SITE SELECTION

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Contents

Summary

The identification and selection of the most suitable site for a plant is important to the success of the project. Site-related factors impact the design, construction, and operation of a desalination plant in many ways. This section addresses site selection methodologies and the systematic approaches which exist. Various types of desalination plants, the criteria to be used in site selection and a flow chart of tasks are given. Engineering, economic and environmental ratings are covered. Site investigations needs and the rating and ranking of candidate sites are discussed. An example of the entire process is presented resulting in the site selection with the best overall benefit to the project.

1. Introduction

Site selection for a desalination plant can be one of the most important decisions in planning a desalination project. The decision affects both the project cost and potentially the project schedule. The increasing concern of governments (to meet their multiple demands within limited budgets), lending institutions, and the general public with locating acceptable sites for industrial plants and facilities is a worldwide trend. The siting challenge affects all industries: desalination plants are no exception.

The current approach to site selection of any desalination facility must take into account a multitude of non-technical factors in addition to engineering/economic factors. It can no longer be assumed that siting decisions based primarily on technical decisions, regardless of how important, will always be acceptable to governments, regulatory

agencies, financing institutions, or the public. It appears that a systematic approach to making siting decisions, properly documented and presented, is what may be needed to avoid some of the potential road blocks to the development of a project.

For the site selection, it is assumed that a preliminary study has been completed. This can be in the form of a master plan for an entire county or an engineering evaluation of the desalination options for a given city or region. These plans or studies will have identified or at least narrowed the choices of such major parameters as:

- Type of desalination process (e.g. multi-stage flash, multi-effect distillation, reverse osmosis).
- Dual purpose desalination/power requirement (will a power plant be co-located with the desalination facility).
- Production capacity of the desalination plant and power plant, if required.
- Type of energy required (steam, electricity, fuel, etc.).

2. Basic Elements of Site Selection

Every industrial site selection has four elements:

(a) Information gathering
(b) Analysis
(c) Reporting
(d) Decision making

Site selection can not be entirely separated from plant type/design and construction considerations. Different types of plants can have different environmental or economic impacts. A site suitable for one type of plant may be unsuitable for another. Therefore, information gathering must include plant/process types to be considered and system/operations/cost related specifics for:

(a) Seawater intake/discharge requirements;
(b) Energy requirements for operation;
(c) Means of efficient delivery of the product to the user;
(d) Safe disposal of by-products/wastes;
(e) Land availability;
(f) Topography;
(g) Environmental impact.

Site selection techniques can be classified into two broad categories: *comparative evaluation*, and *classification and rating*.

In the *comparative evaluation* approach, all plant/site alternatives are compared to a fixed standard or design envelope. This may be a list of required or desirable qualities or an existing plant considered to have acceptable cost and impacts. In the early phases of the site selection study, a multi-disciplinary study team establishes minimum standards based on acceptable criteria which are used to eliminate less acceptable regions or site areas and thus move on to compare candidate sites.

In the *classification and rating* approach, costs and impacts are summarized, generally in a numerical way, for each plant/site alternative in a common or standard format. The objective is to place the alternatives on an equal basis and rate them for comparison.

The main difference between these two approaches is the manner and amount of detail in which the study results are presented or summarized. In practice, a site selection study may include elements of both approaches. Also, regardless of the title given to the methodology, the essential ingredients of any study are data and subjective judgment of experienced practitioners within a multi-disciplinary team. Further, it must be accepted from the outset that it is not economically justified to conduct on-site investigations at all levels of a site selection study, subjective judgments can not be eliminated from the site selection process, and all siting studies involve some degree of uncertainty (Cederborg 1978).

3. Desalination Plant Site Selection

The following sections describe one possible approach to site selection for a desalination plant. Other approaches are possible and may be more desirable for a specific project; the purpose of this section is to highlight some facility-specific considerations. For an actual project, greater or lesser efforts may be indicated and utilized for site selection. Figure 1 illustrates the various terms used and Figure 2 presents an activity/task flow chart to assist the reader with the description of the site selection process.

