A Systematic Framework for Designing and Implementation of Quality Management Practice: The Case of a Consulting Engineering Company

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About This Paper

In this article, we aim to present a framework to develop an integrated methodology of a quality management practice in a consulting engineering company based on ISO 9000 and 14000 series. We explained the strategy to overcome internal barriers in the company by stimulating both top management and employee engagement. A top-down approach was adopted at the beginning to obtain support and total commitment from top management that has to provide necessary resources to implement the process. On the other hand, to elaborate standardized work instructions used in a daily basis we use a bottom-up approach to assure the effectiveness of the practice. As result, several procedures, work instructions, forms, and key indicators were created to monitor and gather data for analysis of non-conformity and opportunity for continual improvement. The framework proposed was certified and has been used successfully by the company.

Keywords: Project Management, Quality Management Practice, Continual Improvement.

1. Introduction

Creative design, innovation, and reduction of non-quality costs are reported amongst factors that influence company competitiveness and productivity. Nowadays, Quality Management Practices (**QM**), according to ISO 9000 series, have been implemented in most competitive company as a way to achieve process efficiency (McTeer & Dale, 1994; Sousa and Voss, 2000; Koc, 2007; Shan, Zhao, & Hua, 2013, p. 211) via continual improvement that incorporates stakeholders (e.g., employees, customer, supplier, etc.) engagement. Stakeholder engagement has been indicated as a mandatory process to guarantee the effectiveness of a quality management practice (Mata-Lima & Vasconcelos, 2006) since the

participation of employees (instead of only top management) facilitate the design of user friendly procedures (e.g., work instructions, form), and identification of non-conformity and opportunities for improvement. The implementation of a corporate quality process should be based on detailed analysis (see **Exhibit 1**) in order to guarantee a process suitable with company profile and strategy.

Exhibit 1. **Process for corporate quality** (Arbeitsgruppe *in* Kirsch et al., 2010, p. 2)

Quality management practice (QM) has been benefited companies with advantages, namely owing to its contribution to increase company competitiveness and performance (Yamada et al., 2013), stimulate creative problem solving and innovation (Kim et al., 2012), and employee involvement in the process of creation of knowledge for the company (Shan, Zhao, & Huan, 2013; Zu et al., 2008). This is only possible when top management provide necessary support by demonstrating strong commitment to QM, and willingness to guarantee necessary resources for quality improvement (e.g., instituting a quality-based compensation policy, training programs, etc.) (Zu et al., 2008). The **Exhibit 2** synthesizes some of the best management principles of quality management that we adopted in our work.

Exhibit 2. Some traditional QM practices and Six Sigma practices (modified from Zu et al., 2008, p. 632)

Practices	Description of domain and examples of techniques
Top management support	Top management accepts responsibility for quality and is evaluated based on quality performance. Top management participates in quality improvement efforts and makes strategies and goals for quality improvement.
Customer relationship	Customer needs and expectations are assessed. Customers are involved in quality improvement projects. Customer satisfaction is measured. There is a close contact with key customers.
Workforce management	Employees are involved in quality decisions. Employees are evaluated based on their quality performance and their contributions to quality area recognized and rewarded. Managers encourage team working. There is training on QM for managers and employees.
Quality information	Quality data are available to managers and employees. There is an effort to collect timely quality data. Quality data are used for improvement.
Process management	There is emphasis on mistake-proof process design. There is consistent use of statistical process control, and preventive maintenance. Managers and employees make efforts to maintain clean shop floors and meet schedules.
Six Sigma structured improvement procedure	There is an emphasis on following a standardized procedure in planning and conducting improvement projects or design projects. Teams apply the appropriate QM tools and techniques as prescribed in each step of the structured procedure.
Six Sigma focus on metrics	Quantitative metrics are used to measure process performance and product quality performance, and set project goals. Business-level performance measures and customer expectations are integrated with process-level performance measures.

