D2.3
BASELINE REPORT

101113621 – LIFE22-CCA-NL-LIFE WATERSOURCE

DELIVERABLE

D2.3 Baseline report

This baseline report provides a description of the premises from PWN at Andijk where the LIFE WATERSOURCE project will be constructed.

This includes insights into the composition of the soil and the impact on the current nature present.

DISSEMINATION LEVEL

Public

DATE

March 2024

Content

SUMMARY

Currently, drinking water supply company PWN provides almost 2 million people with drinking water in the Province of North-Holland, using water from Lake IJsselmeer as its main source. This surface water is treated intensively using a lot of energy and chemicals for the drinking water production. Additionally, several challenges are ongoing caused by climate change, such as an increase in water temperatures, excessive algae bloom, increased saltwater intrusion into Lake IJsselmeer and a poor ecological functioning of the lake. Due to populations growth, this is combined with an increased drinking water demand. To address these issues, PWN invests in nature-based solutions to (pre-)purify water, instead of seeking more technologically advanced methods, to make the drinking water production process more robust and sustainable. In order to do so PWN is aiming to construct a 'Climate buffer' where the freshwater availability is enhanced by creating extra storage reservoirs, while improving the ecological quality of Lake IJsselmeer with the creation of wetlands and a natural purifying ecotope surrounding the reservoirs. New habitats will be created for several bird and fish species and the vegetation in the ecotope allows natural purification of the water from Lake IJsselmeer. Similar as the additional treatment with bank filtration within the Climate buffer. Within the LIFE WATERSOURCE (LWS) project these natural pre-treatment steps will be demonstrated on a small scale.

The LIFE WATERSOURCE demonstration will be constructed on the premises of PWN in Andijk. Here water is pre-treated and drinking water is produced. The area envisioned for the demonstration does currently not have any purpose. In preparation of the demonstration several studies have been executed to make sure this area is suitable to use. These concern amongst others, a hydrological inventory of the subsurface, an ecological study, soil quality measurements, and an archaeological desk study of the demonstration site. The results of the soil quality measurements show little contamination, but not exceeding any limits resulting in the ability to 'reuse' the soil in the LWS area. Approximately 0.01 km^2 will be used to construct the purifying ecotope, for which some trees had to be removed. Further, there will be no (negative) impact on the nature present surrounding the demonstration site. The bank filtration will also be constructed, comprising an area of approximately 4000 m^2, where a part of the current reservoir 'Waterwinstation Prinses Juliana' (WPJ) , will be used to mimic the residence time of the water (similar to the current treatment step in the reservoirs). The results of the studies show that the land is appropriate to be used for the LIFE WATERSOURCE demonstration. Some remarks are formulated in the studies, while constructing the demonstration (unexpected) items are encountered, to make sure the demonstration will be constructed carefully.

LIFE WATERSOURCE: DEMONSTRATING A CLIMATE-RESILIENT DRINKING WATER SOURCE, ADOPTING NATURE-BASED SOLUTIONS

Currently, drinking water supply company PWN produces about 112 billion Liters of drinking water per year using Lake IJsselmeer as its main source. This provides almost 2 million people with drinking water in the Province of North-Holland. In Andijk the freshwater from Lake IJsselmeer first resides in reservoirs, after which it is (pre-) treated intensively. If the water quality does not meet the requirements, the intake of water from Lake IJsselmeer is temporally ceased and the water which was stored in the reservoirs beforehand is used. This way, a maximum of 4 to 10 days of intake stops can be bridged. The current drinking water production process relies heavily on dosage of chemicals and consumes significant energy, resulting in a high CO2 footprint. Additionally, several challenges are ongoing caused by climate change, such as increase in water temperatures, excessive algal blooms, increased saltwater intrusion into Lake Ijsselmeer and a poor ecological functioning of the lake. Due to populations growth, this is combined with an increased drinking water demand. To address these issues, PWN invests in nature-based solutions to (pre-)treat water, instead of seeking more technologically advanced methods, to make the drinking water production process more robust and sustainable.

In order to do so, PWN is aiming to construct a ‘Climate buffer’ where the freshwater availability is enhanced by creating extra storage reservoirs, while improving the ecological quality of Lake IJsselmeer with the creation of wetlands and a natural purifying ecotope surrounding the reservoirs. In this natural landscape a diversity of habitats for various animal species will be created and the water is pre-treated naturally. The vegetation, like reeds creating a ‘helophyte filter’ and water plants allow purification as well as the additional treatment of bank filtration. With LIFE WATERSOURCE (LWS) these natural pre-treatment steps will be demonstrated on a small scale on the premises of PWN in Andijk.

P W N

Currently the water treatment of WPJ and 'Pumping Station Andijk' (PSA) as stated above occurs on the premises of PWN in Andijk. This land was originally water and shore of the 'Zuiderzee'. However, after the 'Afsluitdijk' was built in 1932 Lake IJsselmeer was created. In 1968, the PSA treatment facility and the PSA reservoir was created, followed by the WPJ treatment and reservoir in 1980. Before PWN started drinking water production at the Andijk site, the area held a (former) tidal flat with gradual transitions from land to lake, with probably high ecological value.

Figure 1 Maps of Lake Ijsselmeer and the location of the premises of PWN at Andijk in 1940 (top left), 1975 (top right), 1990 (bottom left) and 2023 (bottom right) (source: Kadaster, Topotijdreis)

LAKE IJSSELMEER

The water lake Ijsselmeer is utilized by various users in the North of the Netherlands. It is used as freshwater source for agriculture and nature, used for shipping and has multiple recreational purposes. For PWN it is the main source of freshwater. Over 70 percent of the drinking water produced by PWN originates from Lake IJsselmeer. This man-made freshwater lake comprises about 1100 km^2 and has an average depth of approximately 4 m. The water in the lake mainly originates from the river Ijssel, which is a branch of the river Rhine. River 'Overijsselse Vecht' and rainwater surpluses from the areas surrounding the lake are the other, smaller contributors. The water level in the lake is managed by Rijkswaterstaat, the national water management service, which differs from its behaviour in a natural system. During summer the water level in the lake is maintained high to ensure a large water supply (0.1-0.3 m below sea level), and during winter, the level is lowered (0,4 m below sea level) to accommodate water during high discharge and/or high rainfall events.