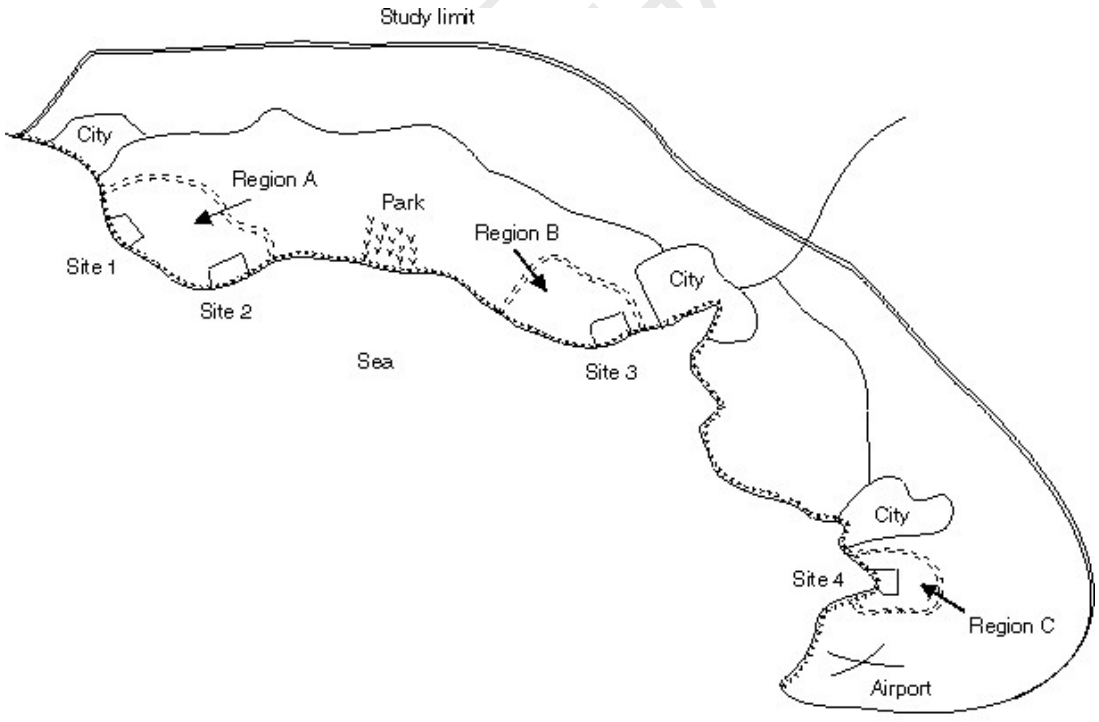

Figure 1. Desalination plant site selection illustration.