On the other hand, unfortunately, there are several companies that, so far, do not have perception about the relevance of a **QM** to boost process efficiency (Mata-Lima, 2014) as well as activity profitability due to the reduction of non-quality costs (Yamada et al., 2013). Companies lacking this perception – even when certified under quality management certification – are not committed to continual improvement since they use certification mainly for marketing process. They do not use **QM** as a strategy to prevent non-conformity or performing risk management via a daily continual learning process.

This work shares the experience respecting to a quality management practice (**QM**) of a medium sized consulting engineering company, which made the option of using the available standards (e.g., ISO 9000, and 14000 series), and team motivation and expertise to improve its performance by defining rule of thumb concerning all engineering (e.g., project design) and administrative (e.g., human resources,

marketing, legal and financial issues) tasks as part of the strategic management plan, including goals, visions and mission.

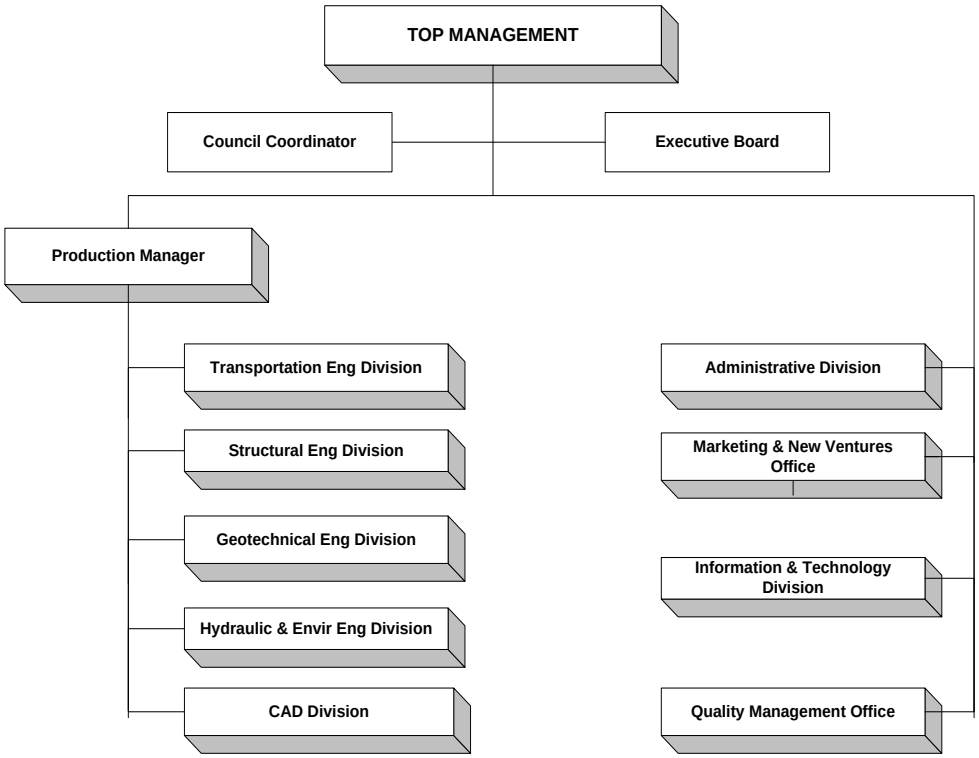
2. Case Study: the company profile

The framework analysed hereby aims to suite a broad range of engineering companies that offer services on the area of project design and evaluation so that it was developed and tested in a consulting engineering company devoted to civil engineering projects. It is a medium sized company that provide services on the areas of structural, geotechnical, transportation (road and rail design), drainage, and environmental engineering. The company has more than 30 years of experience and comprises a young team with background and academic qualifications on three mains areas: civil, geotechnical, hydraulic, and computing engineering. Other team members are designer, urban planner, and administrative workers. **Exhibit 3** shows the eight main units identified in the company in order to draw the organizational chart (see **Exhibit 4**), which illustrates the map of company units.

