alteration and demolition work on buildings and civil engineering works carried out on the construction site itself and vicinity including the previous preparatory work on the ground;
>
> In addition, the word "construction" includes the installation, repair and maintenance of machinery and equipment, work carried out in part on the construction site itself and in part in the shop, moving of buildings, transportation of employees, dredging, turfing, cutting and pruning of trees and shrubs and laying out of golf courses, but solely in the cases determined by regulation.

1.5 LAWS AND REGULATIONS

Divers in the construction industry are subject to:

- the Act respecting labour relations, vocational training and workforce management in the construction industry (R.S.Q., c. R-20);
- the Regulation respecting the vocational training of workforce in the construction industry (R-20, r.6.2);
- the four sector-based collective agreements of the construction industry;
- the National Building Code – Canada 2005 (NBC);
- the Québec Building Code, Chapter 1, "Building" and Chapter 5, "Electricity";
- the Act respecting occupational health and safety (R.S.Q., c. S-2.1);

- the Regulation respecting occupational health and safety (c. S-2.1, r 13);
- the diving standards of the Canadian Standards Association (CSA) (CSA-Z275.5-05, CSA-Z275.4-02, CSA-Z180.1, etc.);
- the Safety Code for the construction industry (R.Q. c. S-2.1, r.6 and, for lifting loads, c. S-2.1, r.4);
- the Act respecting industrial accidents and occupational diseases (R.S.Q., c. A-3.001);
- the Regulation respecting the professional activities that may be engaged in by a hyperbaric chamber operator, Medical Act (R.S.Q., c. M-9, a. 3), Professional Code (R.S.Q., c. C-26, a. 94, par. *h* and a. 94.1);
- Competency of Operators of Pleasure Craft Regulations and Navigation Safety Regulations;
- explosives transportation and handling regulations, where applicable;
- environmental standards of the ministère du Développement durable et des Parcs (water quality, restrictive provisions with respect to fish spawning, turtle nests, etc.);
- hazardous materials transportation laws;
- municipal bylaws, where applicable;
- internal standards and regulations specific to client companies.

1.6 WORKING CONDITIONS[5]

The following information provides an overview of the conditions and context of the work of divers, as commented by the participants in the occupational analysis workshop. To obtain up-to-date and complete information that has legal effect, it is necessary to refer to the construction industry's four sector-based collective agreements.

5. The general data on working conditions are taken from the construction industry's four sector-based collective agreements and from the following document, published by the Commission de la construction du Québec: *Carreers in Construction*, 2011-2012 edition.

Salary

The average annual salary of a diver who worked at least 500 hours in 2010 was $63,594. 76% of divers had cumulated at least 500 hours.

A diver's daily hourly wage was as follows at May 1, 2011:

- Industrial: $35.80
- Institutional and commercial: $35.80
- Civil engineering and roads: $35.80
- Light residential: $32.65

Vacations and time off

Mandatory annual holidays of four weeks – two weeks in summer and two in winter at periods predetermined in collective agreements – are the general rule in the construction industry. To avoid penalizing employers and employees experiencing special constraints, the industry's four collective agreements allow certain changes to these prescribed vacation periods. In addition to these vacation periods, employees receive eight statutory holidays and a lump sum for sick leave.

Pension plan

Construction industry workers participate in a pension plan. They retain their eligibility for this pension plan throughout their career in construction, even if they change employer, trade or sector.

Insurance

The group insurance plan (medications, illness, disability, death) is fully paid by employers. Workers (and their families, as the case may be) are eligible for it so long as they remain active in the construction industry and work the required number of hours, whether or not they change employer.

Physical requirements

According to the Regulation respecting occupational health and safety (part XXVI.I, sec. 312.57), divers must pass a physical examination every two years to obtain a medical certificate to the effect that they are able to dive. In practice, divers 40 years of age and over usually take the medical examination each year. That examination is demanding (it includes a stress test), so divers must stay in good physical condition to be able to practice their occupation[6].

In addition to good physical condition, the work requires average strength, and a lot of endurance in particular. The participants emphasize that weaklings cannot be divers; tolerance of physical discomfort is an essential trait for those who want to practice this occupation. Bad weather (divers work almost exclusively outdoors, above or under water) and frequently precarious housing conditions in remote regions require divers to be in good health and able to adapt to a variety of conditions. In addition, divers must not have respiratory problems, which would make it difficult to practice the occupation (and impossible to obtain the medical certificate).

Work schedules

A 40-hour work week from Monday to Friday is the general rule in all construction industry sectors. However, for work done in the civil engineering sector, the regular work week is 45 hours from Monday to Friday, with a daily limit of 9 or 10 hours. In addition, for work done on isolated construction sites where the employer provides housing and cover, the regular work week is 50 hours.

To avoid penalizing employers and employees experiencing special constraints, the industry's four collective agreements allow many possibilities for changing the schedule prescribed by the general rule: compressed schedule, schedule shift, etc. In this regard, the participants mentioned that the formula of four consecutive 10-hour days is more and more popular.

Indeed, since divers work in remote regions most of the time, and given the time spent travelling, those three days off enable them to go home on weekends, which would be more difficult with only two consecutive days off.

6. Every 2 years, divers must undergo a physical examination by a diving physician or more often if the physician deems it necessary and obtain a medical certificate attesting that they are fit to dive. The medical certificate is valid for a maximum of 2 years. The diving supervisor may also require that a diver again undergo the physical examination referred to in the first paragraph of section 312.57 and obtain a new medical certificate, if the supervisor considers that the diver is unfit to dive safely.

Near large urban centres, divers work mainly during the week and in the daytime, 40 to 45 hours a week. In remote regions, work weeks are longer (often 55 to 60 hours or more); the work takes place in the daytime, but also in the evening, or even at night. Moreover, in some cases, divers' schedules follow the tides. Generally, the persons consulted agree that whatever the type of work, their schedules are varied and often difficult to predict. In the words of one participant, "We know when we'll leave, but not when we'll return!"

Divers must be prepared to travel beyond the region of their residence and stay for relatively long periods. A diver wanting to work only in his own region would find it difficult to earn a living.

Lastly, the seasonal aspect of divers' work should be pointed out. They generally work five to seven months a year, mainly from June to December.

1.7 JOB MARKET ENTRY CONDITIONS[7]

To practice the specialized occupation of diver on a construction site, a worker must:

- Hold a competency certificate-occupation issued by the CCQ and requiring the following:
    - being 18 years of age or over;
    - having successfully passed a studies program recognized by the CCQ: the AEC - Plongée professionnelle (ELW.08);
    - having successfully passed the course *Santé et sécurité générale sur les chantiers de construction*;

AND, according to the number of places reserved depending on labour needs determined annually by the construction industry:

- having successfully passed the *Cours de connaissance générale de l'industrie de la construction* (CCGIC);

OR, during a labour shortage and a labour-pool opening:

- present a guarantee of employment produced during a labour-pool opening by an employer registered with the CCQ, for at least 150 hours over a period of at most three consecutive months;

7. Other conditions than those listed above may apply. For a complete list of conditions for entering the trade, see the Act respecting labour relations, vocational training and workforce management in the construction industry (R.S.Q., c. R-20). You can also consult the CCQ's website: http://www.ccq.org/en/DevenirTravailleur/E_CertificatsCompetence.

- hold the vocational qualification required, in accordance with CSST regulations (including the requirement of passing a medical examination, and the competency standards in force of the Canadian Standards Association (CSA).

Since May 1, 2007, there have been two classes of divers: Class 2, workers with less than 2,000 hours of experience, and Class 1, workers with over 2,000 hours of experience.

Eleven of the thirteen participants took training before starting to practice their occupation. Most studied in Quebec and three outside Quebec (Florida, Ontario, Texas).[8]

Moreover, certain qualities are sought by employers hiring divers. The following list presents the main qualities, in the order they were mentioned and not in order of importance:

- initiative;
- punctuality;
- perseverance;
- experience with the types of work to be done;
- references from colleagues or employers;
- ability to work within a team, integrate with an existing team, and maintain harmonious relations with colleagues and with workers from other trades or occupations.

According to the CCQ, the average age of divers is significantly less (34 years) than that of construction workers as a whole (39 years). The participants think this difference is due to the fact that many persons begin as divers but quit the field after a few years. The following reasons are given to explain this situation:

- The actual work environment of divers is quite different from the conditions experienced during training. Many candidates are attracted by diving and its recreational possibilities. But when they start working on construction sites, the realities of construction work often differ widely from what the candidates had imagined. Given that the training is dispensed at the college level, some graduates don't expect to become construction workers, since construction jobs are often associated with high-school vocational training.

8. The training programs did not yet exist in Quebec when two of the participants started working as divers.

- To someone starting out in this field, it is often difficult to work enough hours to earn an acceptable income, and this may discourage many divers. In fact, even experienced divers often have to work at a second job to earn a sufficient income (6 of the 13 persons consulted have a second job).

- The requirement to be frequently away from home for relatively long periods may be difficult to reconcile with family life.

- The work requires good physical condition, so some persons, with age, will prefer a less physically demanding line of work.

1.8 PLACE OF WOMEN IN THE OCCUPATION

Section 126.0.1 of the Act respecting labour relations, vocational training and workforce management in the construction industry pertains to women's access to the construction industry: "The Commission, after consultation with the Commission des droits de la personne et des droits de la jeunesse, shall develop measures to favour the access of women to and their maintenance and greater representation on the labour market in the construction industry."

According to the CCQ[9], 6 women were practicing the diver occupation in 2010, out of a total of 114 divers, i.e., a percentage of 5.26%. According to the participants, no task-related factor prevents a woman from practicing this occupation. The necessary physical strength for performing some of the tasks may be compensated both by work methods and by the fact that divers always work in teams so that tasks can be allocated according to each diver's abilities. However, the participants mentioned that the obligation to stay outside one's region, often for relatively long periods, may not be suitable for young women wanting to start a family.

1.9 CAREER PROSPECTS

Opportunities for advancement are relatively limited for divers. After experience of varied duration depending on the employers and candidates, divers may become team leaders or foremen. Others, more rarely, may create their own company.

9. Commission de la construction du Québec, *Careers in Construction*, 2011-2012 edition.

The participants consider that too may divers are trained annually, which has created a vicious cycle for many years. Since the annual volume of work offered to divers varies little, the more divers there are, the less chances each diver has to work enough hours. As in every field, newcomers are generally the last to be hired, and when they succeed in getting a job they are the first to be laid off for lack of available work. If they don't work enough, many new divers will likely quit the occupation to find more stable and higher-paying work, which then justifies the training of new recruits.

The first year of work is reportedly crucial for career opportunities in this field. At the end of college training in professional diving, students must take an internship, often before the start of the peak work season, so before employers have hired all the divers they will need.

New divers appreciated by employers during that internship are often hired afterward. Those new employees at times replace those whom the employer had hired in the previous year and whose services he had somewhat appreciated.

In addition, recent graduates "cost less" to their employer, since they are paid 85% as much as a more experienced person (who has completed his 2,000 hours of apprenticeship[10]). So the financial aspect may have an influence in some cases. In short, a diver starting out in this field must succeed in convincing his employer that it is more profitable to hire him from year to year than to hire a recent graduate.

Lastly, another factor makes it difficult to evaluate labour needs: the way contracts are awarded during the year. Contracts are often awarded at the end of the budget year, i.e., in the fall, to companies hiring divers. Thus, employers who need to hire divers in October, for example, find it very difficult to find candidates, since most have already been hired. This situation is temporary, but for employers who don't find personnel, it's easy to conclude that the labour pool is insufficient, which results in the training of more and more divers, who will perpetuate the situation described in the preceding paragraph.

10. An employee joining the construction industry as a diver is paid 85% of the salary for the first 2,000 hours recorded with the CCQ as a diver under code 751. In application of that salary rate, such an employee is considered a Class 2 diver.

1.10 DEVELOPMENT OF THE OCCUPATION

The following principal changes have occurred in recent years:

- stricter application of occupational health and safety regulations;
- the introduction of new gaseous mixtures (e.g.: Nitrox) and new types of equipment (e.g.: in-line carbon dioxide sensors);
- the introduction of hot-water diving suits, thus extending the work season and considerably improving the comfort of divers;
- the use of portable computers and specialized software making it easier to control diving activities;
- the introduction of tools and equipment designed especially for underwater work.

The participants also mentioned that in the medium term, new construction sites could result in divers working in somewhat different conditions. Currently, work done in Quebec is done using surface-supplied breathing apparatus, given the relatively limited depths to be reached. However, work in deeper water may be done in coming years. Such work – for example, the installation of drilling platforms in the Gulf of Saint-Lawrence – would require saturation diving logistics, which would constitute a major change in the work of divers. The participants specify that they are able to do this type of work, but that further training in diving deeper than 165 feet would be necessary for their adaptation to this context, as well as training in high-seas emergency measures.

