# APPLYING WORKING WITH NATURE TO NAVIGATION INFRASTRUCTURE PROJECTS

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## ABSTRACT

The Working with Nature philosophy is based around the concept of utilizing resources in beneficial ways, working alongside the environment, in order to benefit all parties. It outlines three key stages which should be followed to facilitate a more sustainable delivery of economic, social, and environmental benefits associated with infrastructure planning and implementation.

*Keywords: Working with Nature (WwN), Building with Nature, sustainable development, Infrastructure development planning.*

## INTRODUCTION

The natural environment is under increasing pressures from engineering projects such as, infrastructure, coastal defenses, and urbanization. These pressures often lead, in the worst case, to loss of habitats or reduced functioning from ecosystem services. Working with Nature aims to address these problems, in an integrated manner; to identify and exploit win-win solutions which respect the natural world, whilst proposing solutions which are acceptable to both project proponents and environmental stakeholders. Key to the success of Working with Nature is its integration early on in project planning. By adopting a proactive approach from project conception, through to the completion, frustrations, delays and their associated extra costs can be reduced and opportunities can be maximized [1].

The requirements in place, when considering the potential environmental impacts of proposed projects for ports, navigation or other associated infrastructure are already well-established, but the process can often be quite convoluted and difficult. Also, if the design concept for a particular project has begun before the environmental implications are considered, then the environmental impact assessment can often become an exercise in mitigation or damage limitation potentially leading to substandard solutions and potentially missed opportunities.

Working with Nature requires that a fully integrated approach be taken the moment the project objectives are known – i.e. before implementation of the initial design is developed. This encourages consideration of how the project objectives can be achieved given the particular, site-specific, underlying characteristics of the ecosystem in question. The process is more than just avoiding or mitigating the environmental impacts of a pre-defined objective. Rather, it sets out achievable project goals, through identification of ways to work alongside and with natural processes to deliver environmental sustainability, protection, restoration or enhancement.

At the most fundamental level, Working with Nature involves a change in the order of planning. It can be divided into three stages:

**Stage 1. Working with Nature**
- Establish the project needs and objectives;
- Understand the environment;
- Make meaningful use of stakeholder engagement to identify win-win opportunities;
- Prepare initial project proposals/design to benefit both navigation and nature.

**Stage 2. Build and Implement**
- Build/implement design, (with monitoring and adaptation)

**Stage 3. Monitor, Adapt and Manage**
- Ongoing monitoring of project, with further adaptations and careful management.

For these reasons Working with Nature requires that a subtle but important evolution occurs during project development. Ultimately focusing on achieving the project objectives with ecosystem at the forefront rather than assessing the consequences of a predefined project; and identifying the win-win solutions rather than simply minimizing ecological harm [1].

**Project Phases**

**Stage 1. Working with Nature**

*Establish project needs and objectives:*

Fundamental to understanding how to "work with nature" on projects, is an understanding of the project objectives and how to show that utilizing Working with Nature can ultimately enhance the project.

The Working with Nature paradigm, by nature is not binary, rather, it is a process that can be used to reduce energy requirements associated with construction or maintenance, increase habitat function, and/or improve ecosystem services in-line with project requirements. It is often found that there is no single solution in the context of navigation and waterborne infrastructure projects, instead there may be a range of available options with different degrees of environmental enhancements.

In keeping with traditional project planning, the needs and objectives within a Working with Nature context will be project-specific; this includes regional, site, hydrological and ecological variations. With this in mind, project objectives should be defined in terms of the ecological and human services provided and can be compared to that of lost services associated with the project work or implementation.

Project objectives should focus on minimizing environmental/ecological harm, with environmental impacts associated with construction, and the environmental impacts associated with the final working product. It is important that methods/techniques to enhance the ecosystem services are identified, to enable enhancement of existing habitats, created new habitats in partnership with the development, and identify human manipulation that can enhance the final working product. Finally, energy use associated with the final working product should be minimized wherever possible, this includes time and resources; utilizing natural systems to create a more natural end product in-keeping with environmental surroundings. Ultimately working with nature to leverage natural environmental forces (e.g. wind, hydrodynamic, biological, and chemical).