Exhibit 3. Eight main company divisions

Company units	Main duty as defined by the unit's representative
Top management	Responsible for company strategic management and is represented by a chef executive officer (CEO).
Transportation engineering	Responsible for road and railway project design.
Structural engineering	Responsible for bridges (or similar structures), retention wall, and others structures for slope stabilisation).
Geotechnical engineering	Responsible for soil and rock mechanics, and foundation engineering studies.
Hydraulic and environmental engineering	Responsible for design stormwater drainage systems as well as perform environmental studies.
Computer Aided Design – CAD	Responsible for project output such as drawing elements.
Information and technology (IT)	Responsible for hardware, software, and network maintenance.
Production manager	Responsible for the management of all projects – in cooperation with all above mentioned technical divisions.
Marketing & new ventures	Responsible for diffusion of company image and capabilities, finding new market opportunities (both national and international).
Administrative and Financial	Responsible for administrative and financial duties, law issues, and human resources management.
Quality Management Office	Responsible for the entire quality management system according to ISO 9001 and integration with environmental management system (ISO 14001).

Exhibit 4. Company organogram



Legend: Executive board – comprises the top management and production manager; Council coordinator – comprises the Top management, production manager, and all divisions and office coordinators.

3. Methodology: Project Approach

The overall methodology considered to design and implement a Quality Management Practice (**QM**) was delineated in two main phases as described in next paragraphs.

Phase I

First of all, an extensive literature review was conducted to define key issues for the development of a **QM** in a consulting engineering company bearing in mind the idea of a multidimensional process that must take into account social (e.g., employees' profile) and economic context of the company. Historical data of the company was analyzed to define company profile and, therefore, identify the main tangible objectives to be accomplished by Quality Management Practice (QM). As a result, the following points were found as the main goals to be pursued:

- **Administrative innovation** – design innovative structures, policies, systems, and processes of management and organization to improve the efficiency and the effectiveness of managerial

systems and processes by adopting adaptive management that incorporates stakeholders (internal and external) engagement;

- **Technological innovation** – meet needs of existing customers, and also explore new customers and markets (internationalisation) by developing existing competencies via incremental innovation, which include refining, broadening, or combining a current technical trajectory, knowledge, and skills.

The above two points must be satisfied in a context of low level of risk by working with a greater level of certainty with known information. Readers should refers to Kim et al. (2012, p. 297-298) for more information about technological and administrative innovation.

Phase II

Secondly, following a top-down approach, four meetings were organized with company top managers and employees:

- **meeting 1** – was exclusive with top management in which the purpose of a QM was clarified, and we explain why should the company implement it as a tool to improve competitiveness and reduce non-quality costs. The main goal of this meeting was to attract attention, interest, and commitment of the Chief Executive Officer (CEO);

- **meeting 2** – once the top management was engaged with the implementation of the QM, we promote the second meeting where the CEO explained to intermediate managers how could the QM boost company performance. After his talk, attempt was done to clarify that the implementation of a QM requires a complete engagement of all employees to facilitate the elaboration of suitable procedures and work instructions since such documentation should be according to company identity, which includes, for instance, resources availability, employees' qualifications, and costumer profile;

- **meeting 3** – this was a general meeting with all employees (from all divisions and office) at the same time. It took place in an external organization that provide a short trainee entitled "introduction to quality management system" where all employees (including top managers) attended in order to acquire an essential knowledge on QM. The last part of the meeting was filled with a participated discussion concerning Deming's style of quality management (Deming's 14 points) in opposition to Juran and Crosby's points;

- **meeting 4** – after meeting 3 we assume that all participants were engaged enough so that the meeting 4 was held in the company building – with each division – and aimed at explaining that their active participation in all phases of the development and implementation of the QM is a unique way to reach a satisfactory result. All employees were asked to provide insights to build procedures and work instructions as well as performance indicators.

After all meetings, the rule of thumb concerning the global process for creating and implementing the **QM** was launched step-by-step according to Deming's proposal (see, e.g., Zu et al., 2008, Kirsch et al., 2010). It means that a quality management system follows a fundamental management cycle and consists of planning, implementation, control and feedback. The diagram presented respect the PDCA cycle: quality planning (**Plan**), quality steering (**Do**), quality assurance (**Check**), and quality improvement (**Act**).

Overall methodology adopted entails three main traditional and mandatory stages (see Mohammadi, 2012) that were adapted to our case, as synthesized in **Exhibit 5**, with respective tasks considered.