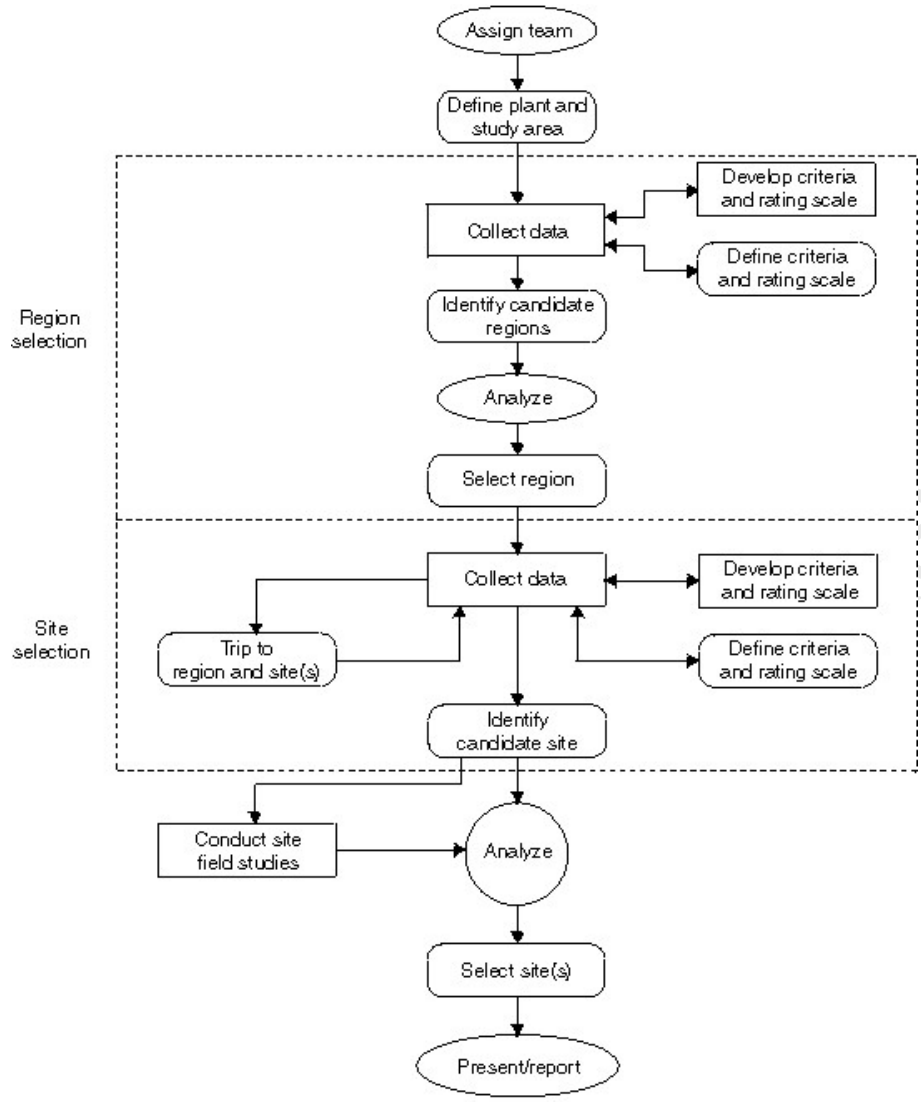

Figure 2. Flow chart of the site selection activities.

3.1. Study Start-up and Information Gathering

At the outset of the study, a multi-disciplinary team of specialists is established. This team starts data collection in the area of desalination plants (systems, process, operational data, and costs) as well as regional site-related data. It also determines the study area to be covered and decides on the basic methodology of site selection to be used, all in close coordination with the project owner (Robinson 1976).

Desalination plants can be described by the processes used to produce desalted water. These are: distillation, membrane, and other processes. Each of these have their own quantities for energy, seawater intake/discharge requirements, and operations. For larger desalination plants (especially if dual-purpose with associated power plants) additional requirements exist and need to be considered in the site selection.

Desalination processes that may be considered are:

- Distillation:
  - Multi-stage flash
  - Multi-effect distillation
  - Vapor compression evaporation;
- Membrane-reverse osmosis;
- Other miscellaneous processes (e.g. freezing, solvent extraction).

Multi-stage flash (MSF) distillation is today the most common seawater desalting technology. The most widely applied MSF process is the brine recycle type. MSF requires steam (generally from an associated power plant) and electricity.

Multi-effect distillation (MED) is not as widely used to-date as MSF. This process consists of a number of evaporators in series. Evaporators can be either of the vertical tube evaporator type (VTE) or horizontal tube multiple effect type (HTME). The process is steam driven and may be coupled to a power plant. MED requires steam (generally from an associated power plant) and electricity.

Vapor compression evaporation (VCE) process can be used in combination with any of the distillation processes but usually with the multi-effect process. The vapor recompression can be done by mechanical methods (MVC-only requires electricity) or by thermal methods by use of steam (TVC). Large seawater desalination plants use TVC.

Reverse osmosis (RO) is a newer desalination process. RO is an electrically driven process. More pretreatment requirements exist than for distillation and deep water intakes are normal practice to avoid fouling of the membranes**.**

3.1.1. Miscellaneous processes

Other processes exist and may be used under some special conditions. These include: electrodialysis, freezing, solvent extraction, etc.

3.1.2. Hybrid process

A hybrid process will combine two of the more conventional desalination processes. For example, RO and MSF can be combined to provide a more economic plant. The advantages of each of the processes can be made to supplement the disadvantages of the other processes.

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Bibliography and Suggestions for further study

A. J. Morton, I. K. Callister, N. M. Wade (1997), *Environmental Impacts Of Seawater Distillation And Reverse Osmosis Processes* ,Desalination, Volume 108, Issues 1-3, Pages 1-10

Ahmed Hashim, Muneer Hajjaj(2005), *Impact Of Desalination Plants Fluid Effluents On The Integrity Of Seawater, With The Arabian Gulf In Perspective* ,Desalination, Volume 182, Issues 1-3, 1 November 2005, Pages 373-393

Alaa M.A. Al-Barakati (2007), *Dispersal Of Thermal And Saline Pollution In Coastal Waters, Red Sea: A Theoretical Study* ,JKAU: Mar. Sci., Vol. 18, pp: 103-120

Al-Barakati, M.A., James, A.E. and Karakas, G.M., (2002), *A Circulation Model Of The Red Sea*, Journal of Faculty of Marine Sciences, Jeddah, 13: 3-17.

Alfred R. Golze(1966), *Relationship Between Storage Capacity And Load Factor Of A Desalination Plant* Desalination, Volume 1, Issue 3, Pages 267-290

Almutaz, I.S. (1991) *Environmental impact of seawater desalination plants*, *Environmental Monitoring* and Assessment, 16: (1): 75-84.

Almutaz, I.S. (1994), *A Comparative Study Of RO And MSF Desalination Plants In Saudi Arabia*, Presented at international specialist conference on "Desalination and water reuse", Moudoch University Perth, Western Australia.