Natural habitat

Lake IJsselmeer, formerly known as the Zuiderzee, was originally a estuary. However, it was partially enclosed by a dam, the Afsluitdijk, in the 1930s, transforming it into a freshwater lake separating it from the Waddenzee. This alteration in the landscape resulted in profound changes to its ecosystem. The introduction of freshwater species and altered salinity levels affected the lake's biodiversity. Additionally, the management of water levels by authorities like Rijkswaterstaat further influenced the lake's ecosystem dynamics. Despite these changes, Lake IJsselmeer is an important Natura 2000 area in the Netherlands and protected under the Bird Directive. The lake and its surrounding wetlands continue to support diverse ecosystems and provide valuable habitats for both resident and migratory species. It is used by birds during migration to rest.

Several freshwater fishes live in the Lake, such as zander, bream, roach, perch, dace, smelt, and eel[1]. Of which smelt, and perch but also round goby are found in the reservoirs of PWN.

PREMISES OF PWN

The separation of the water from Lake IJsselmeer to the premises of PWN is traditional, which means a dike separates the water from land and there is no natural transition zone. Therefore these banks provide insufficient habitats, and the exchange of nutrients and organic matter between water and land is limited. There is no man-made nature created on the terrain. The nature present, like for instance the trees which are situated in the north/western part of the terrain, emerged through to natural processes.

On the terrain water is treated, subsequently transported. In addition, the terrain is also used to dewater the waste stream which is created by coagulation: iron sludge. The sludge is dispersed over a large area so iron sludge can settle prior to disposal.

The premises of PWN are inaccessible for the general public for security reasons. With one exception, in the north/western part of the terrain. In 1992 a contract was signed with a local inhabitant which stated that a small portion of the grass land on the terrain of PWN (about 1 ha) could be used. This was agreed upon with a duration of 6 months in use of loan for free, which was continued silently up until 2023.

[1] Noordhuis et al, 2014. *Wetenschappelijk eindadvies ANT-IJsselmeergebied*

Figure 2 Premises of PWN in Andijk encircled

In addition, there is still space available on the terrain which is currently not in use. This unused area will (partly) be used for the LIFE WATERSOURCE project.

Other than the purpose of drinking water production, the surface water of the reservoirs is also used by birds as rest area.

HYDROLOGICAL CONDITIONS

The geohydrological conditions near Andijk are shown in Figure 3. The surface consists of a layer that has been man-made and is likely to be built up out of clay and peat originating from the Holocene. This layer has a high resistance which means there is (almost) no regional groundwater flow. Where the reservoirs are located, this top layer has been completely removed. At a depth of about 12m below sea level the first sandy aquifer can be found, which does enable regional groundwater flow. Around -30m below sea level a layer of clay acts as aquitard which separates the sandy aquifer in the subsurface from the underlying 200m thick, sandy aquifer. The geological 'Maassluis formation' is considered the hydrogeological base, at a depth of 260m below sea level.

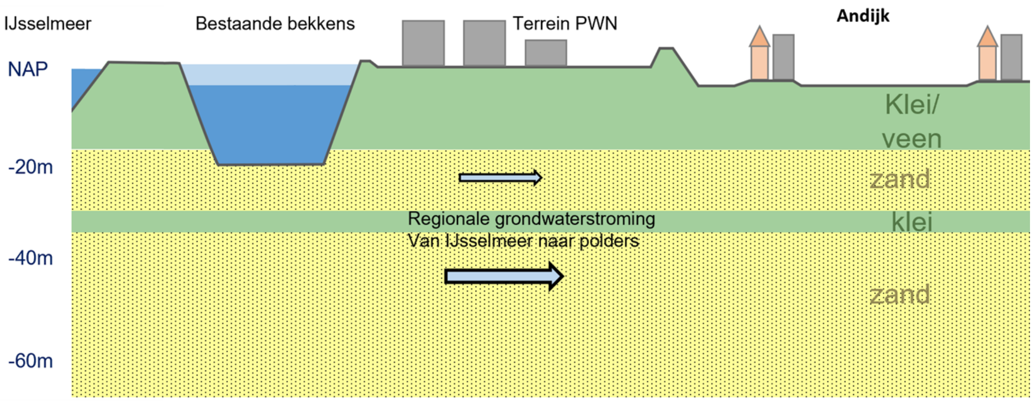


Figure 3 Hydrological cross section of PWN Andijk (the layers consist from surface to larger depths: clay/peat, sand, clay and sand where regional groundwater flow occurs in the sandy aquifers)

CURRENT TREATMENT PROCESS

An intensive treatment process is necessary in order to produce reliable drinking water. The water contains pollutants that originate from upstream sources within the Rhine catchment area, including industrial chemicals, pharmaceutical residues, agricultural run-off and other dissolved pollutants. Additionally, (treated) water from the surrounding waste water treatment plants are discharged in the lake.

Moreover, natural elements also effect water quality. For example, the degradation of algae contributes to the accumulation of excessive suspended solids and dissolved organic matter debris in the water. Due to these factors a robust pre-treatment process is required to ensure a reliable drinking water supply.