Exhibit 5. The main stages considered in development of the quality management practice

Stages	Main Tasks	Remark
PLANNING	Inform the division members about the philosophy, requirements and role of internal assessment in the quality improvement of the division.	This stage was very democratic, participated, and slow in order to guarantee an adequate process.
	Constitute the steering committee of internal evaluation in division.	
	Clarify the mission, goal and objectives of the division.	
	Define the evaluation indicators.	
	Define and formulate the appropriate method for each indicator.	
	Define and formulate the appropriate indicators for each criterion and establish judgment scales.	
	Specify the desired data/information to evaluate the indicators.	
	Design and formulate a uniform measurement process for gathering data.	
	Perform SWOT analysis (strength, weakness, opportunity, threat) based in an adaptation of Ishikawa diagram, as represented in **Exhibit 1**, to establish the company vision (perspective of corporate values: what do we want to be?), mission (the statement of purpose: what is our duty?), and strategies (how do we achieve long-term goals and objectives?), and set quality politics that appropriately describe quality relevant values of the practice. The entire process has to be done bearing in mind that quality goals must be quantifiable and tangible in order to be timely measured.	
IMPLEMENTATION	Gather data from all divisions and offices.	At the beginning, the quality management team must be fully available to help all
	Treat and analyze data trying to find pattern and either some clues of efficiency or inadequacy.	
	Draw procedures and work instruction following the Six Sigma principle, i.e., provide a	

	set of standardized rule of thumb for planning, improvement action, and design projects in which teams follow adequate predefined tools and techniques of a structured procedure.	divisions but never substitute them in the process of creating procedures.
	Write timely, factual report to evaluate the Quality Management Practice (QM).	
PERFORMING SUGGESTIONS AND FOLLOWING-UP	In this stage, with the essential help of the quality team, divisions start attempts to improve their processes based on the results of internal assessment, which allows for identification of relevant corrective action, and opportunities for continual improvement. Here efforts were done to guarantee a full engagement of stakeholders in the process of quality auditing to find non-conformities. Additionally, when corrective actions required new investments, it was necessary to demonstrate to the top management that the annual non-quality cost (i.e., the cost of no action) is higher than the investment to solve the problem.	This stage is of critical importance to identify weaknesses that have to be overcame to reduce non-quality costs.

The overall objectives aimed to reach administrative and technological innovation, so that the role of each company divisions and offices were firstly defined (see next section, project outcome) as a pre-requirement to accomplish the project goals.

3. Project Outcomes

The first result was a general work principle to manage the company activity by establishing the rule of thumb, clarifying the role of each company unit, to be rigorously followed in all project development (see **Exhibit 6**). The teams of each division included in **Exhibits 3**, **4** and **6** know exactly what are their role and responsibility (**Exhibit 6**) and participate actively in the development in each step of the standardized procedures, work instructions, and filling forms for gathering data on non-conformities, and to estimate key indicators for monitoring process and reduction of uncertainty in decision making.