Altayaran, A.M. and Madany, I.M. (1992), *Impact Of A Desalination Plant On The Physical And Chemical Properties Of Seawater, Bahrain*, Water Research, 26: (4): 435-441.

Anthony Withers (2005), *Options For Recarbonation, Remineralisation And Disinfection For Desalination Plants* ,Desalination, Volume 179, Issues 1-3, Pages 11-24

Bechtel Power Corporation (1981) *Site Screen - A Site Selection Methodology*. Power Plant Design and Construction Overview Training Material. Lecture 4. A. Sanver, Gaithersburg, MD, USA.

Bryan Orchard, Christoph P. Pauly, Olga Villa Sallangos (2007), *High Pressure Pumps For Energy-Efficient* desal ,World Pumps, Volume 2007, Issue 493, Pages 30, 32, 34

Cederborg E A (1978) *Application for Site Screen - Hydro And Community Facilities.* Tech Div. Report, Bechtel, Inc., San Francisco, CA.

Chris Mooij (2007)Hamma Water Desalination Plant: planning and funding Desalination, Volume 203, Issues 1-3, Pages 107-118

Chris Mooij ,Krzysztof Karakulski, Marek Gryta, Antoni Morawski (2002), *Membrane Processes Used For Potable Water Quality Improvement* ,Desalination, Volume 145, Issues 1-3, Pages 315-319

Corrado Sommariva, Harry Hogg, Keith Callister (2003), *Maximum Economic Design Life For Desalination Plant: The Role Of Auxiliary Equipment Materials Selection And Specification In Plant Reliability*, Desalination, Volume 153, Issues 1-3, Pages 199-205

Coutant, C. (1970), *Biological Aspects Of Thermal Pollution, Entrainment And Discharge Canal Effects*, CRC Critical Review of Environmental Control Union Carbide Copr., Edit by:Brook, A. J., 341-381. Oak Ridge, Tenn.

David A. Roberts, Emma L. Johnston, Nathan A. Knott (2010), *Impacts Of Desalination Plant Discharges On The Marine Environment: A Critical Review Of Published Studies* ,Water Research,

Eloranta (1983), *Physical And Chemical Properties Of Pond Waters Receiving Warm-Water Effluents From A Thermal Power Plant*, Water Research, 17: 133-140.

Florida Power and Light Company (1979). *Site Selection Study for a Coal-fired Electrical Power Generating Facility*. Final Report, Miami, FL.

François Vince, Emmanuelle Aoustin, Philippe Bréant, François Marechal (2008), *LCA Tool For The Environmental Evaluation Of Potable Water Production* ,Desalination, Volume 220, Issues 1-3, Pages 37-56

GESAMP (1984) IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP joint group of experts on the

scientific aspects of marine pollution, thermal discharges in the marine environment, Report study GESAMP, No. 24.

H. Mehdizadeh(2006), *Membrane Desalination Plants From An Energy–Exergy Viewpoint*, Desalination, Volume 191, Issues 1-3, Pages 200-209

Heinz Ludwig(2003), *Hybrid Systems In Seawater Desalination-Practical Design Aspects, Status And Development Perspectives*, Desalination, Volume 157, Issues 1-3, Pages 31-32

Iris Safrai, Alon Zask (2008) *Reverse Osmosis Desalination Plants — Marine Environmentalist Regulator Point Of View* ,Desalination, Volume 220, Issues 1-3, Pages 72-84

J.-C. Schrotter, S. Rapenne, J. Leparc, P.-J. Remize, S. Casas (2010), *Current and Emerging Developments in Desalination with Reverse Osmosis Membrane Systems Comprehensive Membrane* Science and Engineering, Chapter 2.03, Pages 35-65

J.R. Stange, W.S. Hsieh (1979), *Considerations In The Site Selection And Equipment Specification For The Yanbu 380 M3/Hr Desalination Plant*, Desalination, Volume 31, Issues 1-3, Page 69

Jacques Andrianne, Félix Alardin(2004) ,*Desalination Site Selection On North-African Coasts* Desalination ,Volume 165, Pages 231-239

Jacques Andrianne, Félix Alardin (2003), *Thermal And Membrane Processe Economics: Optimized Selection For Seawater Desalination*, Desalination, Volume 153, Issues 1-3, Pages 305-311

Jim McSorley(1999), *The Taweelah A2 Independent Water And Power Project* , Desalination,Volume 125, Issues 1-3, Pages 191-202

Juma K. Al-Handhaly, A.M.O. Mohamed, Munjed Maraqa (2003) *Impact of chemical composition of reject brine from inland desalination plants on soil and groundwater*, UAE Desalination, Volume 156, Issues 1-3, 1 August 2003, Page 89