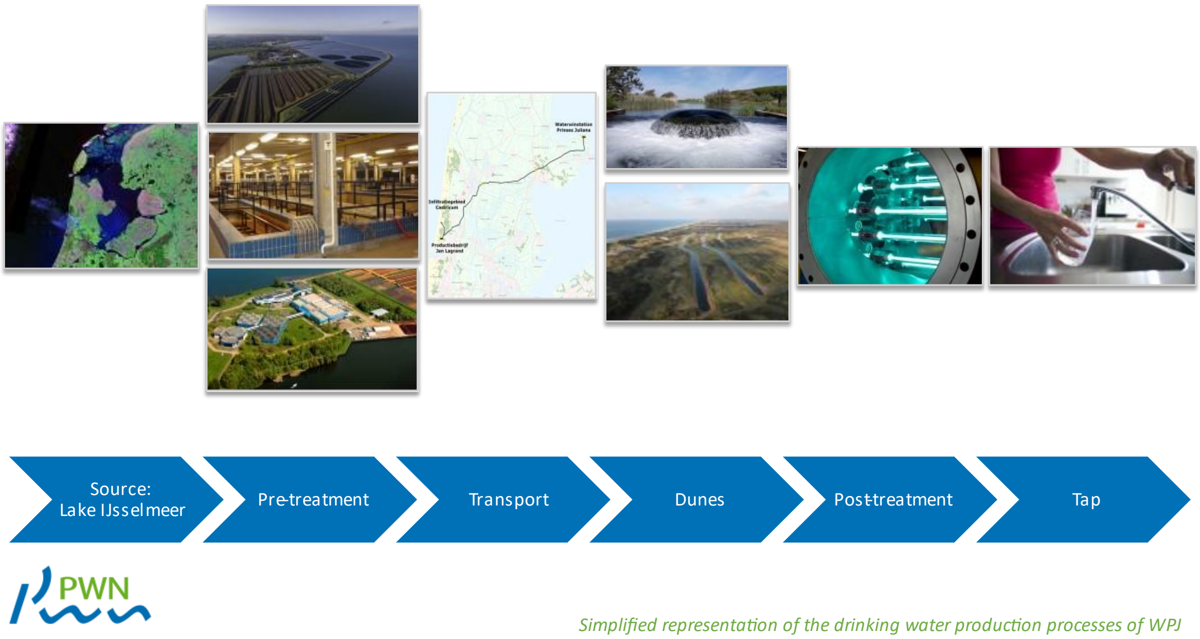


Figure 4 Simplified treatment steps of the drinking water production

SELECTIVE INTAKE

The intake of water from Lake IJsselmeer is dependent of primarily the chloride concentration at the intake (visible in Figure 5). The water which is used to produce drinking water has to comply with the Dutch law which states that the legal limit for the yearly averaged concentration of chloride of 150 mg/L cannot be exceeded. The maximum daily value for chloride to take water in is 200 mg/L. During summer and autumn the (freshwater) discharge from the river IJssel, as main water supply for lake IJsselmeer, is lower compared to the winter and spring. This makes that salt water from the Waddenzee intrudes more easily towards the end of the summer and autumn, which causes higher salinity in the Lake. Saltwater intrusion occurs due to ships passing the locks and leakages of salt water at the water gates of the Afsluitdijk. Mostly during dry years, especially in and after summer (the months August and September), this requires alertness due to salinization of the lake and the water is taken in selectively, which means that the gate to let the water in from the Lake towards the reservoirs will (temporarily) be closed. Salinization can also occur in other winter and spring due to water coming from Lake Markermeer (more saline) and the Wieringermeerpolder close to Andijk (fed by saline seepage).

In Figure 5 the chloride level of the Lake IJsselmeer is shown between 2004 and 2021. Clearly visible are the higher levels of Chloride during and after the summer limiting it to use the water from the Lake for the drinking water production. Especially in 2018 the chloride levels exceeded 200 mg/L multiple days which was critical. This resulted in the preparation of additional measures to secure the drinking water production (by having ships ready to collect fresh water from the river mouth and bringing it to Andijk), which in the end were not needed. Ever since, the water management authority is more aware and improved mitigation of the Chloride level in Lake Ijsselmeer.