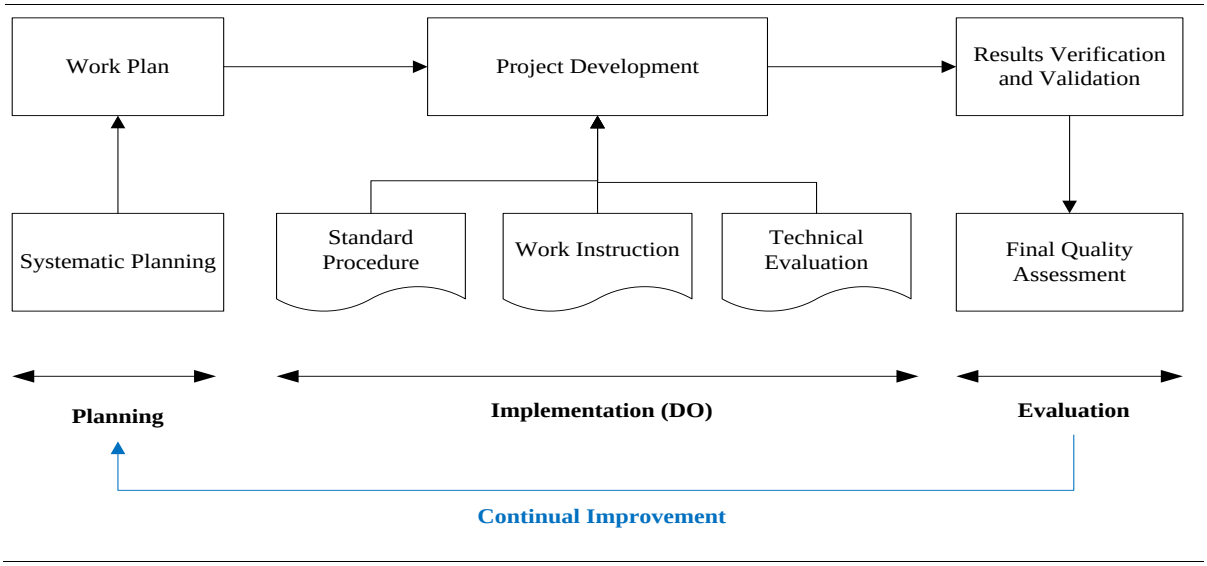
Exhibit 6. The main role of each company division in quality management practice

Company unit	Main role in quality management practice
Top Management	Support quality management process by providing resources and demonstrating commitment to quality management practice (**QM**).
Administrative	Manage human and financial resources, guarantee the compliance with law and standards, and maintain an updated library.
Marketing & New Venture Office	Promote company image, attract projects and new costumers, and explore new ventures.
Quality Management Office (**QMO**)	Design and monitoring the quality management system, including linkage with environmental and health safety concern. Elaborate timely reports about the performance of QM, and contribute to find solution to detect non-conformities through a bottom-up approach. Measure satisfaction of internal (employee) and external customers.

Production Management	Transportation Engineering	Define best practices concerning road and railway design. Identify current no-conformity, opportunity for improvement, and training to qualify the team work. Prepare work instructions under supervision of QMO.
	Structural Engineering	Define up to date structural design procedures according to Eurocodes. Identify current no-conformity, opportunity for improvement, and training to qualify the team work. Prepare work instructions under supervision of QMO.
	Information and Technology	Guarantee up to date technology (e.g., hardware and software) to accomplish project goals. Prepare work instructions under supervision of QMO.
	Geotechnical Engineering	Define up to date geotechnical design procedures according to Eurocodes. Identify current no-conformity, opportunity for improvement, and training to qualify the team work. Prepare work instructions under supervision of QMO.
	Hydraulic & Environmental Engineering	Define up to date hydrological and hydraulic design procedures. Identify environmental aspects and impact of projects to propose mitigation measures. Identify current no-conformity, opportunity for improvement, and training to qualify the team work. Prepare work instructions under supervision of QMO.
	CAD	Produce high quality layout of projects, and print and compile all necessary documents; identify current no-conformity, opportunity for improvement, and training to qualify the team work. Prepare work instructions under supervision of QMO.

The overall principles adopted in company is that all activities must undergo a global standardized procedure that start with a work plan to define the rule of thumb of the project to guarantee a development according to available internal procedure covering the phases of Planning, Implementation, and Evaluation (performing suggestions and following-up), as depicted in **Exhibit 7**.