June-Seok Choi, Sangho Lee, Jin-Min Kim, Suingil Choi (2009), *Small-Scale Desalination Plants In Korea: Technical Challenges*, Desalination, Volume 247, Issues 1-3, October 2009, Pages 222-232

Marian G. Marcovecchio, Sergio F. Mussati, Nicolás J. Scenna, Pío A. Aguirre (2009),*Global Optimal Synthesis Of Integrated Hybrid Desalination Plants* ,Computer Aided Chemical Engineering, Volume 26, Pages 573-578

Mohamed A. Eltawil, Zhao Zhengming, Liqiang Yuan(2009),review of renewable energy technologies integrated with desalination systems ,Renewable and Sustainable Energy Reviews, Volume 13, Issue , Pages 2245-2262

Mohamed M. ELabbar(2008),*The Libyan experimental on the environmental impact assessment for desalination plants* ,Desalination, Volume 220, Issues 1-3, Pages 24-36

Mohamed M. Elabbar, Farej A. Elmabrouk (2005),*Environmental Impact Assessment For Desalination Plants In Libya. Case Study: Benghazi North And Tobrouk Desalination Plants* Desalination, Volume 185, Issues 1-3, 1 November 2005, Pages 31-44

Monteiro, P.M.S. and van der Plas, A.K.(2006), *Low Oxygen Water (LOW) variability in the Benguela System: Key Processes and Forcing Scales Relevant to Forecasting. Large Marine Ecosystems*, Vol 14, .

Mushtaque Ahmed, Aro Arakel, David Hoey, Muralee R. Thumarukudy, Mattheus F.A. Goosen, Mansour Al-Haddabi, Abdullah Al-Belushi (2003), *Feasibility of salt production from inland RO desalination plant reject brine: A case study Desalination*, Volume 158, Issues 1-3, Pages 109-117

Mushtaque Ahmed, Walid H. Shayya, David Hoey, Juma Al-Handaly (2001), *Brine disposal from reverse osmosis desalination plants in Oman and the United Arab Emirates*, Desalination, Volume 133, Issue 2, Pages 135-147

Nicos X. Tsiourtis (2008),*Criteria And Procedure For Selecting A Site For A Desalination Plant Desalination*, Volume 221, Issues 1-3, Pages 114-125

Panagiotis Tsiakis, Lazaros G. Papageorgiou (2005),*Optimal Design Of An Electrodialysis Brackish Water Desalination Plant* ,Desalination, Volume 173, Issue 2, Pages 173-186

Patsani G. Kumambala, Alan Ervine (2009), *Site Selection For Combine Hydro, Irrigation And Water Supply In Malawi: Assessment Of Water Resource Availability* ,Desalination, Volume 248, Issues 1-3, Pages 537-545

Rachel Einav, Kobi Harussi, Dan Perry (2003),*The Footprint Of The Desalination Processes On The Environment* ,Desalination, Volume 152, Issues 1-3, Pages 141-154

Roberto Borsani, Pietro Bozzini, Antonio Germanà, Patrizio Peluffo, Adel Al Radif (1994), *12 Migd Multistage Flash Desalination Plant A Challenge For The Next Years* ,Desalination, Volume 96, Issues 1-3, Pages 325-339

Robinson J (1976) Delphi and Group Dynamics - A case study. *Proceedings of Seminar on Site Option for Power Plants*. Atlanta: Dames and Moore.

S.F. Mussati, P.A. Aguirre, N.J. Scenna(2005), *Optimization Of Alternative Structures Of Integrated Power And Desalination Plants* ,Desalination, Volume 182, Issues 1-3, Pages 123-129

Sabine Lattemann, Thomas Höpner (2008), *Environmental Impact And Impact Assessment Of Seawater Desalination* Desalination, Volume 220, Issues 1-3, Pages 1-15

Stover R.L., M. Nelson and J. Martin (2007), *The 200,000 m3/day Hamma Seawater Desalination Plant - Largest Single -Train SWRO Capacity*. Proceedings of the International Desalination Association World Congress, Maspalomas de Gran Canaria, Spain,.

Thomas Peters, Domènec Pintó (2008),*Seawater Intake And Pre-Treatment/Brine Discharge — Environmental Issues* ,Desalination, Volume 221, Issues 1-3, Pages 576-584

Young M. Kim, Seung J. Kim, Yong S. Kim, Sangho Lee, In S. Kim, Joon Ha Kim (2009),*Overview Of Systems Engineering Approaches For A Large-Scale Seawater Desalination Plant With A Reverse Osmosis Network,* Desalination, Volume 238, Issues 1-3,Pages 312-332