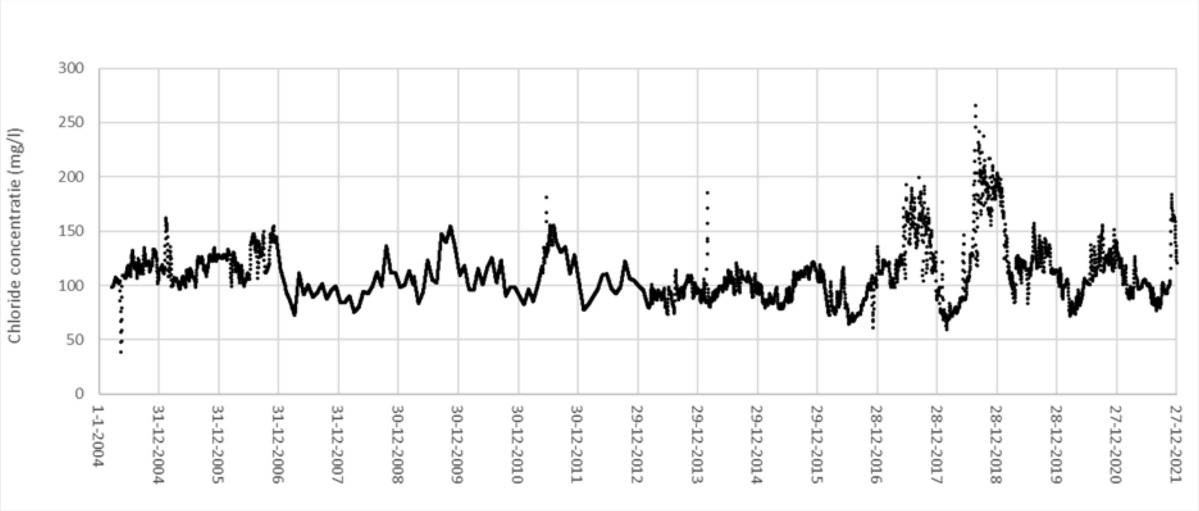


Figure 5 Chloride concentration of Lake IJsselmeer near the inlet of Andijk

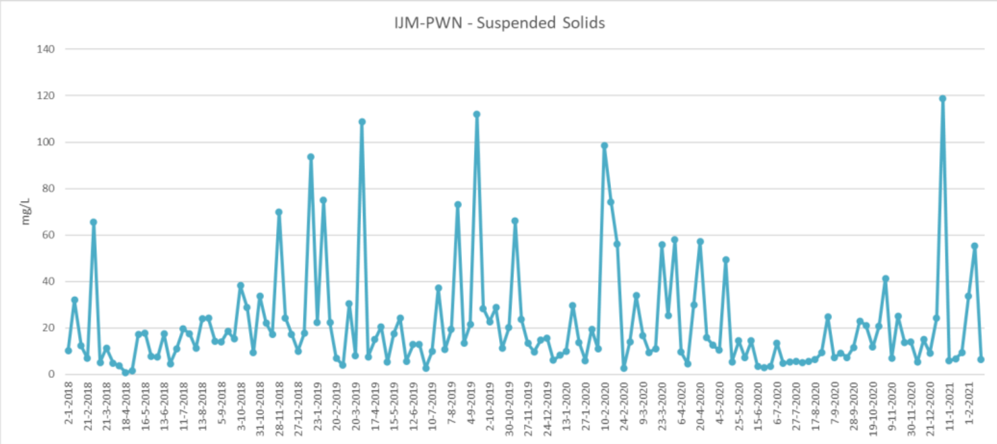
Additionally, when a plume of polluted water is observed or expected (for instance because of a leakage from ship fuel or algae blooms), the gate to take the water in will temporarily be closed to ensure good water quality. PWN is rapidly improving it’s prediction capabilities to support this, using satellite and sensor data, hydrological models, and various data from others stakeholders (mainly: water managers).

WATER QUALITY IN RESERVOIRS

The water quality is measured regularly at the inlet of Lake IJsselmeer, which feeds the PWN reservoirs. In this baseline report, there is focus on the concentration of suspended solids, DOC, NO2/NO3, and NH4 which are shown below between 2018 and 2021. These parameters have the most impact on the pre-treatment of the current drinking water production and are expected to improve with the addition of the natural pre-treatment. This serves as baseline for the water quality concerning the inflow into the reservoir subsequently drinking water treatment in Andijk.

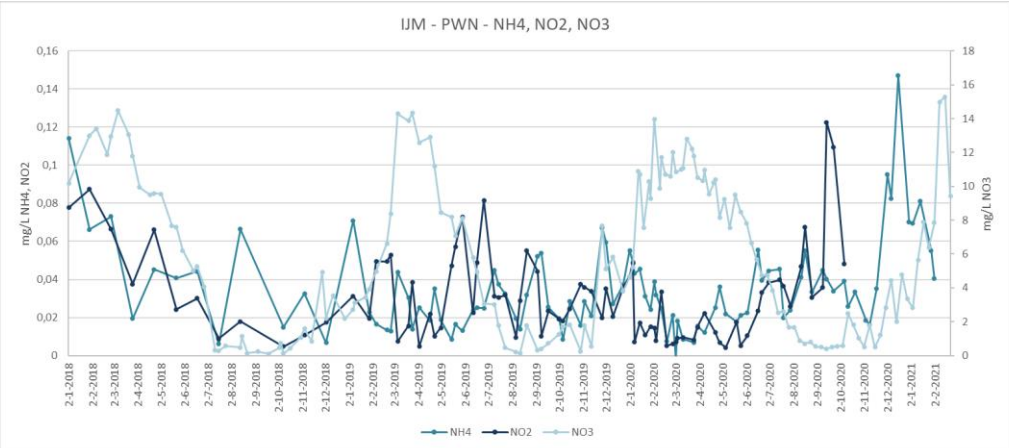
Water quality parameters

Suspended solids



The graph above depicts the concentrations of suspended solids in Lake IJsselmeer measured in milligrams per liter (mg/L). Notable fluctuations in suspended solids concentration are evident, marked by numerous peaks occurring at different points in time. The peaks in suspended solids reach levels as high as 120 mg/L, indicating significant variability in the particle content within the lake. It is noted that concentrations between 50 to 200 mg/L are considered elevated for freshwater. What is more important for PWN: since the water comes from a Lake, the suspended solids largely consist of organic material (algae, dead organic matter), suspended in the water column. This type of suspended matter is harder to remove than clastic material and can more easily cause blockage of microsieves in the water treatment.

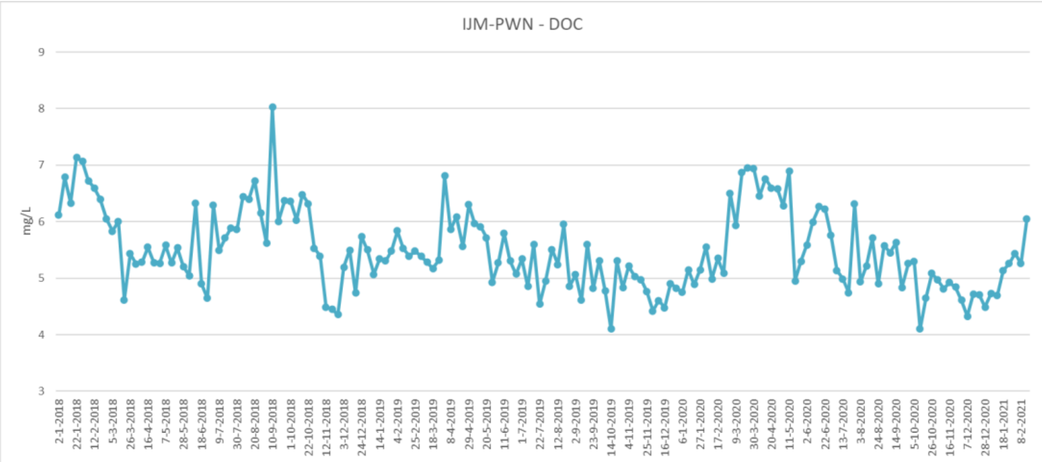
Ammonium (NH_4), Nitrate (NO_3) and Nitrogen dioxide (NO_2)



The graph illustrates the concentrations of NH4, NO2, and NO3 in lake Ijsselmeer over a period of three years. NH4 and NO2 exhibit consistently low levels, peaking at a maximum of 0.15 mg/L, with synchronous trends. Concentrations below 0.2 mg/L are considered low for freshwater sources, but still high for drinking water. In contrast, NO3 demonstrates an inverse pattern, peaking when NH4 and NO2 reach lows, aligning with the expected nitrification process (NH4 → NO2 → NO3). The

NO3 concentrations spike up to 15 mg/L, which is the result of the influx of NO3 from IJssel, Vecht and the polders surrounding the Lake IJsselmeer. Unpolluted freshwater generally have nitrate levels below 1 mg/L, thus 15 mg/L is considered high. For drinking water there is no limit exceedance, but the presence of NO3 does hamper the UV-treatment of PWN, resulting in a large increase in energy consumption.