Lastly, the participants mentioned that keeping a supervisor’s logbook, although not yet an established practice, should become more important in coming years.

1.11 IMPACT OF ENVIRONMENTAL STANDARDS ON THE PRACTICE OF THE OCCUPATION

The application of environmental standards is important to the work of divers. More specifically, the following aspects were mentioned:

- generally, a diver must take many precautions to avoid altering the environment in which he works;
- residues and debris found at the bottom of the water must be recovered, whereas previously they were left in place, which participants say increase the diver's number of working hours;
- the schedule for performing certain tasks is organized according to various environmental considerations (e.g.: fish spawning);
- biological oils must be used for hydraulic tools and equipment;
- recyclable materials must be deposited in bins provided to that effect;
- waste oils must henceforth be recovered and collected under motors in operation.

2. WORK DESCRIPTION

2.1 TASKS AND OPERATIONS

During the workshop, a table of tasks and operations performed by divers was suggested to the participants. Following discussions, changes were made to the table. The final version is presented in the following pages. It should be noted that the order in which the tasks are presented does not necessarily reflect their importance in the occupation.

The tasks have been grouped into three blocks: diving tasks, repair tasks and installation tasks. The first block's tasks represent the three main roles that must be played in turn by each diver in a diving team: diving, has to play in turn: diving, assistance, and directing operations. In addition, diving apparatus maintenance has been included in this block. The two other blocks describe construction work that divers have to do.

In addition to the tasks below, the participants mentioned that they may occasionally perform other activities, such as refloating submerged construction equipment, fitting steel parts, etc. However, those activities are quite rare, so it did not seem relevant to include them in the list of divers' regular tasks.

A diver's tasks

SECTION I: DIVING[11]

Task 1	Dive
Task 2	Assist the diver during a dive
Task 3	Direct diving operations
Task 4	Maintain and repair diving apparatus, other equipment and tools

11. Diving with air or gaseous mixtures, in all environments (including environments with specific hazards, such as contaminated or confined environments, those with underwater currents or pressure differentials, those under ice, etc.).

SECTION II: REPAIR WORK

Task 5	Prepare to repair submerged structures
Task 6	Repair submerged concrete structures
Task 7	Repair submerged steel structures
Task 8	Repair submerged wood structures

SECTION III: INSTALLATION WORK

Task 9	Prepare installation work
Task 10	Install pipes
Task 11	Install membranes
Task 12	Install anodes
Task 13	Install cofferdams and stop logs

Table 2.1 Tasks and Operations

TASKS	OPERATIONS					
SECTION I: DIVING						
1. DIVE	1.1 Plan the work	1.2 Establish emergency procedures	1.3 Mobilize the equipment	1.4 Put the diving equipment on	1.5 Check the operation of diving apparatus	1.6 Descend to the intervention area
	1.7 Secure the work area, if applicable	1.8 Perform the intervention	1.9 Return up to the surface	1.10 Demobilize the equipment	1.11 Fill out the diving log and logbook	
2. ASSIST THE DIVER DURING A DIVE	2.1 Plan the work	2.2 Establish emergency procedures	2.3 Mobilize the equipment	2.4 Check the operation of diving apparatus	2.5 Help the diver put his diving suit on	2.6 Launch the diver
	2.7 Make sure support devices are operational	2.8 Provide the diver with materials and tools	2.9 Bring the tools back up to the surface	2.10 Bring the diver back up to the surface	2.11 Demobilize the equipment	
3. DIRECT DIVING OPERATIONS	3.1 Plan the work	3.2 Establish emergency procedures	3.3 Direct the equipment mobilization	3.4 Control the operation of the various systems (e.g.: breathable air)	3.5 Direct the verification of the diving apparatus's operation	3.6 Direct the diver's launch
	3.7 Direct the tasks to be performed	3.8 Ensure the quality of the work	3.9 Direct the diver's return up to the surface	3.10 Direct the equipment's demobilization	3.11 Make sure that diving logs and logbooks are filled out	

TASKS	OPERATIONS					
SECTION I: DIVING						
4. MAINTAIN AND REPAIR DIVING APPARATUS, OTHER EQUIPMENT AND TOOLS	4.1 Determine repair needs	4.2 Replace diving helmet components	4.3 Check the harness and the bailout	4.4 Repair the lighting system	4.5 Repair umbilical cord components	4.6 Repair the diving suit
	4.7 Repair the breathable gas distribution system	4.8 Repair the hot water system	4.9 Maintain and repair the tools	4.10 Maintain generators, internal combustion engines, and compressors	4.11 Maintain welding and cutting equipment	4.12 Repair hydraulic and electric pumps
	4.13 Maintain the diving unit	4.14 Ensure the quality of the work to maintain and repair diving apparatus, other equipment and tools	4.15 Fill out the maintenance logbook			
SECTION II: REPAIR WORK						
5. PREPARE TO REPAIR SUBMERGED STRUCTURES	5.1 Read the plans and specifications	5.2 Mobilize the diving station's work area	5.3 Establish the position in relation to surface markings (chaining and bathymetry)	5.4 Clean and secure the structure	5.5 Note construction defects and breakages	5.6 Take residual thickness ultrasound measurements)for metal parts)
	5.7 Take measurements, install measuring instruments and take readings	5.8 Determine necessary materials for the work	5.9 Install scaffolds, if applicable	5.10 Excavate, if applicable	5.11 Rig the elements to be hoisted, if applicable	5.12 Direct the hoisting, if applicable
	5.13 Install a current deflector, if applicable	5.14 Install a sedimentation curtain, if applicable				

TASKS	OPERATIONS					
SECTION II: REPAIR WORK						
6. REPAIR SUBMERGED CONCRETE STRUCTURES	6.1 Do the tracing and marking	6.2 Saw the concrete	6.3 Break and, if applicable, roughen the concrete to be removed	6.4 Drill the mass concrete	6.5 Place the reinforcing steel, anchors and tie beams, if applicable	6.6 Clean the structure
	6.7 Build the formwork and put it in place	6.8 Make sure the formwork is watertight	6.9 Place the concrete or cement grout in the formwork	6.10 Strip the formwork, if applicable	6.11 Ensure the quality of the work	6.12 Resurface the concrete
	6.13 Do an “as-built”	6.14 Fill out your daily report				
7. REPAIR SUBMERGED STEEL STRUCTURES	7.1 Prepare the parts on th surface	7.2 Cut the steel in the water	7.3 Align and install structural elements	7.4 Place the concrete or cement grout inside the steel structure	7.5 Ensure the quality of the work	7.6 Do an “as-built”
	7.7 Fill out your daily report					
8. REPAIR SUBMERGED WOOD STRUCTURES	8.1 Prepare the parts on the surface	8.2 Cut the wood in the water	8.3 Align and install structural elements	8.4 Ballast the wooden parts	8.5 Replace stringpieces, foot planks and cross-pieces	8.6 Install log bolts or tie beams
	8.7 Consolidate the structure (inner or outer riprap)	8.8 Ensure the quality of the work	8.9 Do an “as-built”	8.10 Fill out your daily report		

TASKS	OPERATIONS					
SECTION III: INSTALLATION WORK						
9. PREPARE INSTALLATION WORK	9.1 Read the plans and specifications	9.2 Mobilize the diving station's work area	9.3 Coordinate with other trades and occupations and with your work team	9.4 Establish the position in relation to surface markings (chaining and bathymetry)	9.5 Clean support surfaces (for anodes and cofferdams)	9.6 Take residual thickness ultrasound measurements (for metal parts), if applicable
	9.7 Excavate or check the excavation (for pipes)	9.8 Install retaining plates, trunnions and sills (for cofferdams)	9.9 Rig the elements to be hoisted, if applicable	9.10 Direct the hoisting, if applicable	9.11 Install a current deflector, if applicable	9.12 Install a sedimentation curtain, if applicable
10. INSTALL PIPES	10.1 Prepare pipe sections on the surface	10.2 Align and place the pipe section	10.3 Level the pipe section	10.4 Abut the other pipe sections	10.5 Consolidate the pipe sections	10.6 Ensure the quality of the work
	10.7 Backfill	10.8 Do an "as-built"	10.9 Fill out your daily report			
11. INSTALL MEMBRANES	11.1 Prepare membrane sections on the surface	11.2 Extend the membrane section	11.3 Ballast or anchor the membrane section	11.4 Backfill the membrane section	11.5 Cut the excess membrane section, after backfilling	11.6 Place the other sections so that they overlap
	11.7 Consolidate the membrane sections	11.8 Ensure the quality of the work	11.9 Do an "as-built"	11.10 Fill out your daily report		

TASKS	OPERATIONS					
SECTION III: INSTALLATION WORK						
12. INSTALL ANODES	12.1 Prepare the anodes on the surface	12.2 Remove the existing anode system, if applicable	12.3 Do the tracing and marking	12.4 Align and adjust the anodes	12.5 Weld the anodes in place	12.6 Connect cables and terminals
	12.7 Install sheathing for electric cables	12.8 Ensure the quality of the work	12.9 Do an “as-built”	12.10 Fill out your daily report		
13. INSTALL COFFERDAMS AND STOP LOGS	13.1 Check the cofferdam bedding	13.2 Prepare cofferdam components or stop log grooves	13.3 Install the retaining system for the cofferdam or stop log	13.4 Align and adjust the cofferdam	13.5 Fill the cofferdam with water, if applicable	13.6 Secure the cofferdam or stop log to the structure, if applicable
	13.7 Install submersible pumps and hoses, if applicable	13.8 Plug the leaks, if applicable	13.9 Ensure the quality of the work	13.10 Demobilize the cofferdam or stop log	13.11 Do an “as-built”	13.12 Fill out your daily report

2.2 OPERATIONS, SUB-OPERATIONS AND CLARIFICATIONS

The following pages contain sub-operations related to most of the operations[12], as well as a few clarifications made by the participants.

Table 2.2 Sub-Operations and Operation Clarifications

SECTION I: DIVING

TASK 1: DIVE

Given the rotation of roles, operations 1.1, 1.2, 1.3, 1.5, 1.6 and 1.10 are always performed in cooperation with the other member's of the diver team. For example, for Operation 1.1, the one who dives is not solely responsible for planning the work. That is done by the team, and the person responsible remains the diver directing the diving operations (Task 3).

Operations	Sub-Operations	Clarifications
1.1 Plan the work	1.1.1 Find out about the work to be done 1.1.2 Choose a location for the diving station 1.1.3 Delimit the diving area (buoy, ropes, flags, launching ramp, etc.) 1.1.4 Install a launching system 1.1.5 Examine the work's characteristics (depth, necessary tools and equipment, etc.) 1.1.6 Assess the hazards (currents or pressure differentials, etc.) 1.1.7 Plan a lockout, if applicable 1.1.8 Determine, as a team, each member's responsibilities 1.1.9 Ensure that the material is available 1.1.10 Agree with the other members of the team about the conduct of the work 1.1.11 Participate in developing the diving plan	The diving table is chosen while the diving plan is developed (1.1.11).

12. The sequence of operations may vary according to the products and materials used.

SECTION I: DIVING

TASK 1: DIVE

Operations	Sub-Operations	Clarifications
1.2 Establish emergency procedures	1.2.1 Participate in the safety meetings 1.2.2 Participate in developing the rescue plan 1.2.3 Perform a rescue exercise 1.2.4 Establish contact with resource persons regarding use of the chamber 1.2.5 Ensure that the rescue equipment is available and operational 1.2.6 Ensure that communication links with emergency services are operational	
1.3 Mobilize the equipment	1.3.1 Assemble the diving station 1.3.2 Install the compressor and radio 1.3.3 Mobilize the hyperbaric chamber, if applicable 1.3.4 Mobilize the launching equipment 1.3.5 Prepare the tools and equipment and make sure they are operational	
1.4 Put the diving suit on		
1.5 Check the operation of diving apparatus	1.5.1 Make a visual inspection 1.5.2 Perform operational tests	
1.6 Descend to the intervention area	1.6.1 Use a cage, ladder of rope 1.6.2 Install the ascent line 1.6.3 Announce your descent	
1.7 Secure the work area, if applicable	1.7.1 Make an exploration dive to detect hazards, among other things (e.g.: suction source) 1.7.2 Secure the space (unstable objects and other hazards)	

SECTION I: DIVING

TASK 1: DIVE

Operations	Sub-Operations	Clarifications
1.8 Perform the intervention	1.8.1 Detach the equipment 1.8.2 Ask to have tools lowered 1.8.3 Communicate information (situation status, film, etc.) 1.8.4 Perform the necessary tasks 1.8.5 Rig the equipment to be raised	
1.9 Return up to the surface	1.9.1 Announce your ascent 1.9.2 Determine the reference points 1.9.3 Apply the decompression table	
1.10 Demobilize the equipment	1.10.1 Stop the machines and equipment 1.10.2 Disconnect, clean and store diving apparatus 1.10.3 Remove the lockout device, if applicable	
1.11 Fill out the diving log and logbook		The diving log, filled out by each diver after a dive, contains the following information: names and profiles of team members, altitude, depth reached, dive duration, landings, etc. The diving logbook is filled out each day by the supervisor. It repeats all data contained in the diving log and focuses on the description of tasks performed, incidents that occurred, etc. Lastly, the daily report, also filled out by the supervisor, contains data on the chronology of tasks performed during the day.

