MONITORING ABSTRACTION FOR AGRICULTURE

Globally 70% of freshwater resources are used by agriculture. Farmers in the UK are finding it increasingly difficult to access enough water to irrigate their crops. Climate change is increasing the risk of drought conditions on top of changes in the regulation of abstraction which risk eroding the long-term rights to licences held by farmers. The National Farmers Union (NFU) recognises that monitoring data is becoming increasingly important for farmers to make decisions. It is also becoming increasingly important for farmers to collect their own data on water use to demonstrate compliance with abstraction licences. So which technologies are commonly used for monitoring abstraction? What innovation has there been in monitoring and modelling to aid decision making? And how can data be used to ensure compliance with abstraction licences? More importantly for this publication, how can the instrumentation industry help the agricultural sector meet the goal of sustainable water management?

Most people who work with the 50 year old abstraction system in England and Wales would agree that it is no longer fit for purpose and will not stand up to the challenges of climate change, but how is it being modernised and reformed for agricultural purposes? Since 2011 Water Framework Directive (WFD) principles of 'no deterioration' in groundwater have affected irrigation licences. For farmers that has meant a volumetric limit has been applied to groundwater abstraction. Across East Anglia volume use has been cut which has constrained the future use of headroom (buffer) that farmers keep for dry years. The Government White paper 'Water for life' published in 2011 first introduced the idea of abstraction reform. There are plans to move abstraction into environmental permitting regulations, in effect changing licences into permits. There are also plans under the Environment Bill (due to return to parliament in the Autumn) to give the Environment Agency (EA) powers to change the historic rights contained in abstraction licences. Paul Hammett, National Water Specialist for the NFU is concerned that this will erode the long-term rights to irrigation licences held by farmers and others. "We are concerned that those changes to abstraction licences can be made without the need to compensate the licence holder for that loss," explains Mr Hammett, "the removal of abstraction rights is particularly hard for farmers because they lack the ability of water companies that can rely on a basket of other abstraction licences and who can invest in alternative measures as long as customers are willing to pay for them." Indeed, an irrigation licence gives no guarantee that water will be available when needed but it is valued by farmers because it gives them some clarity on their future access to water, informing their long term cropping plans and giving supermarkets who buy from them some confidence and assurance that farmers can deliver their product on time and to specification. The EA clarifies that they are working towards a more flexible abstraction regime, with the aim of achieving a sustainable abstraction status for a particular location. This is why long-term abstraction rights have to be converted to sustainable abstraction rights. Farmers will need time to plan and adapt their businesses to regulatory change and to find alternative water sources points out Mr Hammett.

The demand for water for spray irrigation and water abstraction can outstrip the supply of water at peak times and in dry years in the East of England (figure 1). This has driven farmers to increasingly build water storage reservoirs or irrigation ponds on their land especially in water stressed catchments like East Anglia, but these are expensive and the planning regime is difficult to navigate. "There are still barriers to overcome before reservoirs become the widespread solution to drought," explains Paul Hammett who is lobbying the UK Government to give water for food production the same 'essential water status' that is given to water for energy and public water supply. Effective management of both surplus water (flood) and insufficient water supplies (drought) both affect food production and food security. Water is critical for farming not just for yield but for crop quality.

Ensuring that the right volume of water is in the right place at the right time is a difficult balance to strike for water supply, farming and nature. There are various regional water transfer schemes in operation which move water to where it is needed. But when the increasing demands of population growth and variability in rainfall due to climate change are taken into account these may not be enough to manage water resources sustainably; other transfers (figure 2) will be needed plus continued efforts to reduce demand and make efficient use of water. Stakeholders will need to be smarter in how water is used.