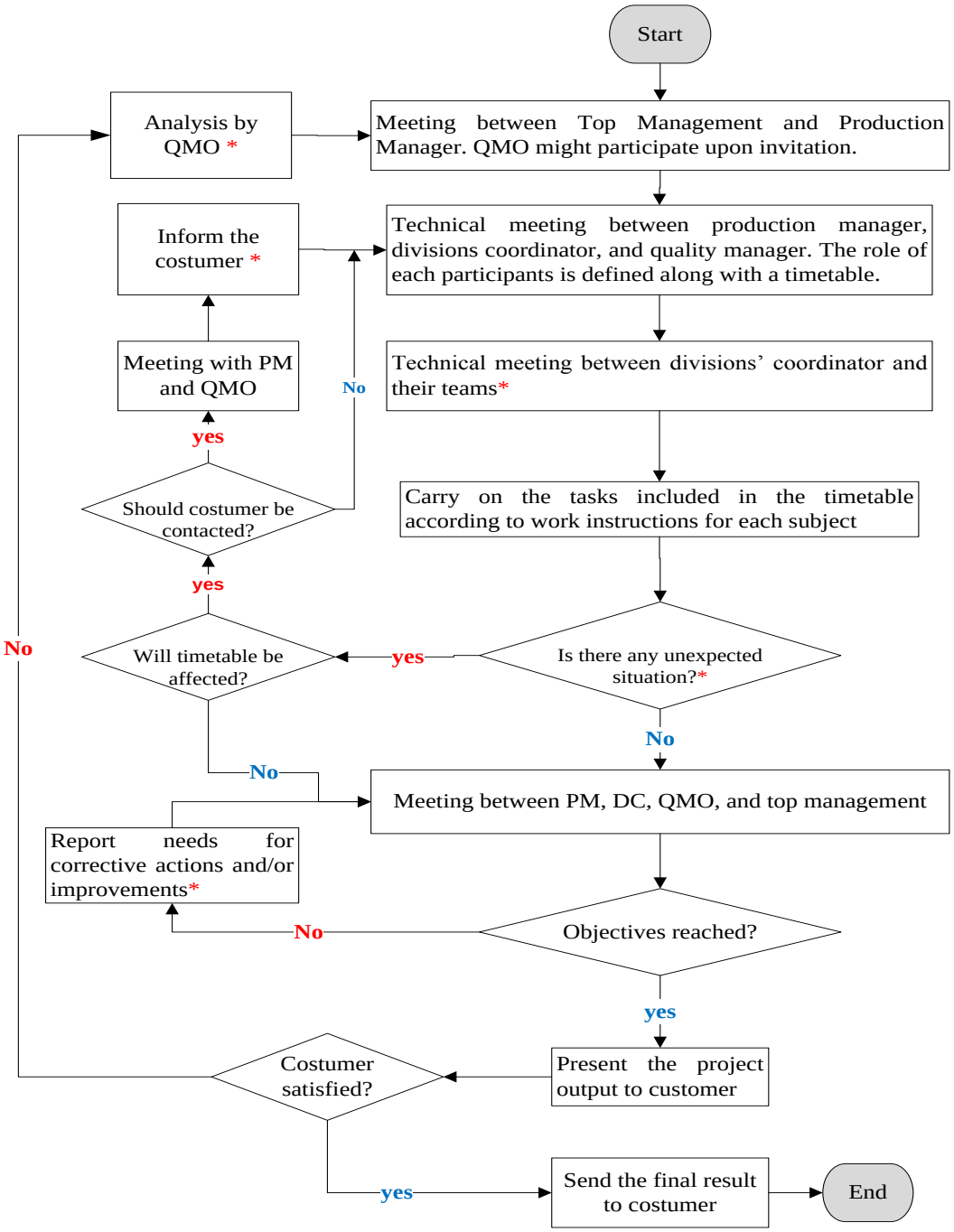
Exhibit 7. Company main process for Quality Management Practice



Based on the main strategy mapped in **Exhibit 7**, a general standardized procedure was delineated with the collaboration of all divisions in order to provide an integrated procedure for project development,

which satisfies quality management requirements (see **Exhibit 8**). This approach presumes that timely assessment of costumer's satisfaction is done by QMO using a 5-point likert scale from 1 (not at all) to 5 (large extent).

Exhibit 8. General procedures to develop project according to quality management practice

Process	Documents
	There are Work Instructions for each step, and some of them include forms that must be filled in order to guarantee process traceability.

Legend: **PM** – Production manager; **QMO** – Quality management office; **DC** – Division coordinator; ***** – Appropriate form must be filled according to company's work instructions.

The figure shows that there was concern with global internal stakeholder engagement at the beginning because it seems advantageous to have all parts involved to guarantee that all divisions will work together to fulfil the customer requirements and, ultimately, the company mission. Some simplification should be considered, if necessary, when the workflow reaches maturity with time. There is no reason for, at that time, all parts do not understand the usefulness of some simplification if the quality manager explains with evidence that changes should be done for the betterment of the process flow rate.