SECTION I: DIVING

TASK 2: ASSIST THE DIVER DURING A DIVE

Given the rotation of roles, operations 2.1, 2.2, 2.3, 2.5 and 2.11 are always performed in cooperation with the team's other members. For example, for Operation 2.1, the one who assists during a dive is not solely responsible for planning the work. That is done by the team, and the person responsible remains the diver directing the diving operations (Task 3).

Operations	Sub-Operations	Clarifications
2.1 Plan the work	2.1.1 Find out about the work to be done 2.1.2 Choose a location for the diving station 2.1.3 Delimit the diving area (buoy, ropes, flags, etc.) 2.1.4 Install a launching system 2.1.5 Examine the work's characteristics (depth, necessary tools and equipment, etc.) 2.1.6 Assess the hazards (currents or pressure differentials, etc.) 2.1.7 Plan a lockout, if applicable 2.1.8 Determine, as a team, each member's responsibilities 2.1.9 Ensure that the material is available 2.1.10 Agree with the other members of the team about the conduct of the work 2.1.11 Participate in developing the diving plan	
2.2 Establish emergency procedures	2.2.1 Participate in the safety meetings 2.2.2 Participate in developing the rescue plan 2.2.3 Perform a rescue exercise 2.2.4 Establish contact with resource persons regarding use of the hyperbaric chamber 2.2.5 equipment is available and operational 2.2.6 Ensure that communication links with emergency services are operational	

SECTION I: DIVING

TASK 2: ASSIST THE DIVER DURING A DIVE

Operations	Sub-Operations	Clarifications
2.3 Mobilize the equipment	2.3.1 Assemble the diving station 2.3.2 Install the compressor and radio 2.3.3 Mobilize the hyperbaric chamber, if applicable 2.3.4 Mobilize the launching equipment 2.3.5 Prepare the tools and equipment and make sure they are operational	It may be necessary to decontaminate the diving apparatus by cleaning it with products designed to that effect.
2.4 Check the operation of diving apparatus	2.4.1 Make a visual inspection 2.4.2 Perform operational tests	
2.5 Help the diver put his diving equipment on	2.5.1 Make sure the respiratory equipment is disinfected 2.5.2 Put the diving harness in place 2.5.3 Make sure the respiratory equipment is well installed and locked 2.5.4 Connect the hot water, if applicable	
2.6 Launch the diver	2.6.1 Escort the diver to the launching point 2.6.2 Ensure the umbilical cord's free movement 2.6.3 Direct operations for descending a cage (or other), if applicable	
2.7 Make sure support devices are operational	2.7.1 Make inspection rounds 2.7.2 Detect and correct eventual defects 2.7.3 Ensure the devices are fuelled	
2.8 Provide the diver with materials and tools	2.8.1 Inform the diver before any action 2.8.2 Check the diver's safety while tools, materials or equipment descend 2.8.3 Rig and lower tools, materials or equipment 2.8.4 Keep the diver informed of ongoing work on the surface	

SECTION I: DIVING

TASK 2: ASSIST THE DIVER DURING A DIVE		
Operations	**Sub-Operations**	**Clarifications**
2.9 Bring the tools back up to the surface	2.9.1 Ensure that items to be raised are correctly rigged 2.9.2 Respond to the diver's orders	
2.10 Bring the diver back up to the surface	2.10.1 Ensure the umbilical cord's free movement 2.10.2 Roll up the umbilical cord progressively 2.10.3 Escort the diver as he emerges from the water 2.10.4 Remove the helmet quickly	
2.11 Demobilize the equipment	2.11.1 Clean and disinfect the helmet 2.11.2 Rinse the tools and equipment 2.11.3 Flush the umbilical cord hoses and the hot water hoses	

SECTION I: DIVING

TASK 3: DIRECT DIVING OPERATIONS		
Operations	**Sub-Operations**	**Clarifications**
3.1 Plan the work	3.1.1 Find out about the work to be done 3.1.2 Check the premises' accessibility 3.1.3 Examine the work's characteristics: depth, currents, pressure differentials, necessary tools and equipment, etc. 3.1.4 Hold safety meetings 3.1.5 Plan a lockout, if applicable 3.1.6 Allocate tasks among team members 3.1.7 Ensure that the material is available 3.1.8 Agree with the other members of the team about the conduct of the work 3.1.9 Notify the authorities concerned 3.1.10 Develop the diving plan	When planning the work, one must take into account several factors, such as rules regarding the diver's health (e.g.: acclimation to the altitude), tide tables, the altitude of the construction site's access roads, etc.

SECTION I: DIVING

TASK 3: DIRECT DIVING OPERATIONS		
Operations	**Sub-Operations**	**Clarifications**
3.2 Establish emergency procedures	3.2.1 Contact the hyperbaric medicine centre, if applicable 3.2.2 Develop an evacuation plan 3.2.3 Determine the procedures to follow 3.2.4 Explain the emergency plan to the team members 3.2.5 Make sure the emergency equipment is available and operational 3.2.6 Ensure that communication links with emergency services are operational 3.2.7 Organize a rescue test 3.2.8 Plan necessary measures in case of pressure differentials 3.2.9 Establish contact with resource persons regarding use of the chamber, if applicable 3.2.10 Determine who is responsible for the chamber, if applicable	
3.3 Direct the equipment mobilization	3.3.1 Direct the installation of the hot water pump, burner, compressor, electric power supply, launching equipment, carbon monoxide detector, radio, etc. 3.3.2 Direct the diving station's assembly 3.3.3 Direct the mobilization of the launching equipment and, if applicable, of the hyperbaric chamber 3.3.4 Direct the preparation of tools and equipment	
3.4 Control the operation of the various systems (e.g.: breathable air)	3.4.1 Check the condition of low-pressure filters 3.4.2 Flush the air tank 3.4.3 Adjust the hot water temperature, to avoid burns	
3.5 Direct the verification of the diving apparatus's operation	3.5.1 Perform tests from the diving station (light, umbilical cords, camera, communications system, etc.)	

SECTION I: DIVING

TASK 3: DIRECT DIVING OPERATIONS

Operations	Sub-Operations	Clarifications
3.6 Direct the diver's launch	3.6.1 Assess the launching height 3.6.2 Establish a safe launching method 3.6.3 Direct operations for lowering a cage (or other), if applicable	For safety reasons, when launching is done in more than three metres, mechanical means must be used (e.g.: cage), whereas in less than three metres a ladder may be used.
3.7 Direct the tasks to be performed	3.7.1 Plan the tools, materials and equipment needed by the person who will be diving 3.7.2 Coordinate the activities of all team members 3.7.3 Choose the work methods and procedures	
3.8 Ensure the quality of the work	3.8.1 Continuously monitor the performance of tasks (camera or information sent by the person who is diving) 3.8.2 Make a final inspection, with the assistance of the person who is diving and who is inspecting the work while filming 3.8.3 Check the observance of rules, standards, client requirements, etc.	
3.9 Direct the diver's return up to the surface	3.9.1 Monitor the speed of the diver's ascent (decompression tables) and intervene if necessary 3.9.2 Respond to eventual emergency situations	
3.10 Direct the equipment's demobilization	3.10.1 Direct the demobilization of equipment mobilized in operation 3.3 3.10.2 Determine equipment decontamination needs and methods, if applicable 3.10.3 Determine equipment maintenance or repair needs	
3.11 Make sure that diving logs and logbooks are filled out	3.11.1 Ensure that the one who has dived has filled out his diving log 3.11.2 Fill out the diving logbook	See the clarifications on Operation 1.11. In some companies, the person directing diving activities must also fill out a supervisor's log. But this practice is not present in all companies.

SECTION I: DIVING

TASK 4: MAINTAIN AND REPAIR DIVING APPARATUS, OTHER EQUIPMENT AND TOOLS

Operations	Sub-Operations	Clarifications
4.1 Determine repair needs	4.1.1 Draw a checklist for each piece of equipment 4.1.2 Make a visual inspection 4.1.3 Perform operational tests 4.1.4 Detect signs of wear, anomalies or breakages 4.1.5 Note the repairs to be made	
4.2 Replace diving helmet components	4.2.1 Perform the annual maintenance 4.2.2 Check the check valve 4.2.3 Check the shell and flange 4.2.4 Check all other components 4.2.5 Check the operation of the communications system	This operation requires a certification issued by the helmet manufacturer (DSI – Diving Systems International)
4.3 Check the harness and SCBA	4.3.1 Check straps, belts and attachments 4.3.2 Check the reserve air pressure	
4.4 Repair the lighting system	4.4.1 Replace bulbs 4.4.2 Replace defective cables, wiring sections and connections 4.4.2 Strengthen the support	
4.5 Repair umbilical cord components	4.5.1 Change the wiring 4.5.2 Waterproof the connections 4.5.3 Consolidate the connections 4.5.4 Tie the components together with adhesive tape	
4.6 Repair the diving suit	4.6.1 Repair hoses 4.6.2 Patch the suit 4.6.3 Repair valves 4.6.4 Have the zipper replaced by an expert, if applicable	
4.7 Repair the breathable gas distribution system	4.7.1 Change connections 4.7.2 Change the hoses 4.7.3 Change the valves 4.7.4 Change the filters 4.7.5 Replace the regulators 4.7.6 Check the pressure gauges 4.7.7 Have instruments calibrated, if necessary	

SECTION I: DIVING

TASK 4: MAINTAIN AND REPAIR DIVING APPARATUS, OTHER EQUIPMENT AND TOOLS

Operations	Sub-Operations	Clarifications
4.8 Repair the hot water system	4.8.1 Replace the coil 4.8.2 Descale the system 4.8.3 Replace the tank anodes 4.8.4 Clean the pump blades 4.8.5 Replace the filters (gasoline diesel, water) 4.8.6 Check the operation of valves	
4.9 Maintain and repair the tools	4.9.1 Get the tools dried 4.9.2 Flush the tools 4.9.3 Lubricate the tools 4.9.4 Disassemble the tools, if necessary, and replace components 4.9.5 Label the repaired tools	
4.10 Maintain generators, internal combustion engines, and compressors	4.10.1 Change the oil and filters 4.10.2 Keep a maintenance log on that equipment	The diver must dispose of waste oil in accordance with environmental regulations.
4.11 Maintain welding and cutting equipment	4.11.1 Check the operation of pressure gauges and regulatorss 4.11.2 Replace the handles of welding and cutting tools 4.11.3 Check the welding machine's grounding and operation 4.11.4 Replace defective components	
4.12 Repair hydraulic and electric pumps	4.12.1 Disassemble the pumps 4.12.2 Clean the blades 4.12.3 Replace hydraulic connections 4.12.4 Have pumps repaired in a workshop, if applicable	
4.13 Maintain the diving unit	4.13.1 Prevent water from accumulating inside the unit 4.13.2 Clean the work area 4.13.3 Store the unit and keep the area in order	

SECTION I: DIVING

TASK 4: MAINTAIN AND REPAIR DIVING APPARATUS, OTHER EQUIPMENT AND TOOLS		
Operations	**Sub-Operations**	**Clarifications**
4.14 Ensure the quality of the work to maintain and repair diving apparatus, other equipment and tools		
4.15 Fill out the maintenance logbook		

SECTION II: REPAIR WORK

TASK 5: PREPARE TO REPAIR SUBMERGED STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
5.1 Read the plans and specifications		
5.2 Mobilize the diving station's work area	5.2.1 Delimit the work area on the surface 5.2.2 Move tools and equipment to the work area 5.2.3 Limit access to the site	It is essential that all members of the work team correctly interpret the plans' information and have a common vision of the work to be done. The plans are often posted; they are thus accessible to everyone and must be consulted frequently. The specifications are reserved for the team leader, who will then give instructions to the other team members.
5.3 Establish the position in relation to surface markings (chaining and bathymetry)	5.3.1 Check the sea floor (echo sounder, surveying tape, depth gauge, etc.) 5.3.2 Write on the plans the data found on the site 5.3.3 Indicate the exact location of work on the structure	The location of work must be indicated on the structure with paint or keel. The sea floor must be examined carefully, since it is always possible that changes have occurred since the plans were produced.
5.4 Clean and secure the structure		The structure may be cleaned with sandblasting, water jet, a grinding stone, a brush or a scraper. The action of "securing the structure" consists of fastening or removing any unstable object (e.g.: part of the structure, residues, etc.) that could fall and injure the diver or damage the equipment.