Innovative ideas have therefore arisen in response to demand for better water resources management. Various decision-making support tools are available that can be used by farmers to help them schedule irrigation for the maximum benefit of crops, for example the Water Portal developed by the UK Centre for Ecology and Hydrology (CEH). This provides real time information on river flows, groundwater levels, rainfall and soil moisture deficits. The Water Portal already provides a useful planning tool for farmers to track what is happening in their local water body, and provides an indication of whether they might run out of water and when. The Environment Agency are transferring their large legacy of manual abstraction licences into a digital licensing service. At present the EA can provide simple administrative help to farmers e.g. help with submitting abstraction returns. The EA's Future of National Telemetry (FoNT) project will upgrade their data communications infrastructure by 2024. A single platform will collect national data through cellular network IP communications, via telemetry systems connected to monitoring stations, thus allowing users to see river flow level data (and other datasets) in real time. "More and better data will be available with less delay which will enable better forecasting in the medium term" explains Paul Sadler, Manager of the Water Resources Team at the EA. So in future the EA will be able to provide a tool for farmers to better manage abstraction

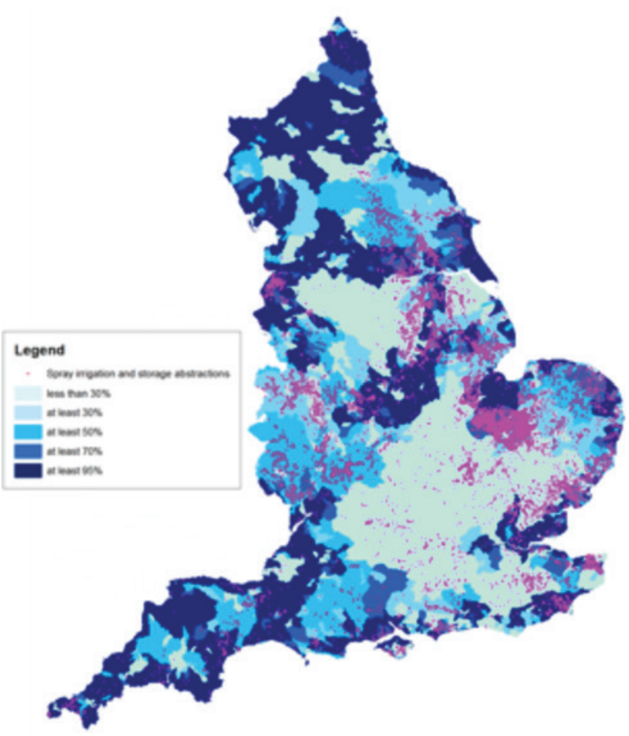

Figure 1: Spray irrigation and storage abstraction against water resource reliability expressed as percentage of time available
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licences by tracking seasonality, monitoring river flows in real time and potentially linking this with smarter notification of activation of licence conditions.

Concepts of water trading and water sharing have been put into practice. In Lincoln a group of farmers share one communal abstraction licence and every year decide how to share the volume of water allocated between them on a mutually agreeable basis.

In 2018 some farmers ran out of their annual allocation for water during an agricultural drought. In response the NFU created a Water Bank to link up farmers who need water with those with water to spare. The EA agreed to temporary trades (subject to protecting the environment and other abstractors) and then built on the Water Bank idea by creating their own trading water rights information mapping system. Now water trading platforms are being developed to facilitate future trade on a more permanent basis for example the Wheatley Watersource platform. However, Mr Hammett says that often it is easier for farmers to temporarily trade land than to trade water; approval for a trade can take as long as applying for a new licence.

Farmers may prefer the idea of sharing water with neighbours rather than commodifying water as part of a trading system. On the River Lark in Suffolk a water sharing scheme has been set up. Farmers work with the EA and local conservation groups. The farmers keep their abstraction licences but share water with their neighbours whilst ensuring the environmental needs of the river are protected.

In the Cambridgeshire Fens there is another example of multisector water sharing. Anglian Water shares water with farmers during peak irrigation season subject to an agreement with the EA that Anglian Water can use high river flows later in the year to recover the contribution made earlier in the year.