Dissolved Organic Carbon (DOC)



The graph depicts the DOC concentration in Lake Ijsselmeer spanning from early 2018 to the beginning of 2021. Throughout this period, DOC levels exhibit fluctuations within the range of 4 to 7 mg/L. Notably, a singular peak is observed in September 2019, where the DOC concentration briefly reaches a maximum of 8 mg/L, which is considered high compared to typical values of freshwater. PWN needs to remove most of the DOC because of the impact on the water colour and because it stimulates biogrowth in the distribution network.

DRINKING WATER PRODUCTION

In Andijk water from Lake Ijsselmeer is taken into two reservoirs, which have a depth of 20m. One is the WPJ reservoir where water is pre-treated in the treatment plant 'Waterwinstation Princes Juliana' (WPJ). The water in the reservoir is aerated in order to circulate the water in the reservoir. At this depth sunlight (natural occurring UV light) does not penetrate anymore, which deactivates the algae in the water. Subsequently the water is sieved whereafter it is treated in the plant using chemicals (ferric chloride(FeCl3), and sodium hydroxide (NaOH)) for coagulation, flocculation, sedimentation, followed by rapid sand filtration. This treated process water is transported to Heemskerk. Here a partial stream of the water post-treated by ultrafiltration (UF) and Reversed Osmose (RO), and the other part is mixed with water from another source (Lekkanaal), subsequently pre-treated with comparable treatment steps as WPJ. After additional pre-treatment with UV/Peroxide (UV/H2O2) this water is infiltrated in the dunes where it passes the naturally present sand which serves as natural purification step. When this water is post-treated in other treatment plants (with aeration, rapid sand filtration and disinfection) this water is mixed with the RO water and distributed as drinking water. The total production of WPJ (pre-treated water) is approximately 50 Mm3/j.

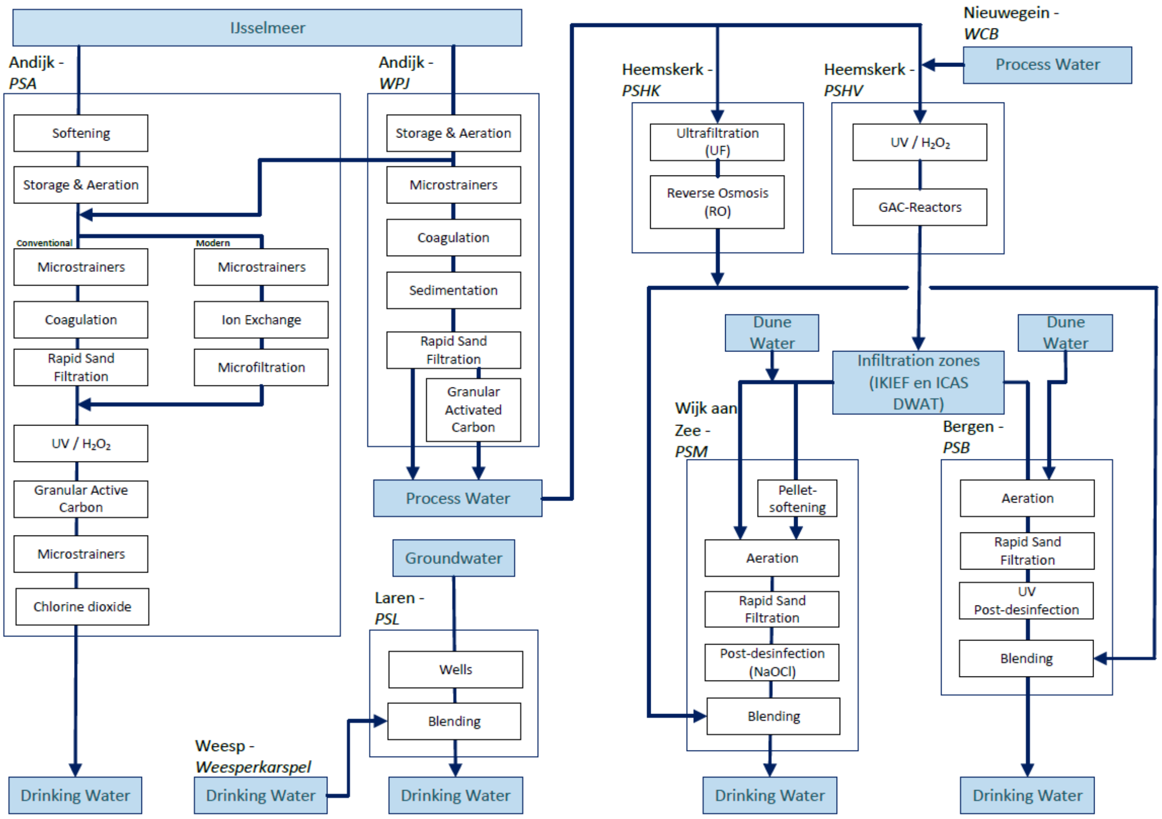


Figure 6 Flow diagram of drinking water treatment of PWN

The water from Lake IJsselmeer which is taken into the PSA reservoir is directly softened by adding sodiumhydroxide (NaOH). After aeration the water is mixed with WPJ water before it enters the treatment plant of Pumping Station Andijk (PSA). Here drinking water is produced directly and is distributed to the surrounding area. The treatment steps are: (micro-)sieves, coagulation, sand filtration, UV/peroxide disinfection, activated carbon and chlorine post disinfection. The total production is 25 tot 30 Mm3/j.