SECTION II: REPAIR WORK

TASK 5: PREPARE TO REPAIR SUBMERGED STRUCTURES		
5.5 Note construction defects and breakages	5.5.1 Note on the plans any detected construction defects and breakages	
5.6 Take residual thickness ultrasound measurements, if applicable (for metal parts)	5.6.1 Take measurements with an ultrasound device 5.6.2 Record on the plans the measures obtained	
5.7 Take measurements, install measuring instruments and take readings		Measuring instruments used are, for example, a plumb line, inverted pendulum, ruler, level, measuring tape, etc.
5.8 Determine necessary materials for the work		
5.9 Install scaffolds, if applicable		
5.10 Excavate, if applicable		Depending on the excavation work's scope (and the nature of the soil), the work may be done by the diver (with a bush hammer, shovel, etc.) or by a mechanical shovel operator (guided by the diver). In rarer cases, the excavation may also be done with explosive charges. The diver's work will then be limited to drilling holes and placing explosive charges under a blaster's supervision. The blaster will be responsible for blasting.
5.11 Rig the elements to be hoisted, if applicable	5.11.1 Weigh the elements to be moved 5.11.2 Chose the hoisting equipment and make sure it is in good condition 5.11.3 Install anchors on the elements, if applicable 5.11.4 Rig the elements with straps, slings, cables, etc. 5.11.5 Perform hosting tests, if applicable	Hoisting may be done with a crane, winch, bridge crane, chain hoist, hoisting balloon, etc.

SECTION II: REPAIR WORK

TASK 5: PREPARE TO REPAIR SUBMERGED STRUCTURES		
5.12 Direct the hoisting, if applicable	5.12.1 Use hoisting signals 5.12.2 Maintain attention on the element being moved 5.12.3 Guide the element with a rope	The diver performs this operation when an operator or crane operator does the hoisting. Instructions may be given by hoisting signals or radio, if the load to be moved is submerged.
5.13 Install a current deflector, if applicable	5.13.1 Prepare the contact surfaces 5.13.2 Install anchors and trunnions 5.13.3 Secure the deflector	
5.14 Install a sedimentation curtain, if applicable	5.14.1 Install anchors and trunnions 5.14.2 Secure the curtain 5.14.3 Ballast the curtain	
TASK 6: REPAIR SUBMERGED CONCRETE STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
6.1 Do the tracing and marking	6.1.1 Determine the area to be repaired 6.1.2 Trace the sawing lines	According to the participants, tracing consists of reproducing a line on the structure, whereas marking is constituted by distinct points. Tracing and marking serve to delimit the part of the structure that has to be removed.
6.2 Saw the concrete	6.2.1 Prepare the sawing equipment (hydraulic or pneumatic) 6.2.2 Check the condition of the blade and other components 6.2.3 Follow the sawing lines traced	
6.3 Break the concrete and, if applicable, roughen the concrete to be removed	6.3.1 Prepare the equipment (hydraulic or pneumatic) 6.3.2 Check the condition of the point and other components 6.3.3 Control the breaking or roughening	
6.4 Drill the mass concrete	6.4.1 Prepare the equipment (hydraulic or pneumatic) 6.4.2 Check the condition of the bit and other components 6.4.3 Follow the drill points established	

SECTION II: REPAIR WORK

TASK 6: REPAIR SUBMERGED CONCRETE STRUCTURES

Operations	Sub-Operations	Clarifications
6.5 Place the reinforcing steel, anchors and tie beams, if applicable	6.5.1 Prepare the reinforcing steel, anchors and tie beams 6.5.2 Proceed with the installation	
6.6 Clean the structure		Cleaning is generally done using high-pressure equipment, so as to remove all concrete residues.
6.7 Build the formwork and put it in place	6.7.1 Prepare the formwork and reinforcements on the surface 6.7.2 Check the dimensions of assembled formwork 6.7.3 Ballast the formwork, if applicable 6.7.4 Immerse the formwork 6.7.5 Position the formwork 6.7.6 Anchor and tighten the formwork 6.7.7 Make sure the formwork covers the entire area targeted	
6.8 Make sure the formwork is watertight	6.8.1 Check the formwork's watertightness 6.8.2 Detect and, if applicable, plug the leaks	Rapid concrete is applied to the formwork perimeter to make the formwork watertight.
6.9 Place the concrete or cement grout in the formwork	6.9.1 Install the concrete pump or grout hoses 6.9.2 Detect and plug eventual leaks	
6.10 Strip the formwork, if applicable	6.10.1 Remove the anchors 6.10.2 Remove the chords 6.10.3 Disassemble and remove the formwork	
6.11 Ensure the quality of the work	6.11.1 Check the repairs made	
6.12 Resurface the concrete	6.12.1 Apply rapid concrete 6.12.2 Do the finish with a surface grinder	

SECTION II: REPAIR WORK

TASK 6: REPAIR SUBMERGED CONCRETE STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
6.13 Do an "as-built"	6.13.1 Draw a sketch of the structure 6.13.2 Copy repair measurements on the sketch 6.13.3 Record repairs on video	
6.14 Fill out your daily report		The daily report contains a list of tasks performed by the diver during his work day. It enables the diver's employer to bill his client for work done.

TASK 7: REPAIR SUBMERGED STEEL STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
7.1 Prepare the parts on the surface	7.1.1 Cut the parts 7.1.2 Grind the parts 7.1.3 Fold the parts 7.1.4 Weld and oxygen cut the parts 7.1.5 Assemble the parts	
7.2 Cut the steel in the water		Cutting may be done by underwater oxygen cutting, or with a grinding stone, a hacksaw, etc. Templates may be used.
7.3 Align and install structural elements	7.3.1 Position the elements 7.3.2 Check and correct their alignment 7.3.3 Fasten the elements by bolting or welding	To align the elements, the diver may use a plumb line, inverted pendulum, ruler, surveying tape, chain, etc.
7.4 Place the concrete or cement grout inside the steel structure	7.4.1 Clean the surfaces before the pour 7.4.2 Fill the structure with concrete or cement grout	Concrete or cement grout is put in place by a concrete pump, injection or gravity.
7.5 Ensure the quality of the work	7.5.1 Compare the work with the plans periodically 7.5.2 Make a full inspection before the pour 7.5.3 Make a full inspection after the pour 7.5.4 Record on video the entire structure, the welds, the bolting, the pour, etc.	

SECTION II: REPAIR WORK

TASK 7: REPAIR SUBMERGED STEEL STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
7.6 Do an "as-built"	7.6.1 Draw a sketch of the structure 7.6.2 Copy the repair measurements on the sketch 7.6.3 Record the repairs on video	
7.7 Fill out your daily log		See the clarifications on Operation 6.14.

TASK 8: REPAIR SUBMERGED WOOD STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
8.1 Prepare the parts on the surface	8.1.1 Predrill parts 8.1.2 Cut parts 8.1.3 Assemble the parts 8.1.4 Apply protection tape	
8.2 Cut the wood in the water	8.2.1 Unbolt and remove the parts 8.2.2 Trace and cut the parts	
8.3 Align and install structural elements	8.3.1 Position the elements 8.3.2 Check and correct their alignment 8.3.3 Fasten the elements	
8.4 Ballast the wooden parts		Wood parts may be ballasted with various materials: steel, lead, sandbags, etc.
8.5 Replace stringpieces, foot planks and cross-pieces		
8.6 Install log bolts or tie beams	8.6.1 Predrill the elements 8.6.2 Proceed with the installation	
8.7 Consolidate the structure (inner or outer riprap)		
8.8 Ensure the quality of the work		

SECTION II: REPAIR WORK

TASK 8: REPAIR SUBMERGED WOOD STRUCTURES		
Operations	**Sub-Operations**	**Clarifications**
8.9 Do an "as-built"	8.9.1 Draw a sketch of the structure 8.9.2 Copy the repair measurements on the sketch 8.9.3 Record the repairs on video	
8.10 Fill out your daily log		See the clarifications on Operation 6.14.

SECTION III: INSTALLATION WORK

TASK 9: PREPARE INSTALLATION WORK		
Operations	**Sub-Operations**	**Clarifications**
9.1 Read the plans and specifications		
9.2 Mobilize the diving station's work area	9.2.1 Delimit the work area on the surface 9.2.2 Move the tools and equipment to the work area 9.2.3 Limit access to the site	See the clarifications on Operation 5.2.
9.3 Coordinate with other trades and occupations and with your work team		
9.4 Establish the position in relation to surface markings (chaining and bathymetry)	9.4.1 Check the sea floor (echo sounder, surveying tape, depth gauge, etc.) 9.4.2 Write on the plans the data found on the site 9.4.3 Use chaining to mark and trace the exact location of the work	See the clarifications on Operation 5.3.
9.5 Clean support surfaces (for anodes and cofferdams)		Surfaces may be cleaned with sandblasting, water jet, high-pressure air jet, a grinding stone, a brush or a scraper.
9.6 Take residual thickness ultrasound measurements (for metal parts), if applicable	9.6.1 Take measurements with an ultrasound device 9.6.2 Copy on the plans the measurements obtained	

SECTION III: INSTALLATION WORK

TASK 9: PREPARE INSTALLATION WORK

Operations	Sub-Operations	Clarifications
9.7 Excavate or check the excavation (for pipes)		See the clarifications on Operation 5.10.
9.8 Install holding plates, trunnions and sills (for cofferdams)		
9.9 Rig the elements to be hoisted, if applicable	9.9.1 Weigh the elements to be moved 9.9.2 Choose the hoisting equipment 9.9.3 Install anchors on the elements, if applicable 9.9.4 Rig the elements with straps, slings, cables, etc. 9.9.5 Perform hoisting tests, if applicable	Hoisting may be done with a crane, winch, bridge crane, chain hoist, etc.
9.10 Direct the hoisting, if applicable	9.10.1 Use hoisting signals 9.10.2 Maintain attention on the element being moved 9.10.3 Guide the element with a rope	The diver performs this operation when an operator or crane operator does the hoisting. Instructions may be given by hoisting signals or radio, if the load to be moved is submerged.
9.11 Install a current deflector, if applicable		
9.12 Install a sedimentation curtain, if applicable		

SECTION III: INSTALLATION WORK

TASK 10: INSTALL PIPES

Operations	Sub-Operations	Clarifications
10.1 Prepare pipe sections on the surface	10.1.1 Clean the bolts 10.1.2 Grease the bolts 10.1.3 Check the bolts 10.1.4 Preassemble the sections	
10.2 Align and place the pipe section	10.2.1 Check the alignment of holes 10.2.2 Check the section's slope 10.2.3 Check the ballast blocks (or other support system) 10.2.4 Make corrections, if applicable (add supports, move obstacles, etc.)	Pipe sections are aligned with a surveyor's assistance.
10.3 Level the pipe section		
10.4 Abut the other pipe sections		
10.5 Consolidate the pipe sections	10.5.1 Check the pipes 10.5.2 Make corrections, if applicable 10.5.3 Do the riprap or install a concrete overlay	
10.6 Ensure the quality of the work	10.6.1 Clean the pipe 10.6.2 Compare the work with the plans periodically 10.6.3 Record on video all pipes, connections, etc.	
10.7 Backfill		Backfilling may be done manually by the diver or by an operator with a mechanical shovel. In the latter case, the diver directs the backfilling, which he will inspect once it is completed.

SECTION III: INSTALLATION WORK

TASK 10: INSTALL PIPES		
Operations	**Sub-Operations**	**Clarifications**
10.8 Do an “as-built”	10.8.1 Note and get approval of the modifications made during the work 10.8.2 Record the modifications on video 10.8.3 Compile information on the work (video, plans, measurements, sketches, etc.)	
10.9 Fill out your daily log		

TASK 11: INSTALL MEMBRANES		
Operations	**Sub-Operations**	**Clarifications**
11.1 Prepare membrane sections on the surface	11.1.1 Roll up the membrane on a ballasted cylinder 11.1.2 Cut excess membrane	The membranes are made of geotextile fabric or rubber.
11.2 Extend the membrane section	11.2.1 Unroll the membrane from top to bottom 11.2.2 Maintain constant tension to avoid folds	
11.3 Ballast or anchor the membrane section		Sandbags attached in rows and placed at the bottom of the membrane constitute an effective ballast.
11.4 Backfill the membrane section		Backfilling may be done manually by the diver or by an operator with a mechanical shovel. In the latter case, the diver directs the backfilling, which he will inspect once it is completed.
11.5 Cut the excess membrane section, after the backfill		
11.6 Place the other sections so that they overlap		

SECTION III: INSTALLATION WORK

TASK 11: INSTALL MEMBRANES

Operations	Sub-Operations	Clarifications
11.7 Consolidate the membrane sections	11.7.1 Check the sections 11.7.2 Make corrections, if applicable 11.7.3 Do the riprap	
11.8 Ensure the quality of the work	11.8.1 Compare the work with the plans periodically 11.8.2 Check the quality of the work 11.8.3 Detect and correct eventual anomalies as the work proceeds 11.8.4 Record on video all sections, overlap, etc. 11.8.5 Check the membrane's watertightness with milk or colorant	
11.9 Do an "as-built"	11.9.1 Compile information on the work (video, plans, measurements, sketches, etc.)	
11.10 Fill out your daily log		See the clarifications on Operation 6.14.