The Felixstowe Hydrocycle project is a more formalised water sharing project set up with funding from the European Regional Development Fund, with additional income from membership fees and shares. Stakeholders include the EA, Suffolk County Council, East Suffolk Internal Drainage Board, East Suffolk Water Abstractors Group, Water Resources East, Essex and Suffolk Rivers Trust, Anglian Water, Natural England, Country Landowners Association and National Farmers Union. The project was set up in response to water stress, to demonstrate the feasibility of groundwater recharge - a controversial prospect in the UK although it is commonplace in other countries. A freshwater pipeline connecting a tributary of the River Deben to the aquifer, which due to land drainage is pumped over the sea wall by an Internal Drainage Board (IDB) pump, will be built by November

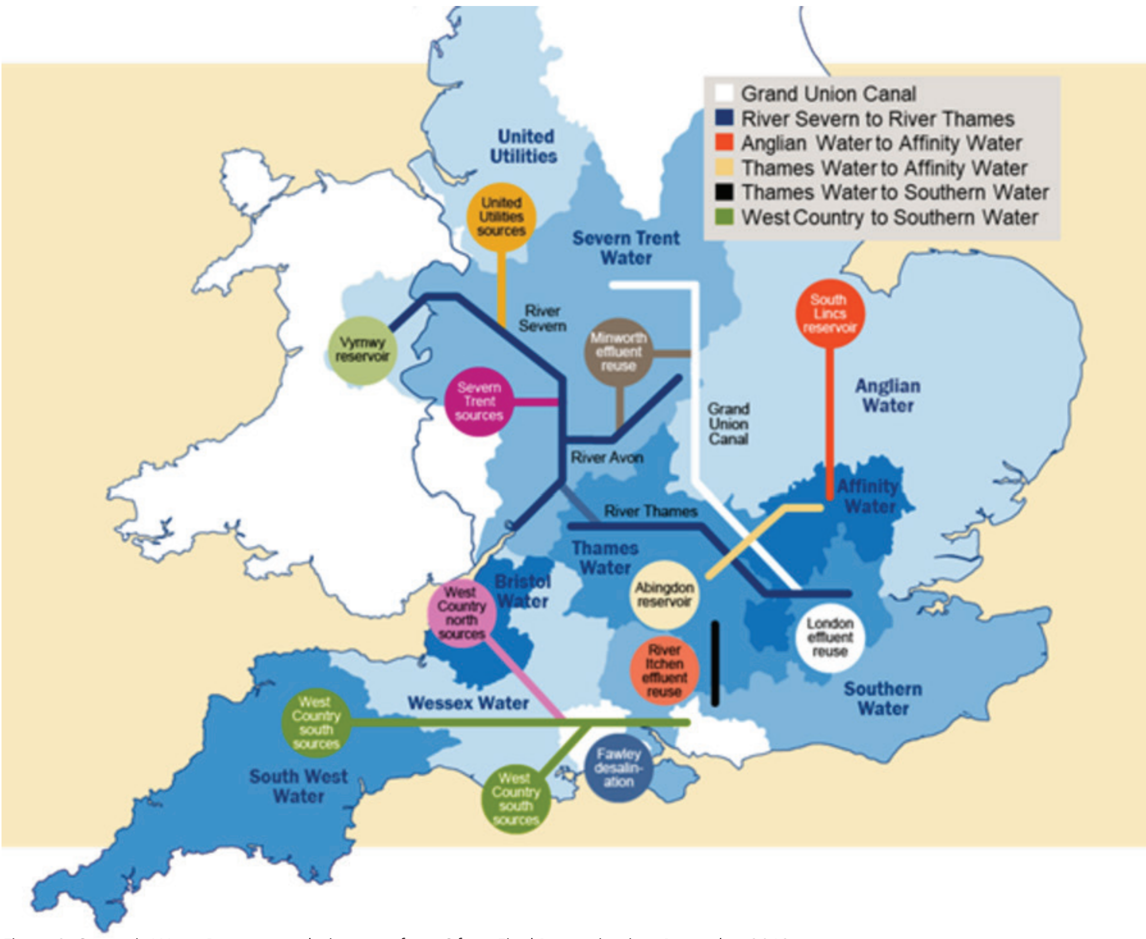

Figure 2: Strategic Water Resources solution map from Ofwat Final Determination, December 2019

Table 1 Advantages and disadvantages of different abstraction monitoring instruments