FUTURE TREATMENT

PWN uses freshwater from Lake IJsselmeer as resource to produce drinking water. However, the necessary treatment is intensive compared to the use of groundwater or river water. The concentration of chloride in the source water also requires attention certainly since dry summers are expected more often and temperatures will rise, resulting in more seawater intrusion and evaporation, and higher salinities as a consequence. With this climate change the presence of algae will also increase, which also increases the necessary treatment effort. Therefore, the better the water quality of the Lake IJsselmeer, the lower the effort and usage of chemicals and energy ergo CO_2 footprint, and the higher the robustness of the drinking water production.

PWN wants to improve the water quality from Lake IJsselmeer as this is the most important source for drinking water in the province of North-Holland. With the natural transition zone from land to water including currently missing habitats the ecological functioning will improve which benefits the water quality.

With the additional and natural pre-treatment of water from the Lake IJsselmeer, the goal is to remove a large amount of suspended solids, nutrients, and organic matter since these will relief the purification effort to a great extent. How this natural purification method will perform in practice and how to manage this best will be studied on a demonstration scale within the LIFE WATERSOURCE project. As well as the usage of bank filtration.

LWS PROJECT

LIFE WATERSOURCE demonstrates the potential of a nature-based solution for drinking water production from surface water of Lake IJsselmeer. This demonstration includes a natural purifying landscape, residence time of the water in a reservoir and bank filtration. This will be constructed on a demonstration scale on the premises of PWN in Andijk and all lessons learned will be used for implementation on a large scale in the 'climate buffer' and used for replication purposes in other countries (like in Spain).

In addition, the reservoirs which will be created with the climate buffer will make sure sufficient water is available in more-and-more frequent times of low water availability and/or salinization of the lake. The impact of these reservoirs (as water body) will be studied with a hydrological model as part of the WATERSOURCE project. For this, the hydrological impact of water fluctuations in the current reservoirs on the area surrounding the reservoirs will be studied.

Also used for replication is a digital twin, a digital prediction model, which will be used for data storage and diverse simulations to predict the behaviour of nature and its impact on the water quality.

The 'physical' aspects of the LWS project will be constructed on the locations as indicated in blue and red as shown in the figure below. Currently the LWS project terrain does not serve any purpose and looks as shown in the photo's below.

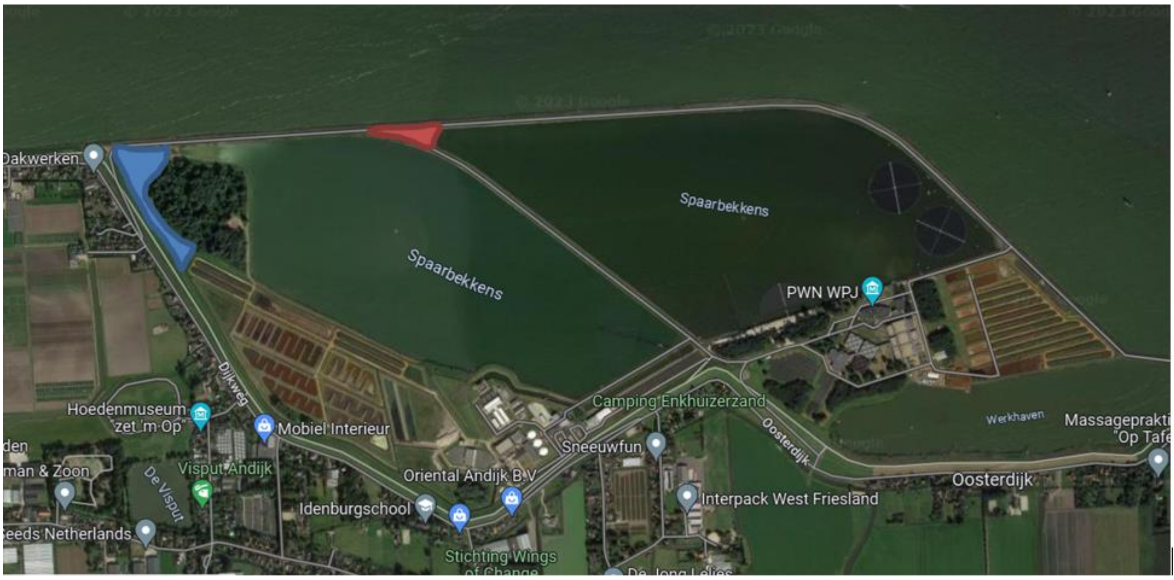


Figure 7 The locations for the demonstration project LWS are shown in blue (purification landscape) and red (bank filtration) (Source: Google Maps)

Figure 8 Drone photo of the premises of PWN and LWS project location (January 2024)

NORTH/WESTERN AREA INDICATED IN BLUE

The area in the north/western part of the premises of PWN (as indicated in blue in Figure 7) is approximately 1.3 hectares and the location where the purifying ecotope will be constructed. South of the purifying landscapes within the narrow section, constructed wetlands will be installed. The purifying ecotope and constructed wetlands together will comprise approximately 0.01 km^2. The surrounding forest in the southeast part of the premises consists of mostly birch and willows trees (aim is to preserve this natural area), at the western side there is a water ditch and fence surrounding the grounds of PWN.

Alongside the grounds of PWN is the 'Westfriese Omringdijk' a dyke, which protects the land from floods and is owned and managed by the regional water authority 'Hoogheemraadschap Hollands Noorderkwartier' (HHNK).

Site preparations

Before the demonstration construction starts preparations on site were necessary. The reservoirs to store sludge (from the reservoir which is performed once every couple years), shown in Figure 9 were removed. In addition, to ensure the accessibility of the site for survey and construction five trees had to be cut down and a pile of stones were removed.