*Understand the environment:*

This plays a fundamental role in the Working with Nature concept, where working with natural environmental processes is a main objective to achieve a solution that positively fits the natural conditions. This, facilitating better social outcomes, reducing capital and operational costs of the project. Correct implementation is by no means simple and requires comprehensive understanding and evaluation of the physical and chemical environment, biological environment, human and socio economic environment, environmentally sensitive areas, as well as governance framework.

The physical and chemical environment is focused on all non-living aspects within the given environment, these include both natural and man-made. These aspects could be physical objects (e.g. land forms) or physical processes (erosion). This environment is intrinsically linked to the biological environment and vice versa, and is divided into several topics which accommodate individual investigations, while sometimes multi-parameter studies are also feasible. Included within these topics are bathymetry and topography; morphology; land use, hydrology, geotechnical, geology, ambient noise (both air and water); water quality; air quality; vibrations; extremes of temperatures; navigational conditions.

Within the biological environment, all living organisms (and includes processes such as photosynthesis) are the focus. It can be studied in two different ways, either at the habitat level, or at the species level. At the habitat level, specific groups of flora and fauna which are reliant on certain chemical and physical conditions found in a specific region (determined by position, substrate, and climate) will be studied. Species level study gives rise to a much larger range, with many more groups of species e.g. vertebrates, invertebrates, plants, and many more relating to taxonomic grouping. The understanding in this area quickly becomes very complex, with many differing factors which need to be accounted for, such as natural instincts, migratory patterns, and behaviors. Due to this complex nature, coupled with the generally large number of species per habitat, and the large number of habitats per site area, species do not often form the focus of a baseline study. The exception to this generality is when a keystone or apex species is identified within is specific site and due to their importance will gain more attention within the initial baseline assessment.

To understand the human and socio economic environment, study and analysis of the project within the context of existing and future lived-in spaces must be taken into account, whilst also taking into account the extensive economic and social functions. It is important to consider the relationship,

connectivity to, and effects on, existing and planned urban developments for both residential and commercial use when proposing and designing navigational projects. The overriding goal must be to harmonize the proposed project with existing and planned land use to sustain natural features whilst accommodating the necessary economic growth (e.g. industry, housing, transportation, public safety and security). The developers must be knowledgeable about local and regional economics, environmental and social objectives, as well as addressing social justice and community issues (where people will live, work and move around). In addition, where development projects take place, cultural prehistory must be taken into account in terms of the impacts on archeologically sensitive sites.

With regards to environmentally sensitive areas, conservation or heritage sites, for example, often gain these distinctions through their unique biological, physical, and or chemical nature. It is important that these sites receive extra attention with regards to studies aimed at understanding the environmental landscape. Due to their unique nature, these sites often have a wealth of knowledge and research surrounding them, this allowing a better understanding of how to better work with them and employ the Working with Nature philosophy during project development.

Governmental frameworks vary significantly across the globe, with different approaches to navigation infrastructure projects, and viewpoints (which can be a result of cultural traditions). It is recommended that a review of the environmental policies and legislation should be carried out and specific attention should be paid to environmental impacts as a result of the project. This includes, legislative framework; federal- and state-level agencies incorporated with respect to legislations; regulatory framework; policy and development plans (Integrated Shoreline Management Plan (ISMP) / Coastal Zone Management Plan (CZMP), cultural resource consultations).

*Meaningful use of stakeholder engagement:*

This section broadly refers to a framework of policies, and techniques which are employed to ensure citizens, communities, groups and organizations have the opportunity to be engaged in a meaningful way during the process of decision making, which may affect them or have a vested interest in.

The key principles for stakeholder engagement processes include: a way of providing information in a format which is readily understandable, and tailored to the needs of the target audience; to provide information in advance of consultation activities and the decision-making; communicate information in ways and in locations that allow ease of access by the necessary stakeholders; it must respect local traditions, languages, timeframes, and the decision-making process; provide two-way dialogue between all stakeholders, in order to facilitate exchange of views and information; there must be in place, mechanisms for responding to any concerns, suggestions, and grievances; and finally a way of incorporating feedback into the project design, and conveying this back to the necessary stakeholders.