Device	Parameter for measureme	Application	Advantages	Disadvantages
Gauge board	Level	Reservoir	• Cheap	• Manual monitoring method • Accuracy depends on technician's method • Results are not digital
Shaft encoder	Level	Borehole	• Very accurate • Not subject to drift	• Manual method • Less convenient • Accuracy depends on technician's method • Results are not digital
Electric contact dip meter	Level	Borehole	• Hand made dip meter can be constructed • Comparatively cheap to other methods	• Commercial dip meters are more expensive • Manual monitoring method • Accuracy depends on technician's method • Results are not digital
Pressure sensor (hydro-static depth method)	Level	Borehole	• Convenient to install • Digital results	• Sensors experience some drift so require regular recalibration
Area velocity flow sensor	Flow	Open channel flow	• Can measure various speeds of flow independent of water level • Does not inhibit the channel	• Expensive
Standard mechanical meter	Flow	Closed pipe	• Cheaper • Digital results	• More prone to damage and drift over time • Moving parts (propellers, gears, couplings etc) naturally wear over time • Wear is accentuated by grit and debris • Meter has no method to report faults e.g. trapped air • Inhibits the channel
Electromagnetic flow meter or 'Mag meter'	Flow	Closed pipe	• Non invasive • No moving parts • Less wear and tear • No drift • Standard product • Available with short lead in times • Modular parts so easy to install and maintain – parts can be replaced easily • High IP rating so suitable for dusty environments or being fully submerged if site floods • Come with various communication protocols e.g. HART, Modbus • Comms allow 'smart' function enabling	• Expensive
Open channel flowmeters (ultrasonic transducers)	Flow and level	Open channels e.g. flumes, weirs	• Non contact measurement so less damage over time and less maintenance needed • Self cleaning face as the ultrasonic pulse cleans off dust, condensation etc to maintain a reliable measurement • All transducers have an integrated temperature sensor • Communication options are available • Smart function can be enabled • Quick start wizards pre-programmed for different applications for ease of use • Can submit the data log to the EA	• Expensive