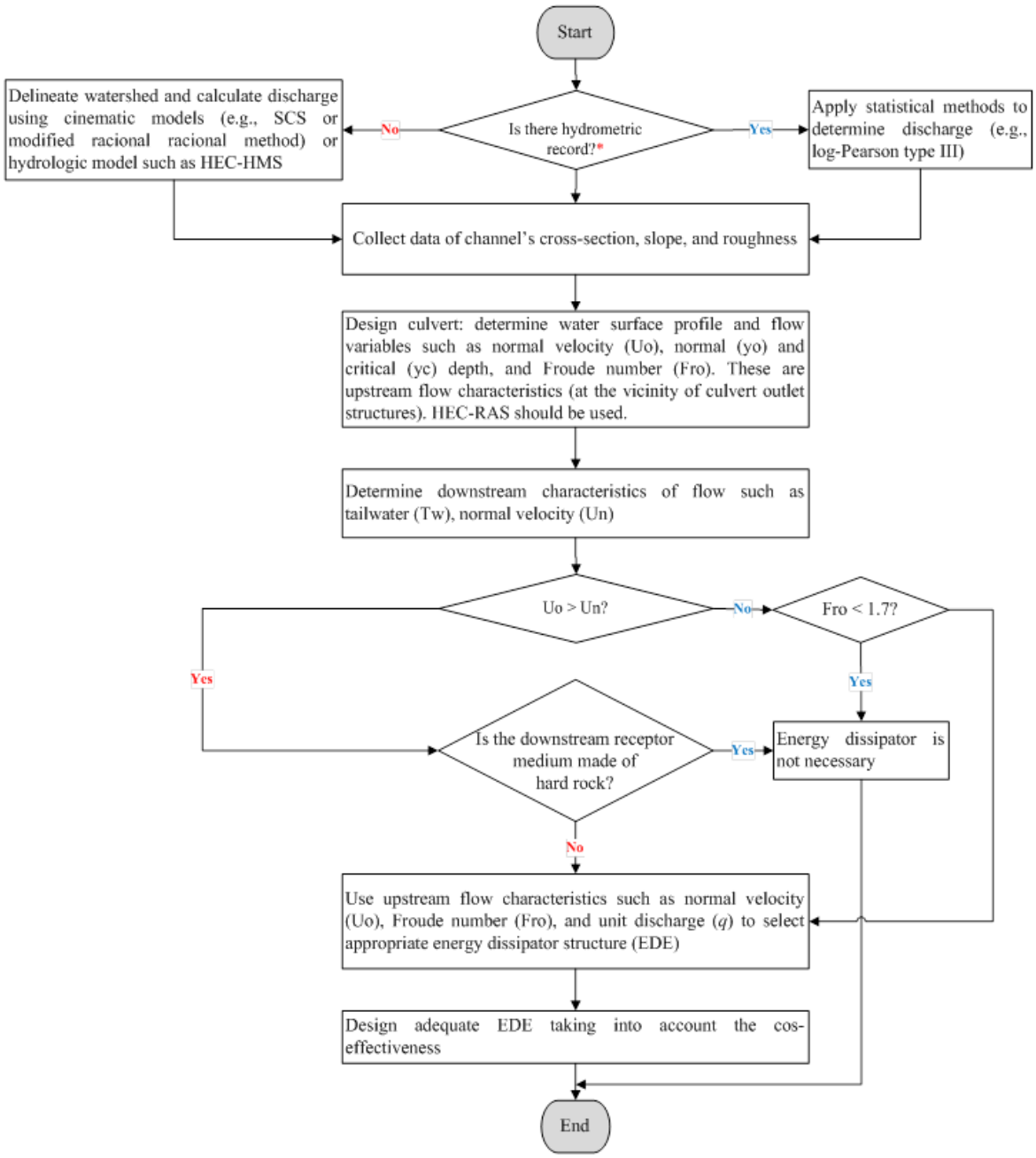
The first meeting, in **Exhibit 8**, between top management and production manager aimed to re-evaluate either if there is all necessary resource to fulfil the project tasks or if it some partnership ought to be considered. Some forms must be filled across the procedure in order to allow the traceability of the entire process and record information that can be useful to make decision respecting to corrective measures or continual improvement.