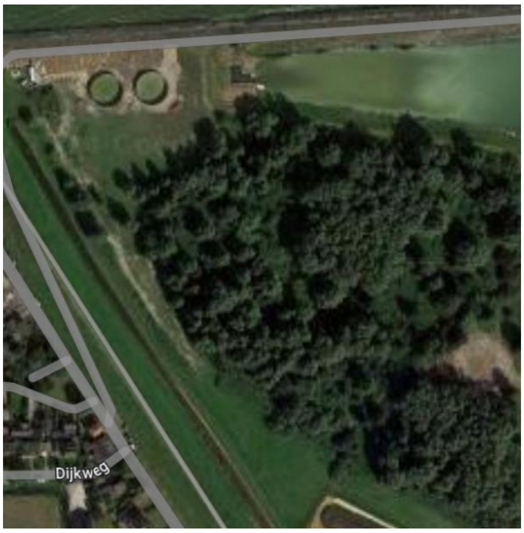


Figure 9 Top view for the location of the purifying landscape (Source: Google Maps)

Figure 10 Photos from the location where the purifying landscape will be constructed (on 6-12-2022)

NORTHERN AREA INDICATED IN RED (FUTURE PILOT RESERVOIR AND BANK FILTRATION)

The search area where the bank filtration will be demonstrated, indicated in red in Figure 7, is approximately 4000 square metres. On this location near the WPJ reservoir, a small part will be utilized to mimic the residence time of the water before it is treated by the bank filtration. This is a fallow terrain covered with bushes, and some trees. The terrain is not used at this moment. This triangle shaped area will also be used to place monitoring and measuring equipment protected in a container.

Figure 11 Top view for the location of bank filtration (Source: Google Maps)

Figure 12 Photos from the location where bank filtration will take place (2 November 2023)

Survey

To enable construction, on-site measurements were performed on the demonstration locations, which are visible in Figure 13. This information is used to determine the amount of excavation which is necessary.

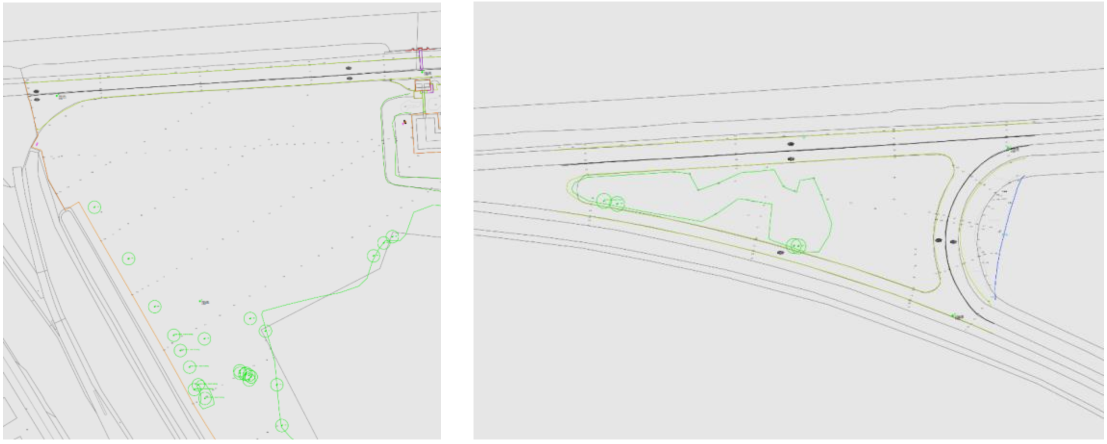


Figure 13 Site measurements of the LWS construction locations

PREPATORY STUDIES

Besides the necessity for the design of the demonstration site, PWN is required to perform several prepatory studies in order to obtain permits to allow the construction, as mandated by the Dutch law (Table 1).

The following subjects were studied:

Table 1 Prepatory studies

Subject	Description	Type of research
Underground infrastructure	Pipeline and cable network information from cable and pipeline operators such as: - Data - Electricity - Water - Gas - Sewage system	Desk research
PWN transportcables	Private PWN Pipeline and cable network information	Field research
Archaeology	Research on historical remnants	Desk research
Bombs, weapons and Ammunition 2nd World War	Remnants of the 2nd World War (Bombs and Ammunition, plane wrecks and military strongholds)	Desk research

Soil survey	Determination of different type the type of subsurface layers, density and soil contamination	Desk and field research
Geotechnical research	Technical research on ground parameters/layers in order to maintain stability of Civil objects and structures.	Desk and field research
Ecology	Flora and Fauna research because of the Natura 2000 protected area and species.	Desk and field research

Underground infrastructure

To study the underground infrastructure two trenches were dug. Here two cables of PWN (data and electricity) where located parallel to the dike near the project site.

Conclusion: *The risk of damaging the underground infrastructure is very low since we are aware of the location of the cables.*

Ecology

Research is performed on the potential impact of the project on the nature currently present. The findings are described below.

Flora

To prevent possible damage to the natural habitat (Natura 2000) the occurrence of different kind of animal species, such as bats, martens were studied. Prior to cutting down the trees in the western area, these were inspected by an ecological advisor of PWN (with credentials to perform the study in N2000 area). After thorough examination of the area the trees were cleared to be removed.

Conclusion: *No further effects for the species are expected. No endangered plants were encountered during this field study.*

Mammals

Regularly mammals like foxes, rabits, hedgehogs and mice are spotted in the surrounding of Andijk.

Conclusion: *The risk of disrupting their habitat is ruled out if construction and excavating is done in an orderly fashion.*

Fish, reptiles and amphibians

No negative effects are expected.

Birds

The forest in the western of the PWN premises, is suitable for breeding and foraging of different types of birds. For example Coal Tits, Tjiftjaf, Blackbirds and Robins are quite common. Also, the dike at the other side of the fence from PWN is a possible natural habitat of the Wagtail. The project site and its surrounding are not indicated to be a suspected area for protected spiecies/yearround breeding birds such as birds of prey, Sparrows and Swallow.

Conclusion: *when construction and excavation activities are taking place before or after breeding season, no negative effect are expected.*

Archaeology

Prior to the excavations and constructions activities, archaeological research is needed in order to determine whether historical remnants are present. If so, a special permit has to be obtained. And additional measures, such as taking samples (drilling by hand) or if archaeological assistance during the realization phase is required.

Blue area

Within the southern part of the blue area, remains of the bronze era are, primarily in the most Southern part, expected at a depth of approximately 5 m below the surface. In the northern part there are lower expectations of such findings. Throughout the whole area remains of the Iron age are expected.