*Prepare initial project proposals/design to benefit both navigation and nature:*

This planning step involves organizing, merging, and transforming of steps 1 through 3 of the initial project design in order to benefit the navigational purposes as well as nature and societal demands. This involves the culmination of the environmental impacts and requirements, coupled with the stakeholder engagement communications and any required governance frameworks. It allows for detailed collective information from the outset, and highlights any key areas which need addressing prior to moving forward with planned development works**.**

It must be kept in mind that the scope and depth of the project objectives, environmental assessment, and stakeholder involvement will depend on the overall complexity of the project, as well as the type and sensitivity of the environment, and therefore should be accounted for on an individual basis.

**Stage 2. Build and Implement**

*Build/implement design, (with monitoring and adaptation):*

Here considerations which should be taken in to account during the process of implementing the design, development of the construction, and the operational construction of the project are dealt with. This relies on close partnership between all contractors (e.g. engineers, ecologists, designers and other specialists) and the ability to undertake potentially unconventional work in response to assessments and communications. This requires alternatives to the traditional materials and equipment to be explored (construction techniques and materials) in order to meet environmental requirements. Adjustments to construction sequencing will also have to be accommodated in order to account for unseen adverse environmental impacts, which may be weather/climate related, and or detected through the stringent monitoring program.

Whilst any impacts and optimizations will have been assessed and dealt with at the design stage, it is during the implementation/construction phase, through close monitoring and adaptive management

strategies that any unforeseen issues will need to be addressed.

It is also crucial that any win-win scenarios be identified and explored prior to and during the implementation phase, as in all other stages, by systematically integrating the social, environmental, and economic considerations of the project. It is key that the Working with Nature focus be utilized at every stage of the process with the continual reengagement of stakeholders during the implementation and adaptation phase.

**Stage 3. Monitor, Adapt and Manage**

*Ongoing monitoring of project, with further adaptations and careful management:*

The monitoring and evaluations are crucial elements to assess the success of a particular project. All data, measurements, and observations obtained through careful monitoring and evaluation enable an understanding of why some projects fail or succeed. These observations can be utilized in future projects or during follow-up monitoring/management in order to improve the chances of success. Monitoring can be divided into two categories depending upon the functions and temporal frequency required.

Functions based monitoring includes situation, condition and trend monitoring; it implies intensive programs to evaluate pressures and assess long term trends. Operational monitoring, whereby the effects and success of implementation measures are monitored. Compliance monitoring implies the monitoring required to determine whether license / permit / authorization / consent / requirements have been met. Diagnostic monitoring involves further study to determine causal relationships that lead to observed changes, thereby increasing understanding and providing more information.

Temporal frequency monitoring includes the short term monitoring and evaluation to assess the direct output and effectiveness of the individual investments. Long term monitoring implementation is important for quantitative evaluation of certain outcomes: effects and benefits (ecological, financial, etc.). Long term monitoring also allows for visualization of project evolution, and subsequently, allows for suitable (re)action to occur leading to a higher quality/level of the delivered product [2].

**Case studies**

*Kreetsand, Germany, DE*

In order to safeguard seaward access of the Port of Hamburg, the Hamburg Port Authority and Federal Waterways and Shipping Administration employed an innovative concept for a sustainable development of the tidal Elbe River, with the objective to dissipate tidal energy and decrease flood current in order to reduce upstream sediment transport and dredging necessities.

The project planned to utilize a 30 ha area on a previously realigned dyke, with the excavation of 2 million $m^3$ of soil to allow a 1 million $m^3$ tidal volume to flow in and out. The Working with Nature concept was employed from the outset, with an in-depth analysis of the site taking place before starting the planning phase, in order to understand the environment (protected areas/species, etc.). Important significance was given to defining and describing the NATURA 2000 habitats, in order to adjust planning needs sufficiently. Stakeholders were engaged from the outset, with the HPA setting up communication strategies for the planning and execution phase of the project. Early and continuous involvement from the local community, conservationist, and figure heads was implemented allowing for the project background and concepts to be clearly explained to all parties. Win-win solutions were identified through synergistic effects, with the main objectives (tidal/sedimentation) combining with the ability to create valuable shallow-water areas, with a natural riparian shape and vegetation. Leading to benefits for the HPA dredging activities and also positive effects on the nature conservation and habitat creation. Beyond the legal requirements the project managed to benefit nature and enhance natural environments by creating shallow-water areas, marsh and mudflat habitats, with new spawning and nursery areas for fish population.