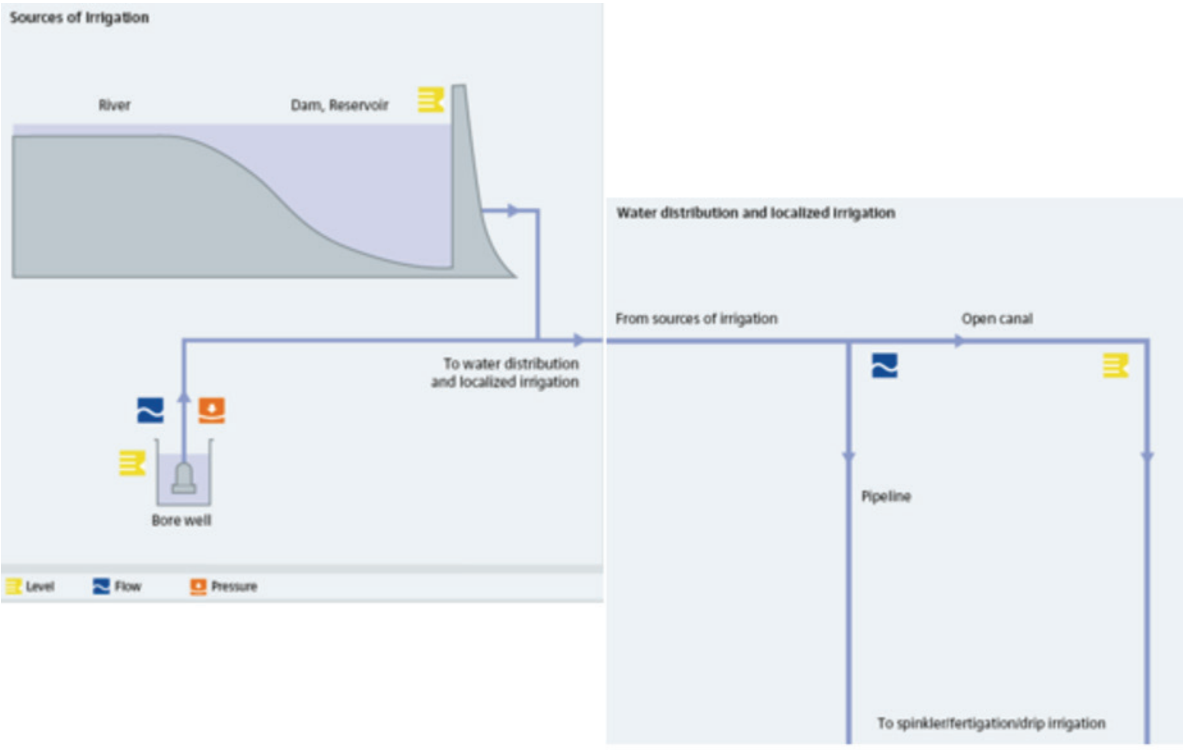

Figure 3: Diagrammatic representation of an irrigation system with points and types of measurement indicated © Siemens, 2020.

2020. As the land has been drained for agriculture the land is below sea level and the water needs to be pumped up into the groundwater level. The Managed Aquifer Recharge trial will be operational by January 2021. If successful, other areas in the East of England have been highlighted as being potentially suitable for Managed Aquifer Recharge.

Flexible abstraction – allowing temporary changes to abstraction licence conditions – by the EA has also helped farmers, for example during dry weather farmers have been allowed to abstract from reservoirs when flows are high (not just in winter). The EA wants to encourage farmers to look at their longer term resilience and make firmer plans rather than rely on flexible abstraction. "We're working with the NFU, farmers and growers to encourage licences to be varied so that there is longer term resilience," explains an EA representative from the Water Resources Assessment Team. The Government's abstraction plan has a much stronger focus on catchment management now. "Farmers are responding positively to the catchment-based approach," says Mr Hammett, "with ideas around local solutions and local decision making being adopted and supported by farmers".

Investment in obtaining monitoring data to support an application to increase abstraction can pay off. In Burnham Deepdale, Norfolk, a farmer wanted to increase his existing summer river abstraction licence to operate an additional irrigation machine. In this case a tidal sluice releases freshwater to a saltmarsh (SSSI). Flow monitoring data was collected using an Area velocity flow sensor measuring velocity and flow plus telemetry. The data indicated an annual discharge of 2.1 million m3. The EA used the recorded data to model against local catchment data (river flows) which showed that enough water was available to increase the summer licence for spray irrigation. Natural England also used the monitoring data to ensure that birds on the local SSSI had enough water and abstraction did not cause harm to the local ecology. With his increased abstraction licence, the farmer is able to increase the area growing irrigated high value crops such as potatoes and carrots for supermarket contracts.

Modelling and sustainable management of water intrinsically rely on the collection of reliable and accurate data on water abstraction and discharges, or at least using well founded estimates. Monitoring technologies range in price from the relatively cheap depth gauge at one end of the scale to the mag meter at the other end. Table 1 summarises some of the advantages and disadvantages of different monitoring technologies. The next step is to add in telemetry to transmit real time data and data visualisation software to show data in a dashboard – the same data can then be used by different users for multiple purposes. Monitoring and data collecting technologies like these will be on display at the Water, Wastewater and Environmental Monitoring (WWEM) Exhibition at Telford International, UK on 25-26 May 2021 (https://www.ilmexhibitions.com/wwem/).