TASK 12: INSTALL ANODES

Operations	Sub-Operations	Clarifications
12.1 Prepare the anodes on the surface	12.1.1 Grind the sides to ensure weld adherence 12.1.2 Weld C-shaped profiles, if applicable 12.1.3 Align the flat irons 12.1.4 Number the anodes, if applicable	The numbering of anodes facilitates the work follow-up and the quality control.
12.2 Remove the existing anode system, if applicable	12.2.1 Sling the anode system with the flat iron support 12.2.2 Cut the welds 12.2.3 Remove the system and remove it from the water 12.2.4 Clean the surface	
12.3 Do the tracing and marking	12.3.1 Mark the anode's exact position	

SECTION III: INSTALLATION WORK

TASK 12: INSTALL ANODES

Operations	Sub-Operations	Clarifications
12.4 Align and adjust the anodes	12.4.1 Straighten the anode legs 12.4.2 Make sure the anodes do not come in contact with the structure 12.4.3 Align the anodes	
12.5 Weld the anodes in place	12.5.1 Do the grounding 12.5.2 Adjust the welding machine to the correct amperage 12.5.3 Weld on the required length 12.5.4 Check the quality of welds 12.5.5 Make corrections, if applicable	
12.6 Connect cables and terminals	12.6.1 Extend the cables to the junction box 12.6.2 On the surface, connect the cables to the terminals 12.6.3 Perform a continuity test	
12.7 Install sheathing for electric cables	12.7.1 Weld angle irons to the predetermined locations 12.7.2 Weld on the required length	
12.8 Ensure the quality of the work	12.8.1 Compare the work with the plans periodically 12.8.2 Check the quality of the work 12.8.3 Detect and correct eventual anomalies as the work proceeds 12.8.4 Record on video all the work, welds, etc.	
12.9 Do an “as-built”	12.9.1 Note and get approval of modifications made during the work 12.9.2 Record the modifications on video 12.9.3 Compile information on the work (video, plans, measurements, sketches, etc.)	
12.10 Fill out your daily log		See the clarifications on Operation 6.14.

SECTION III: INSTALLATION WORK

TASK 13: INSTALL COFFERDAMS AND STOP LOGS

Operations	Sub-Operations	Clarifications
13.1 Check the cofferdam bedding	13.1.1 Check the structure's solidity 13.1.2 Prepare support surfaces	
13.2 Prepare cofferdam components or stop log grooves	13.2.1 Ensure the good operation of valves, hoses and sealing joints 13.2.2 Install cofferdam components on the surface, if applicable	
13.3 Install the retaining system for the cofferdam or stop log	13.3.1 Drill and install anchors in the existing structure, if applicable 13.3.2 Secure the cofferdam with the existing attachment system, if applicable 13.3.3 Use trunnions to secure the cofferdam to the retaining system	
13.4 Align and adjust the cofferdam		
13.5 Fill the cofferdam with water, if applicable		
13.6 Secure the cofferdam or stop log to the structure, if applicable		
13.7 Install submersible pumps and hoses, if applicable	13.7.1 Arrange the hoses so as to facilitate the diver's movements 13.7.2 Check the condition of collars 13.7.3 Connect the hoses to the pumps 13.7.4 Make sure the hoses are not twisted	
13.8 Plug the leaks, if applicable	13.8.1 Detect leaks 13.8.2 Repair leaks	

SECTION III: INSTALLATION WORK

TASK 13: INSTALL COFFERDAMS AND STOP LOGS

Operations	Sub-Operations	Clarifications
13.9 Ensure the quality of the work	13.9.1 Compare the work with the plans periodically 13.9.2 Check the quality of the work 13.9.3 Detect and correct eventual anomalies as the work proceeds 13.9.4 Ensure that the quantity of leaks detected does not exceed requirements 13.9.5 Record all the work on video	
13.10 Demobilize the cofferdam or stop log		
13.11 Do an “as-built”	13.11.1 Note and get approval of modifications made during the work 13.11.2 Record the modifications on video 13.11.3 Compile information on the work (video, plans, measurements, sketches, etc.)	
13.12 Fill out your daily log		See the clarifications on Operation 6.14.

2.3 ACHIEVEMENT CONDITIONS

Data on achievement conditions were collected for the diver occupation as a whole. The data pertain to aspects such as workplaces, work instructions, health and safety hazards, reference documents consulted, material resources used, etc.

Table 2.3 Achievement Conditions

ACHIEVEMENT CONDITIONS
Workplaces[13] Divers almost always work outdoors, but some activities may be performed on their employer's premises (planning the work, writing the diving log, etc.). Divers have to work in lakes, rivers and the St. Lawrence River, so in fresh or salt water. They work mainly for civil engineering construction companies that work on various types of submerged structures: port facilities, hydro-electric dams, bridge pillars, dykes, stockades, navigational locks, paper mill infrastructures, basins, etc. To that end, divers work from the shore or from crafts, piers, barges, launching ramps, bridges, etc. The sites where the work is done present a wide variety of characteristics: some sites pose specific hazards such as underwater currents, pressure differentials, contaminated water, ice, etc. Other hazards are very limited visibility and, in some cases, very cold or hot water (e.g.: paper mill basins).
Collaboration and supervision All the work is done in a team of at least three divers[14]. In that team, the following roles are allocated clearly and precisely: diving, assistance, and directing operations. In addition to members of their team, divers have to collaborate with workers from other trades (reinforcing steel erectors, crane operators, electricians, carpenter-jointers, etc.) and with various professionals such as engineers, surveyors, etc. Underwater work is done individually, with the support of personnel on the surface, and under the supervision of the team leader. In some cases, a client representative may also supervise the divers' work.

13. Non-exhaustive list.
14. The number of divers required for doing the work is determined by decree 425.2010 amending the Act respecting occupational health and safety and the Act respecting industrial accidents and occupational diseases.

ACHIEVEMENT CONDITIONS
Instructions Divers receive verbal instructions from their team leader or the supervisor, and in some cases from a client representative. Instructions are also given by the manufacturers of products or equipment used.
Stress factors The main stress factors that divers must cope with are the following: ▪ risks inherent to various work environments; ▪ presence of certain marine wildlife species; ▪ weather factors (intense cold or heat, wind, current, waves, etc.); ▪ limited visibility; ▪ requirement to satisfy the client and the employer; ▪ work that is more complex or difficult; ▪ work that would require assistance from another diver, but is done individually; ▪ risks involved in using certain tools (e.g.: concrete saw); ▪ relations with the client, team leader and team members; ▪ poor communication with others involved; ▪ productivity requirements and tight deadlines; ▪ complexity of certain plans; ▪ job insecurity.
References The main references used by divers are the following: ▪ decompression tables; ▪ plans and specifications; ▪ nautical charts; ▪ manuals of equipment manufacturers; ▪ CSA standards; ▪ health, safety and environmental regulations; ▪ WHMIS data sheets; ▪ rules specific to certain clients; ▪ the employer’s documents.

ACHIEVEMENT CONDITIONS
Raw materials, tools and equipment Annex 1 of this report contains a list of material resources used by divers in practising their occupation.
Health and safety hazards According to the participants, the main health and safety hazards facing divers are the following: ▪ drowning; ▪ hypothermia; ▪ barotrauma; ▪ problems caused by decompression; ▪ backache and joint pain caused by the weight of equipment and materials to be transported; ▪ joint pain related to humidity and intense cold; ▪ electrocution; ▪ injuries from contact with marine wildlife (e.g.: sea urchins); ▪ pulmonary problems (gas disease, lipid pneumonia, etc.); ▪ intoxications from diving in contaminated environments; ▪ various injuries caused by pressure differentials, equipment in motion, moving a load, etc. ▪ etc. Moreover, Annex 2 of this report contains a more detailed list of hazards related to the tasks and operations of the diver occupation, as well as applicable preventive measures.

2.4 PERFORMANCE CRITERIA

Performance criteria were gathered for each task. They are used for assessing whether the tasks were performed satisfactorily. The criteria pertain to aspects such as the quantity and quality of work done, the observance of a work procedure, the attitudes adopted, etc.

To draw the list of criteria for each task, the participants worked in teams of two or three. Some criteria may thus be relevant for other tasks than those for which they were retained.

Table 2.4 Performance Criteria

TASK 1 DIVE
Performance Criteria
▪ Observance of health and safety regulations ▪ Harmonious relations with other team members ▪ Correct installation of the rescue system ▪ Breathing control ▪ Complete and compliant evacuation plan ▪ Meeting deadlines ▪ Economy of material ▪ Careful use of tools and equipment ▪ Methodical work ▪ Adequately securing the work areas (removing unstable elements, appropriate delimitation of the work area, etc.) ▪ Observance of descent and ascent times (decompression tables) ▪ Adequate control of the umbilical cord's position ▪ Complete, legible and signed diving logbook ▪ Effective planning of tool and equipment needs ▪ Clear and precise communications
TASK 2 ASSIST THE DIVER DURING A DIVE
Performance Criteria
▪ Observance of health and safety regulations ▪ Harmonious relations with other team members ▪ Effective planning of tool and equipment needs ▪ Preparing all tools and equipment ▪ Well-supplied and operational diving apparatus ▪ Carefully cross checking the good condition and appropriate installation of diving apparatus ▪ Emergency equipment in good condition and well installed ▪ Carefully checking that all team members understand the emergency plan ▪ Methodical work ▪ Attentive support, until launching, to the one who will dive ▪ Carefully checking the umbilical cord's free movement ▪ Proactive and alert attitude toward the diver's tool and equipment needs while he is diving ▪ Meticulous detection of any breakage or defect ▪ Constantly monitoring the equipment ▪ Orderly arrangement and solid fastening of tools and equipment after their use ▪ Careful use of tools and equipment ▪ Calm and initiative

TASK 3 **DIRECT DIVING OPERATIONS**

Performance Criteria

- Observance of health and safety regulations
- Effectively planning, organizing, directing and monitoring the work
- Effective planning of tool and equipment needs
- Observance of decompression tables
- Diligent control of work quality
- Harmonious and trusting relations between team members
- Effective management of eventual disputes
- In-depth experience of the field
- Meeting schedules and deadlines
- Clear guidelines given to team members
- Quick and appropriate reaction to unforeseen events
- Establishing a climate of trust with the client
- Leadership and self-confidence

TASK 4 **MAINTAIN AND REPAIR DIVING APPARATUS, OTHER EQUIPMENT AND TOOLS**

Performance Criteria

- Observance of health and safety regulations
- Attentive inspection of tools and equipment
- Meticulous detection of any breakage or defect
- Correctly determining repairs to be made
- Effective temporary repair of items to be repaired by an expert
- Following manufacturer recommendations about tools and equipment
- Observance of repair methods and rules in effect
- Order and cleanliness of the diving unit
- Operational and safe tools and equipment
- Patience and attention de detail

TASK 5 **PREPARE TO REPAIR SUBMERGED STRUCTURES**

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Correct interpretation of plans and specifications
- Exact overall vision of the work to be done
- Precise measurements
- Sound assessment of hazards
- In-depth examination of the structure and materials
- Careful use of tools and equipment
- Appropriately choosing and installing scaffolds, if applicable
- Sound choice of hoisting equipment
- Correct rigging of loads to be lifted
- Appropriate use of hoisting signals

TASK 6 **REPAIR SUBMERGED CONCRETE STRUCTURES**

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Manifest experience with formwork and concrete work
- Following tracing instructions
- Careful use of tools and equipment
- Observance of bushhammering, drilling, concrete breaking and armature pinning
- Watertight and well positioned formwork
- Precise injection of products, if applicable
- Clear and precise “as-built”
- Complete daily report

TASK 7 REPAIR SUBMERGED STEEL STRUCTURES

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Accurate and exact measurements
- Observance of welding (Arcair) and cutting techniques
- Careful use of tools and equipment
- Aesthetic structure or assemblies
- Precise assemblies
- Quick execution
- Clear and precise “as-built”
- Complete daily report

TASK 8 REPAIR SUBMERGED WOOD STRUCTURES

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Careful use of tools and equipment
- Observance of methods and techniques
- Precise work execution
- Quick execution
- Observance of budgetary constraints
- Clear and precise “as-built”
- Complete daily report

TASK 9 **PREPARE INSTALLATION WORK**

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Exact overall vision of the work to be done
- Accurate and exact measurements
- Sound interpretation of plans and specifications
- Careful use of tools and equipment
- Observance of methods and techniques
- Logical sequence of execution
- Immediately signalling any nonconformity or problem
- Quick execution
- Clear and precise “as-built”

TASK 10 **INSTALL PIPES**

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Observance of methods and techniques
- Observance of plans and specifications and surveying data
- Logical sequence of execution
- Careful use of tools and equipment
- Quick execution
- Clear and precise “as-built”
- Complete daily report

TASK 11 INSTALL MEMBRANES

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Observance of methods and techniques
- Observance of plans and specifications
- Logical sequence of execution
- Careful use of tools and equipment
- Quick execution
- Clear and precise “as-built”
- Complete daily report

TASK 12 INSTALL ANODES

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Carefully checking the type of anode and the condition of its components
- Correctly removing the existing system, if applicable
- Appropriately cleaning the surface
- Precisely tracing the installation level
- Observance of methods and techniques
- Observance of plans and specifications
- Compliant welding and at appropriate locations
- Precise measurements for protecting cables
- Quick execution
- Clear and precise “as-built”
- Complete daily report

TASK 13 INSTALL COFFERDAMS AND STOP LOGS

Performance Criteria

- Observance of health and safety regulations
- Observance of environmental regulations
- Effective communication with team members and others involved (surveyors, engineers, etc.)
- Observance of methods and techniques
- Observance of plans and specifications
- Correct installation of the fastening system
- Appropriately installed and correctly located pump hoses
- Watertight cofferdam
- Correctly detecting and plugging of eventual leaks
- Quick execution
- Clear and precise “as-built”
- Complete daily report

2.5 FUNCTIONS

Functions are a set of interrelated tasks. That set may be defined by the work's results or by a procedure.