Overall the project successfully utilized the Working with Nature concept step-by-step. From the beginning of the project it was apparent that an integrative planning process was required to combine the different interests and needs simultaneously (port use, water/sediment management, and nature conservation). The 2 million $m^3$ of excavated soil was analyzed, although one third was unsuitable for reuse (contaminated), the other two thirds were designated for use in harbor construction, and some fractions (good condition) put on the market to be used in other engineering works [3].

*Salhouse, Norwich, Norfolk, UK*

Erosion over a period of several decades caused the spit of land between Salhouse Broad and the River Bure to become significantly narrow, threatening the integrity of the river bank and its riverside mooring. Four geotextile bags of a total length of 170m were put in place to retain 12,000$m^3$ of dredged sediment, forming 7,000$m^2$ of reed-bed to protect the spit.

The project objective set out by the Broads Authority, UK and was developed around beneficial use of dredged sediment in combination with the Working with Nature philosophy. It was decided

that in order to best utilize the dredged sediment, restoration of a lost reed-bed habitat would take place, thereby also protecting the heavily eroded spit of land.

The project followed the Working with Nature concept from the outset, with environmental assessment undertaken to understand the area prior to planning and design. With the Broads being a manmade area, it required specific management to ensure high quality habitat development. From the assessment the aim was to enhance biodiversity by re-creating reed-beds, a habitat which was noted as locally diminished, as well as nationally. By creating this new habitat to protect the spit of land from further erosion, whilst beneficially using the dredged sediment. All stakeholders (landowners, local site managers, Environment Agency, navigation committee, etc.) were involved from the outset. Liaising with all members during individual meetings, interests and conflicts were brought to light, encouraging dialogue between all parties. The win-win opportunities were identified with the project focused on beneficial use of the dredged sediment. Reed-bed habitat was created from suitable dredged material, utilizing locally sourced material for the bioengineering associated with the reed-bed creation.

The project successfully followed the Working with Nature concept, clear environmental assessment (and reassessment where necessary) took place identifying vulnerable areas. Cost implications associated with the project and utilizing the Working with Nature concept came from the sourcing of local material; these not as competitively priced as conventional "off the shelf" products. However, due to the win-win situations involved and the reduction in transport costs, no extra costs were incurred. The final outcome of the project included improved navigation and a healthy reed-bed; essential to local wildlife. A survey conducted five months after vegetation was put in place, recorded good growth over the entire site with a total of 30 different species of wetland plants, with 3 nationally scarce species recognized also [4].

*Middle Mississippi River, Mississippi, United States*

The objectives of the project involved the development of the three-meter deep navigation channel, to ensure reliable navigation depths and widths on a critical 195-mile stretch of the Mississippi River. This particular stretch of the river falls into the "open river" reach, whereby the viability of navigation is not dependent upon locks and dams, the reliable channel was developed using river training structures and dredging.

Prior to installation of the river training structures, physical and environmental monitoring was conducted. Collection of high-resolution multi-beam bathymetric surveys and Acoustic Doppler Current Profiles were performed, as well as fish collection, fish tagging, and macro-invertebrate and substrate sampling. All stakeholders and potential partners were involved prior to planning, this ensured identification of potential options and solutions and the agreement on preferred outcomes. The structures utilized in the engineering works have been employed and developed since the 1980s, they were designed to create environmental diversity and enhanced habitat while still being able to improve the navigation channel. In many locations the structures have eliminated or substantially reduced repetitive maintenance dredging. Along with the structures, islands have been created, and side channels preserved or enhanced. With close collaboration between stakeholders, navigation channels were improved, whilst also creating habitats and enhancing the natural environment.