Overall analysis of previous projects revealed some weaknesses regarding the absence of:

- record of non-conformities;
- periodical training programs defined to face previous non-conformities, technical development or new ventures opportunities;
- a clear career plan based on meritocracy;
- evaluation of costumer satisfaction;
- bottom-up approach to solve problems or reduce inefficiency;
- a practice of recording and keeping information that would be useful for process traceability and legal issues;
- adequate attention to ecodesign principles in order to preserve ecosystems services far beyond legal requirements by adopting modern engineering practices. For example, engineers were not able to fully identify environmental aspects and impacts of different projects scenarios. Some of them had doubt about what is the difference between environmental aspects and impacts.

In the context of this article, we describe in **Exhibit 9** an example of a procedure to guarantee environmental compliance during the design of culvert outlet structures (i.e., energy dissipater).

Exhibit 9. Procedure to design culvert's outlet structures that prevent downstream erosion

Process	Documents
	
	WI-01D.v1
	WI-02D.v2
	WI-03D.v1
	WI-04D.v1

Legend: **HEC-HMS** – Hydrologic Modeling System is a free software available at www.hec.usace.army.mil/software/hec-hms/; **HEC-RAS** – River Analysis System (www.hec.usace.army.mil/software/hec-ras/); **SCS** – Soil Conservation Service hydrological method (Mata-Lima, 2007; Singh, 2015); **Uo** – Upstream normal velocity; **Fro** – Upstream Froude number; **Un** – Downstream normal velocity; **WI** – stands for that a work instruction is available for this step; * – World Meteorological Organization recommends 30-year of hydrometric record, but period of 20-year should also be considered.

The application of the above mentioned procedure contributes to preserve pre-development flow characteristics, so that efforts must be done to always find an alternative that mitigate significant environmental aspects and impacts.

Among the weaknesses identified in the company, opportunities losses due to inappropriate management of information on open call for projects was one of the most critical, in terms of non-quality cost. To overcome this situation an integrated procedure was proposed to search call for projects (under the responsibility of Marketing & New Ventures' Office) and pre-evaluate company ability to fulfil the requirements, such as know-how, technical resources, and ability to fulfil the timetable.

4. Conclusions and Recommendations

The implementation of quality management practice leads to the following main conclusions:

- the support from top management (TM) is of critical relevance to the success of a Quality Management Practice (QM) project, so that quality manager should engage TM and make them part of the team. To be completely successful, the TM engagement process should (**1**) be the first step of the entire program to implement QM (i.e., adopt a top-down approach at the beginning is mandatory), (**2**) includes evidences of non-quality costs (or at least a list of likely factors that represent current weaknesses in the organization), and (**3**) demonstrate how the QM will contribute to boost organization performance;
- the participation of both employee and top management in training concerning QM, at the beginning of the process, promoted either awareness on quality principles/advantages or willingness to participate and accept changing in traditional procedures;
- the bottom-up approach stimulating employee participation using their suggestions to make decisions on how organization operates created an atmosphere of motivation that consolidate the commitment to quality;
- the ability to timely gather information on non-conformities, and others data to calculate indicators depend upon employees commitment to quality, which in turn is relatively related to compensation (e.g., company perks, reward program).
- regarding the continual improvement of the QM, self internal auditing prove to be more fruitful than annual external auditing.

All the above mentioned conclusions contribute to stress the advantages of the implementation of a Quality Management Practice (QM). Therefore, it should be implemented even when the organization is not interested in applying to be issued with an official certification of Quality Management System. Additionally, combining QM with Six Sigma (SS) is an asset that we strongly recommend because SS presumes the existence of a standardized procedure in planning and pursuing improvement or design projects in which teams follow adequate predefined tools and techniques of a structured procedure (see Zu et al, 2008).

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