For the diver occupation, three functions appear to stand out:

- a function related to **diving operations**, and grouping the following tasks:
  - Task 1, "Dive";
  - Task 2, "Assist the diver during a dive";
  - Task 3, "Direct diving operations";
  - Task 4, "Maintain and repair diving apparatus, other equipment and tools";
- a function related to **repairs**, and grouping the following tasks:
  - Task 5, "Prepare to repair submerged structures";
  - Task 6, "Repair submerged concrete structures";
  - Task 7, "Repair submerged steel structures";
  - Task 8, "Repair submerged wood structures";
- a function related to **installation**, and grouping the following tasks:
  - Task 9, "Prepare installation work";
  - Task 10, "Install pipes";
  - Task 11, "Install membranes";
  - Task 12, "Install anodes";
  - Task 13, "Install cofferdams and stop logs."

3. QUANTITATIVE DATA ON TASKS

3.1 OCCURRENCE

Occurrence data concern the percentage of divers who perform a task in the same work environment. The data presented in the tables below are the average results of the divers who attended the workshop. However, they account for tasks performed not only by the participants, but also by all divers working in the companies represented.

Table 3.1 Task Occurrence

	Task	Occurrence
1	Dive	100.00%
2	Assist the diver during a dive	100.00%
3	Direct diving operations	34.23%
4	Maintain and repair diving apparatus. other equipment and tools	52.85%
5	Prepare to repair submerged structures	83.85%
6	Repair submerged concrete structures	97.69%
7	Repair submerged steel structures	98.46%
8	Repair submerged wood structures	76.92%
9	Prepare installation work	82.31%
10	Install pipes	78.07%
11	Install membranes	76.15%
12	Install anodes	60.38%
13	Install cofferdams and stop logs	76.15%

3.2 WORK TIME

Work time, expressed below in percentages, represents the average time allocated to each task by each participant, on an **annual** basis.

Given that diving tasks and repair and installation tasks are performed simultaneously, the participants allocated their work time first between Tasks 1 to 4 and then between Tasks 5 to 13.

Table 3.2 Allocation of Work Time for Each Diving Task

Task		Work Time
1	Dive	23.72%
2	Assist the diver during a dive	26.03%
3	Direct diving operations	34.23%
4	Maintain and repair diving apparatus, other equipment and tools	16.02%
		100.00%

Table 3.3 Allocation of Work Time for Each Repair and Installation Task

Task		Work Time
5	Prepare to repair submerged structures	12.73%
6	Repair submerged concrete structures	22.92%
7	Repair submerged steel structures	24.08%
8	Repair submerged wood structures	8.16%
9	Prepare installation work	8.96%
10	Install pipes	5.65%
11	Install membranes	2.58%
12	Install anodes	6.54%
13	Install cofferdams and stop logs	8.38%
		100.00%

3.3 IMPORTANCE AND DIFFICULTY OF TASKS

The **importance** of a task is estimated according to the more or less harmful consequences of performing a task poorly or not at all. The importance is assessed according to the following scale:

1. Not important at all: Poor execution of the task has no consequences on the quality of the result, the costs, health and safety, etc.

2. Not very important: Poor execution of the task could lead to minimal costs, a result of lower quality, minor injury or accident hazards, etc.

3. Important: Poor execution of the task could lead to an unsatisfactory result, substantial additional costs, injuries, accidents, etc.

4. Very important: Poor execution of the task could lead to an unacceptable result and very major consequences in terms of costs, safety, etc.

A task's **difficulty** is assessed according to the following scale:

1. Very easy: The task involves little risk of error; it requires no notable physical or mental effort. Performing the task is less difficult than average.

2. Easy: The task involves a few risks of error; it requires minimal physical or mental effort.

3. Difficult: The task involves many risks of error; it requires a good physical or mental effort. Performing the task is more difficult than average.

4. Very difficult: The task involves a high risk of error; it requires substantial physical or mental effort. The task is among the most difficult in the occupation.

The data presented in the table below are the average results for the workshop participants.

Table 3.4 Importance and Difficulty of Tasks

	Task	Importance	Difficulty
1	Dive	3.69	2.81
2	Assist the diver during a dive	3.54	2.27
3	Direct diving operations	4.00	3.27
4	Maintain and repair diving apparatus, other equipment and tools	3.92	2.27
5	Prepare to repair submerged structures	3.31	2.54
6	Repair submerged concrete structures	3.38	2.77
7	Repair submerged steel structures	3.31	2.77
8	Repair submerged wood structures	3.31	3.08
9	Prepare installation work	3.23	2.46
10	Install pipes	3.38	2.50
11	Install membranes	3.23	2.60
12	Install anodes	3.27	2.45
13	Install cofferdams and stop logs	3.67	2.75

4. KNOWLEDGE, SKILLS AND ATTITUDES

The occupational analysis enabled us to specify some of the knowledge, skills and attitudes necessary for performing the tasks. Those qualities are transferable, i.e., applicable to a variety of tasks and situations.

The following pages present the knowledge, skills and attitudes that, according to the participants, are considered essential for performing the tasks of the diver trade.

4.1 KNOWLEDGE

Anatomy and physiology

Divers must know the potential effects of diving on the nervous, respiratory, cardiovascular and digestive systems, and on the bone structure, muscles, etc. They must be able to recognize the causes and consequences of illnesses and accidents related to decompression as well as barotrauma, risks of drowning or asphyxiation, gas elimination mechanisms from tissues, etc.

Electricity

Divers must know basic laws and principles of electricity to perform certain tasks and to maintain and repair diving apparatus, radio communication equipment, etc.

Handling and hoisting

Divers must be able to apply necessary calculations for estimating a load's weight. They must know the various types of hoisting equipment available and their respective capacities, so as to choose the appropriate equipment. Knowledge of rigging equipment and techniques is also essential, as well as knowledge of signals used for directing the hoisting. The participants added that divers may have to drive lift trucks; so they must know the safe driving rules for this type of equipment.

Materials and products

Divers must know the basic characteristics (resistance, expansion, contraction, etc.) of materials with which they have to work most often, such as various metals, concrete, etc. They also must know the causes for the deterioration of submerged materials, types of corrosion, etc.

Moreover, because they use various products that may be hazardous to their health and safety, they must know the WHMIS regulations and be able to interpret material safety data sheets correctly.

Mathematics

Divers regularly use the four basic operations to perform calculations related, for example, to taking measurements, calculating the diving period, planning decompression, calculating the weight and volume of loads, calculating the buoyancy of various objects, etc. They also have to apply basic concepts of algebra and trigonometry, calculate angles or areas, convert units from one measurement system to the other, etc.

Navigation

Divers must know the rules for driving small crafts; they must hold the Pleasure Craft Operator Card issued by Transport Canada. They must also know aquatic safety rules[15], regulations in effect, and seamanship techniques (e.g.: knots).

Physics

Drivers must know certain laws and principles of physics; the main ones are:

- the kinetic theory of gases;
- the law of Boyle-Mariotte;
- pressure force;
- Dalton and Henry's law;
- Gay-Lussac's law;

15. According to Transport Canada and Marine Personnel Regulations, FUM A4 is replaced by the Small Vessel Operator Proficiency Certificate and the Pleasure Craft Operator Card. For the application of each one, consult sections 205 and 212 of the Regulations.

- the Archimedean buoyant force;
- the pulley principle;
- the buoyancy principle;
- basic principles of fluid mechanics;
- etc.

Plans and sketches

Although the participants said that the plans that divers have to interpret are relatively simple, divers still must know the basic elements of reading plans (views, symbols, scales, etc.). Moreover, divers must frequently draw sketches, whether to take measurements or to record work done on a structure. Those sketches are hand-drawn, but must follow certain basic principles so that a technician can later reproduce them with drawing software.

Diving

Divers must of course know the techniques of surface-supplied diving with air and enriched air (e.g.: Nitrox), decompression tables, etc. They must master all safety measures regarding the apparatus and work methods, in every environment, including those involving specific hazards. They must be able to provide first aid in emergencies; in fact, they must hold a valid oxygen therapy certificate.

Divers who operate a hyperbaric chamber must know the regulations for installing and using such a chamber; they must hold a certification to that effect, renewable every three years[16]. They must be able to start treatment to divers who require it, while preventing potential accidents related to the use of such chambers.

16. According to the Regulation respecting the professional activities that may be engaged in by a hyperbaric chamber operator, Medical Act (c. M-9, s. 3), Professional Code (c. C-26, s. 94, subsection *h* and par. 94.1).

Welding

Divers use the shielded metal arc welding (SMAW) process and the underwater oxygen cutting process. So they must have a good knowledge of related equipment, techniques and safety measures. Those welding processes are applied in various positions: flat, vertically, horizontally and on the ceiling. Moreover, in some cases, the client company may require the diver to be qualified according to Canadian Welding Bureau (CWB) standards.

4.2 SKILLS

Skills are types of know-how. They are divided into three categories: cognitive, motor and perceptual.

Cognitive skills

Cognitive skills pertain to intellectual strategies applied in working. The main cognitive skills that divers need are the following:

- problem-solving (e.g.: to face unforeseen events and a variety of situations);
- analytic and decision-making ability (e.g.: to choose work methods, assess the danger of a site or of certain tasks).

Motor skills

Motor skills involve making gestures and movements. The main motor skills that divers need are the following:

- dexterity;
- flexibility;
- physical endurance.

Perceptual skills

Perceptual skills are sensory skills enabling a person to perceive by his senses what is happening in his environment.

The main perceptual skills that divers need are the following:

- good vision (e.g.: to detect hazards and determine reference points);
- good hearing (e.g.: for radio communications);
- good sense of smell (e.g.: to detect certain gases);
- developed tactile skills (e.g.: to recognize objects by touch or to perform certain tasks when visibility is almost nonexistent);
- spatial – three-dimensional – representation ability (e.g.: to find one's way according to plans or a verbal description);
- ability to find one's way without visible reference points.

4.3 ATTITUDES

Attitudes are ways of acting, reacting and relating with others or with one's environment. They involve personal skills. The main attitudes that divers need are the following:

- respect for others and team spirit, ability to work and live within a group;
- preventive attitude, for oneself and other team members;
- harmonious and clear communication;
- good morale and positive attitude;
- calm and composure;
- rigour and patience.

The participants insisted on the importance of teamwork for divers. A person who lacks teamwork ability and is incapable of maintaining good relations could not work as a diver. The work requires constant collaboration between all team members. This does not only mean ensuring a pleasant working atmosphere, as in other fields; poor communication can have very grave consequences for the safety of a diver – particularly the one who is diving.

5. TRAINING SUGGESTIONS

Initial training

The participants made the following suggestions about various aspects of initial training:

- tighten the candidate selection criteria and favour candidates with experience in construction or similar work, thus preventing new divers from being shocked when starting to work on construction sites;
- reject candidates who want to take the training in order to learn how to dive but who don't necessarily intend to work in construction;
- plan two internship periods in the workplace during the training – one at the beginning and the other at the end;
- increase the hours of practice related to construction work, as well as the hours of diving. The hours of diving are estimated at 75 hours over two years, in accordance with the CSA's competency standard for diving operations (CSA Z 275.4), but that is insufficient for truly preparing candidates to work as divers in the construction industry;
- dispense training as vocational training in high school, rather than in college, to better suit the actual nature of the occupation in the construction industry.