The project objectives were continually organized and established around the specific area of the river (195-mile stretch). All stakeholders and partners met together for physical modelling meetings, site visits, coordination meetings, and inspection trips. The team member meetings included fisheries and wildlife managers, and biologist that were knowledgeable and understood the specific environment. Win-win situations were adopted through careful partner interactions and use of specialized structures developed to enhance the aquatic environments, whilst solving the issues concerned with safe navigation. Careful monitoring of all sites prior to, during, and after the project works was crucial in the projects' long-term success, with adaptations arising from concerns raised by relevant members also taken on board. The Working with Nature philosophy has been adopted by the group for a number of years, with the collaborative plan adjusted yearly to take into account the needs of navigation and the environment, with close stakeholder relationships in place to allow for practical dialogue between parties [5].

*Mersey Estuary, Liverpool, UK*

The Mersey Docks and Harbor Company are responsible for safe navigation within the port area. Annually 1.5 million tons of sand and 800,000 tons of silt is dredged, which normally is disposed of at the southern Liverpool Bay. The objectives were to apply the Working with Nature philosophy to identify potential beneficial use for the maintenance dredged material. To identify win-win scenarios which meet the environmental objectives outlined under the EU Habitats and Water Frameworks Directive.

To accomplish this, a thorough understanding of the Mersey harbor environment, including the several national and international designations which

were in place, the historical sediment accreting system within the estuary, and also the foreseen sea-level rise and potential effects on important intertidal areas were all required. Meaningful use of stakeholder meetings was employed from the very beginning, identifying the challenges involved in the project, the maintenance dredging required, the environmental impacts and possible solutions.

Identification of the most beneficial win-win scenario came in the form of deposition of the fine-grain sediments which would be preferentially deposited at the mid-river site; leading to sediment retention within the estuary, serving as a supply for intertidal habitats at risk from sea-level rise. The reduced distance for disposal economically benefited the Mersey Docks and Harbor Company due to the reduced shipping costs, as well as reduced carbon.

The pre-project environmental assessment which took place, which included sediment budget surveys, was utilized to allow for correct prediction of natural upstream sediment dispersal, benefiting the required intertidal environments. Close monitoring of sediments using tracer studies allowed for prediction of sediment fate deposited at mid-river site. Monitoring also played a crucial role in accounting for deposition within sensitive and potentially negatively impacting areas.

Overall Working with Nature proved to be beneficial to both the Harbor area and local environment in the long-term, reducing costs, and also reducing associated carbon output, once all involved had adjusted to an alternative view of environmental engineering [6].

## DISCUSSION

As with any project, the needs, objectives and environmental conditions will be project-specific, based on location, and site specifications, taking into account the hydrological and ecological, as well as the societal conditions. Understanding the environment sounds like a simple task, but all too often, only a small part of the environment is understood when project planning is undertaken. It is important to take into account the environment as a whole, understand the complex ecosystem and the dynamic nature which is present in the wider context.

Making the most of the stakeholder engagement is crucial to the success and further implementation of Working with Nature. Although this can be difficult to implement, and often compromise will be necessary, it is necessary for success. Ensuring that the most accurate representatives are present, will ensure that conflicts can be resolved. Creating dialogue early on between all parties is a key step, and should also help to identify the best and most suitable win-win scenarios.

It essentially comes down to the knowledge, and resources, and how best to share this in order to allow others to learn from it. Utilizing experience from different 'fields' and applying the basic outlines/principles to new project works. Ecosystem-based design presents many challenges in how to identify the necessary conditions at each site, in order to create the ideal conditions that promote ecosystem health. Through monitoring and adaptation this can be achieved, pre-emptive strategies utilizing local knowledge, and the correct reaction to problems by using experienced contractors should facilitate a well-organized project. With the correct assessment of the project, along with the suitable management, the Working with Nature concept can succeed in all projects.

## CONCLUSION

The Working with Nature philosophy is not new, but integration of engineering and the natural environment represents a paradigm shift from an old way of working. It is a key sustainable development tool, which if used correctly, and as outlined, can benefit society's needs, whilst also taking into account the fragile and vulnerable ecosystem, which is often taken for granted in our day-to-day lives.

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