From the study an estimation is made which shows that artifacts of the medieval period can be found in certain areas at a depth of 0,6 m below the surface. Further research has to be ruled out during the designing process of LIFE WATERSOURCE. The landscape on the terrain of PWN is constructed in the 70's, for that reason the local government will be consulted and questioned whether further research is necessary and whether archaeological assistance during the realization is advised.

Red area

In het red area, artifacts of the medieval period can be found at a depth of approximately 7 m below surface. According to the first concept of the design for the demonstration, those depths will not be reached.

Conclusion: *No further research is expected.*

Bombs, weapons and Ammunition 2nd World War

During the 2nd World War activities of war took place near Andijk and Lake IJsselmeer. In the period 1940-1945 several British aeroplanes were shot down by the Germans. Therefore, it is highly possible to encounter airplane wreckages and other remnants of war, like weaponry, bombs and ammunition.

Apart from the point of interest (red dot in Figure 14) which is outside the LWS area, the project site is labelled as low risk (green area).

Conclusion: *No impact for LIFE WATERSOURCE is expected, however when unexpected remnants are found during excavation, the protocol "unexpected encounters explosive devices" needs to be followed.*

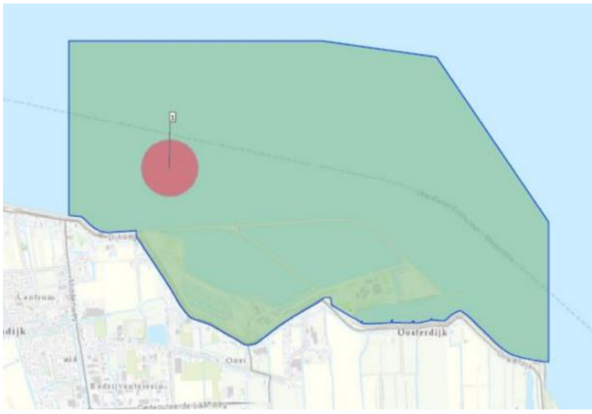


Figure 14 Possible locations of remnants from the 2nd world war

Elevation data

As shown in Figure 15 the surface level of the blue location is estimated between approximately 1,5 and 1,8 m above sea level. And the surface level of the red location is estimated between approximately 2,1 and 3,2 m above sea level.

Figure 15 Topographic map of the LWS construction locations (Source: ESRI)

Soil research

To enable construction, on-site measurements were performed ats the demonstration locations (Figure 16, Table 2). Combined with soil survey the ground types can be determined and the amount of excavation specified. In addition, the soil is examined on different types of pollutions.

Parameters which are studied amongst others are:

- Copper;
- Nickel;
- Cobalt;
- Molybdeen;
- Mercury;
- Mineral oils;
- Lead;
- Zinc;
- PFAS;
- PAK.

Table 2 Depth and soil type

Global depth	Description	Type of soil
0-11,5 below the surface	Holocene deposition	Variety of sandy clay, fine sand, Clay, Peat and little coarse sand

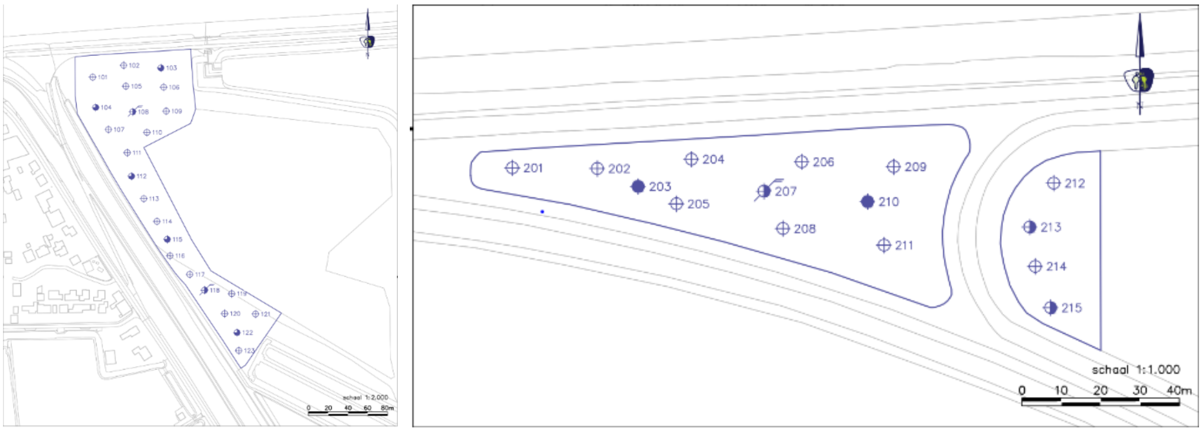


Figure 16 Soil quality sample locations

Soil quality

Blue area

The sand and clay layers were sampled and examined to a depth of 4 m below surface level. No pollution was detected and can be reused. The peat layer at a depth of 5 m deep was slightly contaminated with Nickel. *The sand is classified as "Reusable".*

Red area

The sandy topsoil is slightly contaminated with mineral oils and PAK. *The top layer is classified as 'Industrial'. The with layer of gravel/pebbles were slightly contaminated with Cobalt and Nickel and classified as "Reusable".* Traces of PFAS were found, but were negligible.

On a different location the sandy topsoil is slightly contaminated with Copper, Lead and PAK. Mediocre contamination of Sink was also found. Due the contamination of Copper, *the sample is classified as 'Industrial'. The sand sampled at a depth of 5 m below surface level is clean and is classified as "Reusable".*

The clay is contaminated with mineral oils which makes it not reusable, the classification "Industrial" is exceeded.

Ground water

The groundwater at both areas isn't contaminated, based on analysis according to Dutch (BAL, BKL and Rbk 2022) standards.

Permeability study

The sand within the blue area is fairly permeable. The sandy clay is poorly permeable. The red area is classified as highly permeable.

Additional

No asbestos was found.

WATER SOURCE

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

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