Continuous training and professional development

In terms of professional development, the participants suggest activities pertaining to the following subjects:

- welding;
- pneumatic tools;
- compressor maintenance;
- diving in contaminated environments;
- ultrasound;
- sawing and drilling concrete underwater;
- visual inspection, maintenance and repair of cylinders;
- maintenance and repair of small motors.

The participants also suggested the following:

- adapt the course schedule to the availability of the majority of divers, who are available mainly in January and February;
- group in the same session the three courses on pressure differentials, hyperbaric chambers and oxygen therapy;
- allow more flexibility in access to training, for example by allowing divers to pursue training already taken several years previously;
- choose instructors who are **experts in the subject** of the training, and not necessarily divers.

Annexes

Annex 1

RAW MATERIALS, TOOLS AND EQUIPMENT

During the workshop, lists of raw materials, tools and equipment were presented to the participants. The following pages contain, for each task, a list of raw materials, tools and equipment validated by the participants.

It should be noted that equipment directly related to diving was examined particularly by the teams who focused on Tasks 1 to 4. Thus, the teams who examined equipment necessary for other tasks did not necessarily evaluate the use of diving apparatus. Accordingly, a dash appears in the Task 5 to 13 columns for diving apparatus, to indicate that it was not considered.

Greyed-out boxes indicate items that **are not** used.

Table A.1 Tools and Equipment

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
SUPPLY EQUIPMENT – BREATHABLE COMPRESSED AIR													
Low pressure compressor (flow rate of 80 to 100 SCFM / pressure of 250 to 300 psig) powered electrically or by an internal combustion engine					–	–	–	–	–	–	–	–	–
Compressed air tank (low pressure)					–	–	–	–	–	–	–	–	–
High pressure compressor (flow rate of 20 CFM / pressure of 3000 to 5000 psig) powered electrically or by an internal combustion engine					–	–	–	–	–	–	–	–	–

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Cylinders (200 to 600 ft³)					–	–	–	–	–	–	–	–	–
Connections (pigtails)					–	–	–	–	–	–	–	–	–
High pressure regulatorss (outlet pressure of 600 psig) with pressure gauges and adjustment wheel					–	–	–	–	–	–	–	–	–
Coalescing and absorbent filters (low and high pressure compressor)					–	–	–	–	–	–	–	–	–
Manifold console (air intake and distribution, valves and pressure gauges)					–	–	–	–	–	–	–	–	–
Lines and pipes (high pressure)					–	–	–	–	–	–	–	–	–
Lines and hoses (low pressure)					–	–	–	–	–	–	–	–	–
Continuous analysis system – concentration of contaminant gases					–	–	–	–	–	–	–	–	–
CO analyzer					–	–	–	–	–	–	–	–	–
Diaphragm compressor (Nitrox)					–	–	–	–	–	–	–	–	–
EQUIPMENT – HOT WATER DIVING SYSTEMS													
Boiler water heater (to heat water circulating in the coil)					–	–	–	–	–	–	–	–	–
Water tank (to avoid temperature fluctuations and have a reserve in case the water heater fails)					–	–	–	–	–	–	–	–	–
System controlling the water temperature at the tank outlet					–	–	–	–	–	–	–	–	–
Distribution lines equipped with valves, thermometer and other accessories					–	–	–	–	–	–	–	–	–
Submersible pump (supplying the water heater and tank)					–	–	–	–	–	–	–	–	–
ELECTRIC POWER SUPPLY – DIVING STATION													
Current generator (with grounding)					–	–	–	–	–	–	–	–	–
Reserve generator (breathable air and hot water supply systems)					–	–	–	–	–	–	–	–	–

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Ground leak detection system (for equipment supplying the diving apparatus with alternative current of up to 42 volts)					–	–	–	–	–	–	–	–	–
Radio					–	–	–	–	–	–	–	–	–
EMERGENCY EQUIPMENT													
First aid kit					–	–	–	–	–	–	–	–	–
Oxygen inhalation kit including: – high-concentration masks, multipurpose regulator, on-demand inhaler, ''embue-ballon'' and sufficient oxygen reserve					–	–	–	–	–	–	–	–	–
Automated external defibrillator					–	–	–	–	–	–	–	–	–
Equipped multiplace hyperbaric chamber					–	–	–	–	–	–	–	–	–
Hyperbaric chamber kit					–	–	–	–	–	–	–	–	–
Emergency communications system					–	–	–	–	–	–	–	–	–
Adapted emergency plan					–	–	–	–	–	–	–	–	–
Hyperbaric oxygen therapy tables and protocol					–	–	–	–	–	–	–	–	–
Fire extinguishers					–	–	–	–	–	–	–	–	–
Mesh stretcher and spine board					–	–	–	–	–	–	–	–	–
Life buoy					–	–	–	–	–	–	–	–	–
Rescue equipment (pressure differentials)					–	–	–	–	–	–	–	–	–
Kit in case of a fuel spill					–	–	–	–	–	–	–	–	–
ACCOMMODATION – DIVING TEAMS													
Shelter – diver (to change and rest)					–	–	–	–	–	–	–	–	–
Shelter – diving station					–	–	–	–	–	–	–	–	–
Chemical toilet					–	–	–	–	–	–	–	–	–

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Vehicle					–	–	–	–	–	–	–	–	–
Heating system					–	–	–	–	–	–	–	–	–
EQUIPMENT – LAUNCHING													
Crane, boom truck or compliant device for lifting a worker					–	–	–	–	–	–	–	–	–
RSST-compliant diver platform (more than two metres)					–	–	–	–	–	–	–	–	–
Rescue platform or craft					–	–	–	–	–	–	–	–	–
Launching ladder (two metres or less)					–	–	–	–	–	–	–	–	–
EQUIPMENT – DIVING STATION													
Valve manifold for distributing air to divers					–	–	–	–	–	–	–	–	–
Pressure gauges (breathable air supply pressures)					–	–	–	–	–	–	–	–	–
Regulatorss					–	–	–	–	–	–	–	–	–
Diving lamp power supply (110 volts DC or 42 volts AC) with potentiometer					–	–	–	–	–	–	–	–	–
Digital video camera power supply (with ground leak detector, if necessary)					–	–	–	–	–	–	–	–	–
Spot monitor					–	–	–	–	–	–	–	–	–
Voice box (and breathing monitor)					–	–	–	–	–	–	–	–	–
Contaminant gas concentration indicator for the breathable air supply					–	–	–	–	–	–	–	–	–
Pneumatic depth gauges					–	–	–	–	–	–	–	–	–
Decompression tables					–	–	–	–	–	–	–	–	–
Chronometers					–	–	–	–	–	–	–	–	–
Clock / watch					–	–	–	–	–	–	–	–	–
Thermometer (temperature of water supplying hot water suits)					–	–	–	–	–	–	–	–	–

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Assistant diver's headset					–	–	–	–	–	–	–	–	–
Digital depth gauges					–	–	–	–	–	–	–	–	–
Diving log					–	–	–	–	–	–	–	–	–
EQUIPMENT – DIVER													
Dry isothermal suit					–	–	–	–	–	–	–	–	–
Hot water suit					–	–	–	–	–	–	–	–	–
Non-jettisonable ballasting equipment					–	–	–	–	–	–	–	–	–
Flippers					–	–	–	–	–	–	–	–	–
Safety boots (sea floor work)					–	–	–	–	–	–	–	–	–
Knife					–	–	–	–	–	–	–	–	–
Ankle weights					–	–	–	–	–	–	–	–	–
Diving umbilical cord, hoses and cables to supply: – the diving helmet with air, the lamp and camera with electricity, the pneumatic depth gauge hose with air, the suit with hot water					–	–	–	–	–	–	–	–	–
Pull-out lifeline (connected to the umbilical cord)					–	–	–	–	–	–	–	–	–
Diving harness					–	–	–	–	–	–	–	–	–
Surface-supplied breathing apparatus including: – head-protecting helmet equipped with a pneumatic-control regulator and a manifold equipped with a check valve, and a free flow valve and a supply valve from the emergency self-contained breathing apparatus					–	–	–	–	–	–	–	–	–
Emergency self-contained breathing apparatus					–	–	–	–	–	–	–	–	–
Diving lamp					–	–	–	–	–	–	–	–	–
Camera					–	–	–	–	–	–	–	–	–

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Diving compass					–	–	–	–	–	–	–	–	–
Depth gauge					–	–	–	–	–	–	–	–	–
Bottom time chronometer					–	–	–	–	–	–	–	–	–
Diving computer					–	–	–	–	–	–	–	–	–
Voice communication system (in the diving helmet)					–	–	–	–	–	–	–	–	–
Soap, disinfectant					–	–	–	–	–	–	–	–	–
Neoprene gloves / mittens					–	–	–	–	–	–	–	–	–
Personal safety equipment					–	–	–	–	–	–	–	–	–
HAND TOOLS													
Metric combination wrenches (6 to 24 mm and over)													
Monkey wrenches (15 to 38 cm / 6 to 15 in. and over)													
Metric Allen wrenches (2 to 10 mm and over)													
Imperial Allen wrenches (1/16 to ¼ in. and over)													
Plug-in ratchet wrenches ¼, ⅜ and ½ in. (metric and imperial sockets)													
Plug-in (¼, ⅜ and ½ in.) extension cords (3 and 6 in.)													
Plug-in flex handle (½ to 15 in.)													
Plug-in crankshaft (⅜ and ½ in.)													
Adjustable pipe wrenches (8 to 14 in. and over)													
Long-nose pliers													
Electrician’s pliers													
Diagonal cutting pliers													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Vise-grip pliers									■			■	■
Slip joint pliers	■								■			■	■
Multiple slip joint pliers									■			■	■
Stripping pliers									■			■	■
Retaining ring pliers									■			■	■
Crimping tools				■					■			■	■
Screwdrivers (Phillips No. 2, 3 and 4)				■					■			■	■
Flat head screwdrivers (3/16, ¼ and ⅜ in.)				■					■			■	
Square head screwdrivers (Robertson No. 0, 1, 2 and 3)				■					■			■	■
Screwdrivers (Torx T20, T25, T27, T30)				■					■			■	■
Cross-hatched or bastard files (6, 8 and 10 in.)				■					■			■	■
Hacksaws (12 in.)									■			■	■
All-purpose wood saws (15 and 26 in.)	■								■			■	■
Keyhole saws	■		■			■			■			■	■
Plane	■		■	■		■			■			■	■
Wood chisel	■			■					■			■	■
Shovels	■			■					■			■	■
Levels	■			■									■
Wrecking bars	■			■					■			■	■
Swivel-base vise	■								■			■	■
Pipe vise	■		■						■			■	■
Anvil	■			■					■			■	■

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Stapler	■								■			■	
Air siphon	■											■	■
Pipe wrenches (8, 14 and 36 in.)	■								■			■	■
Square	■			■					■			■	■
Hacksaw	■								■				■
Mallets (2.5 lb)	■			■					■				■
Brick hammers	■			■					■				■
Ball-peen hammers	■			■					■			■	■
Claw hammers	■			■					■			■	
Sledgehammers (5 and 10 lb)	■			■									
Axes	■			■					■			■	■
Imperial combination wrenches (¼ to 1⅛ in. and over)												■	■
Nail claw	■	■	■	■									
Torque wrench	■	■	■	■		■		■	■	■	■	■	■
RIGGING EQUIPMENT													
Ratchet hoist (2 t)									■			■	
Hand winch													
Rope hoist (1 t)	■								■			■	■
Chain tensioner	■								■			■	■
Synthetic slings				■									■
Steel cable slings	■			■								■	■
Chain slings	■			■					■			■	■

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Ropes													
Rigging accessories (hooks, shackles, cable clamps, pulleys, turnbuckles, tackle blocks, swivel hooks)													
Hoisting devices (crane, boom winch, etc.)													
Lift bags													
POWER TOOLS													
Chuck impact drills (½ in.)													
Dremel hand-held grinding stone													
Drill press													
Chuck drills (½ in.)													
Soldering iron													
Jigsaws													
Reciprocating saws													
Circular saws													
Sawbench													
Bench grinder													
Electric disc grinding machine (4 in.)													
Electric disc grinding machine (6 in.)													
Metal chainsaws													
Mitre saws													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
PNEUMATIC TOOLS													
Air hoses and ¾ in. × 50 ft. pneumatic tool fittings with lifelines	■											■	
Mobile compressors for pneumatic tools with flow rate of 80 to 200 ft.³/minute from 150 to 200 psig	■											■	
Plug-in impact wrenches (⅜ in.)	■					■			■			■	■
Plug-in impact wrenches (½ in.)	■								■			■	■
Plug-in impact wrenches (¾ in. and 1 in.)	■	■	■	■									
Pneumatic drills (25 to 40 lb)	■											■	
Concrete breaker (40 to 70 lb)	■											■	
Chipping hammers (11 lb)	■					■						■	■
Pneumatic core drills	■		■			■			■			■	■
Pneumatic underwater grinding machines (4 in. disc)	■		■						■			■	■
Pneumatic underwater grinding machines (7 in. disc)	■								■			■	■
Rivet busters (30 lb)	■											■	
Air siphon	■			■					■			■	
HYDRAULIC TOOLS													
Set of hoses and fittings (for hydraulic tools)	■								■			■	
Hydraulic power station (Stanley for 5 and 10 gpm hydraulic tools)	■											■	
Hydraulic underwater chipping hammer (Stanley CH18)	■		■			■			■			■	■
Hydraulic underwater grinder (10 in. GR29)	■								■			■	
Hydraulic underwater disc chainsaw (Stanley C023)	■		■						■			■	■
Concrete-cutting hydraulic underwater diamond chainsaw (DS11)	■								■			■	■

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Hydraulic underwater chipping hammer (Stanley CH15)													
Wood-cutting hydraulic underwater chainsaw (Stanley CS11)													
Hydraulic underwater hammer drill (Stanley HD45)													
Hydraulic underwater drill (Stanley DL07)													
Hydraulic underwater impact wrench (Stanley IW12)													
Hydraulic underwater impact drill (Stanley ID07)													
Hydraulic core drills													
TOOLS – WELDING ON THE SURFACE													
Arc welders (400 amperes)													
Welding cables (50 ft. with 2/0 fittings)													
Welding cables (100 ft. with 2/0 fittings)													
Whip (for electrode holder with 4/0 fittings)													
Electrode holder (400 amperes)													
Ground clamp (C-clamp 400 amperes)													
Electrodes													
Steel brushes													
Chipping hammers													
Welding helmet													
TOOLS – OXYACETYLENE CUTTING ON THE SURFACE													
Oxygen cutting masks													
Protective clothing													
Acetylene regulatorss													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Oxygen regulatorss													
Oxygen cutting station hoses (50)													
Oxygen cutting station torches with set of tips													
Oxygen cutting station carriages													
Industrial oxygen cylinder													
Acetylene cylinder													
TOOLS – UNDERWATER ARC WELDING													
Arc welders (600 amperes)													
Welding cables (100 ft. with 2/0 fittings)													
Arcair circuit-breaker knife													
Electrode holder (400 amperes)													
Ground clamp (C-clamp 400 amperes)													
Whip (for electrode holder with 4/0 fittings)													
Face shields with lens screens for SuperLite helmets													
Full dry isothermal suit													
Steel brushes													
Chipping hammers													
TOOLS – UNDERWATER WELDING (ARCAIR)													
Arc welders (600 amperes)													
Welding cables (100 ft. and over with 2/0 fittings)													
Cables with oxygen hose for oxyarc, 100 ft. and over													
Arcair circuit-breaker knife													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Ground clamp (C-clamp 400 amperes)													
Electrode holder (Arcair Sea Torch or Broco Torch)													
Oxygen regulator													
Industrial oxygen cylinder banks													
Electrode collars													
Electrode holder spare parts													
Cutting electrode													
Face shields with lens screens for SuperLite helmets													
TOOLS – MEASUREMENT													
Digital multimeters													
Squares													
Measuring tape (25 ft. and 100 ft.)													
Aluminum rules (1 m)													
Wheel – odometer													
Plumb line													
Inverted pendulum													
EQUIPMENT – SITES WITH PRESSURE DIFFERENTIALS													
Spreader bars (No. 1221460)													
Secondary lifelines (200 ft./diver)													
Snap shackles for pulleys													
Figure eight descender (5,000 lb)													
Circular slings (12 ft. for 5,000 lb)													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Pin stretcher with five-point hoisting cables													
Locking and breaking systems (Blue Ship)													
Openable diverting pulleys													
Mechanical ascent system with electric capstan													
Pulling system (4:1 hoist for 100 ft.)													
Diving harness (Sub Divo Pro type)													
Umbilical cord equipped with a strippable lifeline (20 Newton kilos)													
Self-locking and lockable snap shackle													
EQUIPMENT – INTERVENTIONS IN CONTAMINATED ENVIRONMENTS													
Dry isothermal suit with watertight hookup to diving helmets													
Glove mounting assembly on isothermal suit													
Diving helmets with double exhaust flaps and collars mounted on an isothermal suit													
Deflation valves of a dry isothermal suit with double exhaust flaps													
Diver decontamination essentials, including: – brushes, neutralizing products in pressurized containers equipped with a vaporizer													
Diver rinsing equipment													
Neutralizing and rinsing product recovery basins													
Watertight container (recovery of contaminated equipment)													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Equipment to confine and delimit the contaminated area, the decontamination area and the operational support area													
Breathable air supply system including: – two compressed air banks, regulatorss, distribution hoses and lines, and a distribution manifold													
EQUIPMENT – PHOTOGRAPHY													
Electronic flash for underwater camera													
Digital camera with watertight casing													
Accessories (macrophotography and close-up photography)													
Camera system													
CRAFT													
Outboard motor													
Fuel tank and supply hoses													
Inflatable (16 ft.) with soft or rigid hull													
Diaphragm pump (to inflate the inflatable's sponsons)													
Lifejacket													
Floating tie line (50 ft.)													
Re-boarding device													
Manual propulsion device (oars)													
Anchor and cable (50 ft.)													
Manual scoop or bilge pump													
Watertight flashlight													
Pyrotechnical signals (A, B, C type)													

	Dive	Assist the diver during a dive	Direct diving operations	Maintain and repair diving apparatus, other equipment and tools	Prepare to repair submerged structures	Repair submerged concrete structures	Repair submerged steel structures	Repair submerged wood structures	Prepare installation work	Install pipes	Install membranes	Install anodes	Install cofferdams and stop logs
Sound-signalling device													
Navigation lights													
Magnetic compass													
Radar reflector													
Fire extinguisher (ABC class)													
Echosounder													
GPS													
VHF Radio and external microphone for inflatable													
VEHICLES, TRAILERS AND CONSTRUCTION TRAILER													
Vehicle (transportation: team and commissions)													
Tool truck or trailer housing the diving station for transporting equipment to the underwater construction site													
Construction trailer or shelter for workers													
Trailer (transportation of equipment and materials)													

Annex 2
MATRIX OF OCCUPATIONAL HEALTH AND SAFETY HAZARDS

Produced by: **Claude Rochon**, Engineer, Prevention-Inspection Expert
Commission de la santé et de la sécurité du travail

Note: Although the diver occupation consists of performing underwater all the tasks of a construction worker, most of the hazards catalogued below are related to the diving activity. Underwater, any uncontrolled movement or situation can lead to a serious accident and even cause the diver's death. The table below is not exhaustive, but aims at presenting a general portrait of hazards present during a dive.

Table A.2 Occupational Health and Safety Hazards for the Diver Occupation

No.	*Hazards*	*Effects on Health and Safety*	*Means of Prevention*
1	**Physical Hazards and Dangers**		
	Water pressure	• Decompression accident (decompression sickness and barotrauma)	• Being in good shape and healthy for diving. • Following the diving tables according to the diving profile and the breathable mixture used. • Controlling the diving parameters (depth, duration, etc.). • Planning rest periods and travels on aircrafts. • Following diving procedures.
	Pressure differential	• Diver's suction	• Making an inspection dive of the workstation underwater and five metres from the perimeter in a cage or with an approved method. • Locking pumps or any other equipment likely to produce a pressure differential.
	Breathable compressed mixture or breathable compressed air	• Asphyxia	• Using a reserve, using a second air supply source, controlling the dew point in cold weather, wearing a self-contained breathing apparatus for emergencies, using a hot water system to heat air distribution ducts on the diving helmet, observing OHSR section 48.

No.	Hazards	Effects on Health and Safety	Means of Prevention
	Breathable compressed mixture or breathable compressed air (*cont'd*)	• Nitrogen narcosis	• Limiting diving with compressed air to a depth of 50 metres.
		• Hypoxia or hyperoxia (lack or surplus of oxygen in the blood)	• Ensuring the quality and observing the concentration limits of O_2 in the mix, not breathing pure O_2 in depths of more than seven metres, observing the diving tables according to the diving profile and the breathable mixture.
		• Hypercapnia, i.e., carbon dioxide (CO_2) poisoning, and carbon monoxide (CO) poisoning	• Ensuring the quality of the mixture, maintaining the compressor and filtration system, positioning the compressor's air inlet well.
	Water temperature	• Hyperventilation, hypothermia, hyperthermia	• Wearing an appropriate diving suit according to the temperature and work period underwater (damp, dry or temperature-controlled suit). • Not diving in water hotter than 40°C.
	Currents	• Being carried away • Failure of the diving helmet regulator • Exhaustion	• Using a current deflector or an engineer-approved work method for currents faster than one knot.
	Crafts	• Injury from collision with a craft	• Delimiting and identifying the diving area according to the federal Collision Regulations. • Ensuring that no other floating material is moving in that area without the diving supervisor's authorization. • Training the craft's operator.
	Ice fields	• Being jammed and carried away	• Assessing the carrying capacity of the ice. • Not moving more than 50 metres away from one's launching point. • Not performing diving operations with ice fields in motion.
	Using electric tools or equipment	• Electrocution, electrification	• Using a tool or equipment not exceeding 110 volts DC or 42 volts AC, insulated, equipped with a ground leak detector if it uses AC, and grounded.

No.	Hazards	Effects on Health and Safety	Means of Prevention
	Using welding equipment	• Electrocution, electrification, glare	• Ibid electric tool +. • Using straight polarity, a knife to open the circuit, and an insulated glove. • Ensuring that no gas accumulates during welding or cutting work underwater or is inside the electric current's circuit. • Wearing a face shield. • Complying with standard CAN/CSA W117.2.
	Using hoisting equipment	• Injury from a fall or from a collision with a load	• Using a diver's platform. • Developing a hoisting procedure. • Ensuring good communication between the diver and the hoisting device's operator. • Securing the hoisting area and the rigging method.
	Using high-pressure equipment	• Cuts	• Using a method for not being in the jet's trajectory, being stable during pressurization.
	Waves	• Being carried away • Being jammed between the pier and the craft or against concrete facing • Falling on board or outside the craft	• Prohibiting or stopping a dive when waves cause a lack of control over the diver's movements and direction.
2	**Biological Hazards and Dangers**		
	Infections, viruses	• Cold, flu, infections	• Cleaning and disinfecting the mask, helmet and regulator, complying with standard CAN/CSA Z94.4.
	Contaminated water	• Contamination	• Identifying contaminants. • Using appropriate diving apparatus for contaminants, a dry isothermal diving suit (non-absorbent, watertight locking device) and watertight gloves. • Being vaccinated against polio, tetanus and hepatitis A. • Establishing a decontamination procedure including site management.
3	**Ergonomic Hazards and Dangers**		
	Weight of diving apparatus and loads to be handled	• Various aches and pains, notably in the back and neck	• Appropriately using equipment, the assistant's help, the hoisting device and the diver's platform.

No.	Hazards	Effects on Health and Safety	Means of Prevention
4	**Chemical Hazards and Dangers**		
	Compressed gas	• Explosion • Projection • Ignition	• Knowing WHMIS regulations. • Maintaining the cylinders according to standard CAN/CSA Z94.4. • Ensuring the presence of an oxygen concentration detector in the hyperbaric chamber. • Ensuring ventilation in a closed environment. • Not putting any grease, solvent, plastic or synthetic fabric in contact with compressed oxygen or with a mixture that has a compressed oxygen concentration exceeding 23%.
	Concrete and chemicals	• Burns	• Eliminating contact between skin and wet concrete. • Wearing a diving helmet and a dry suit with watertight gloves.
5	**Medical Hazards and Dangers**		
	There are absolute contraindications and temporary ones regarding the following: • heart – heart attack – arterial narrowing – arrhythmia – pacemaker • ORL system and lungs – sinusitis, otitis, rhinitis – asthma • nervous system – epilepsy – stroke • endocrine diseases – type 1 diabetes – any poorly controlled diabetes • pregnancy	• Vulnerability to pressure changes (decompression sickness, barotrauma) • Losing the ability to face mental and sensory requirements underwater (loss of consciousness, convulsions, judgment disorder, panic, etc.) • Insufficient physical capacity to face usual or exceptional (emergency) situations • Risk of losing consciousness underwater, of drowning and of injuries related to depressurization • Risks to the health of the fœtus	• Undergoing a physical examination and a physical aptitude test by a diving doctor at least every two years, or more often if recommended. • Undergoing a medical re-examination after an illness or accident. • Being evaluated daily by the diving supervisor with regard to diving fitness. • Wearing a medical alert bracelet.