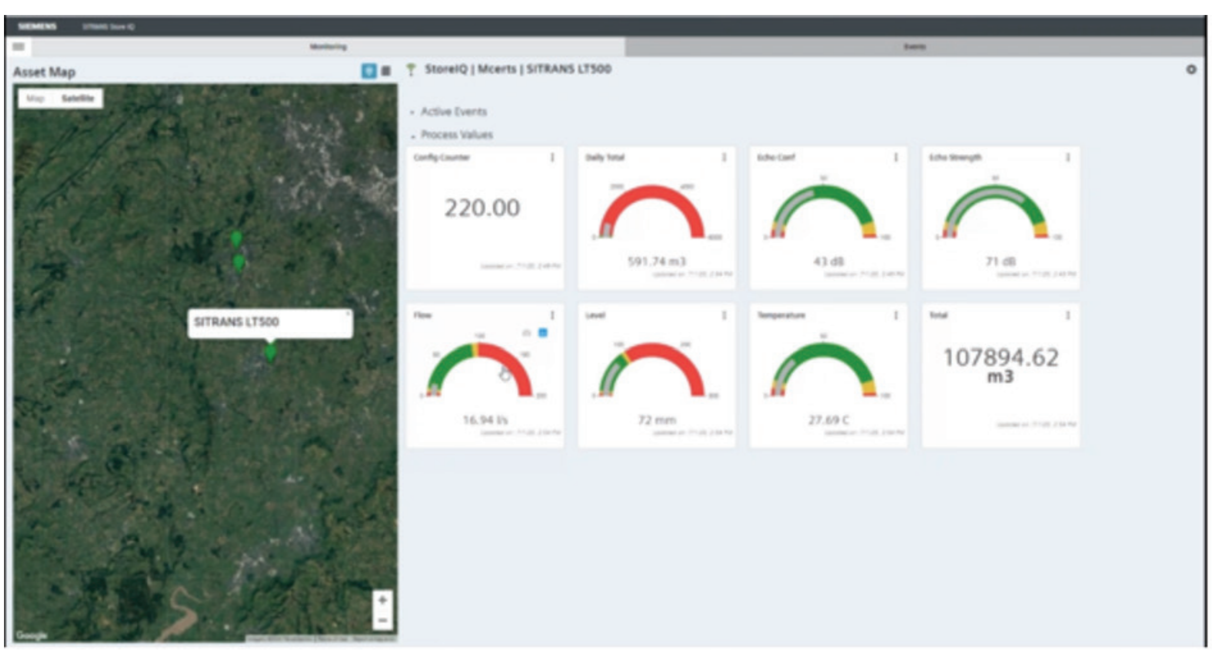

Figure 4: Screen shot of a dashboard in Store IQ © Siemens, 2020.

In the irrigation process there are various points of measurement (figure 3): measurement at the abstraction point, be that from water gravity fed from a river or reservoir or pumped from a borehole. Level measurement can be taken over the reservoir (using a measurement stick or a gauge or a more expensive ultrasonic level sensor). In a borehole, level is measured using a manual method or a more expensive hydrostatic level device (pressure sensor) measuring head pressure to derive level. Water being pumped from a borehole can be measured using an electromagnetic flow meter (AKA a 'mag mater'). As water leaves the source it will be in pumped in a closed pipe or gravity fed in an open channel. In an open channel, level and flow can be measured with the same instrument usually an ultrasonic level sensor. Metering in a closed pipe can be achieved with a mag meter (the transmitter can be compact mounted or remote mounted for ease of access and commissioning). A mechanical meter can be used in a closed pipe but has some drawbacks (see Table 1). Both mag meters and ultrasonic flow meters can be combined with comms technology to create smart instrumentation which can automate logging and reporting. Monitoring data can be transmitted to a gateway device and then stored in a cloud based platform (e.g. Siemens MindSphere), which can be visualised in an app such as Siemens Store IQ by different end users for abstraction monitoring purposes. Store IQ provides a dashboard summary of real time data compatible with both desktops and smartphones (figure 4). Real time alarms and notifications can be set up for low flows or unexpected values from sensors that highlight the need for maintenance. Farmers could come together as a cooperative so that stakeholders can benefit from economies of scale whilst having the benefits of this real time data.

Abstraction monitoring data is valuable to farmers for multiple purposes, which include; demonstrating compliance with abstraction licences, gathering a robust evidence base to support the renewal of abstraction licences, which if done in the right way can help abstractors save money. James Dodds, Water Management Specialist at Envireau Water explained "Monitoring data is invaluable to ensure water resources are being managed effectively and can prove that an abstraction isn't detrimental to the environment". Nevertheless, investing in good quality monitoring is imperative to meeting compliance, with data on abstraction volumes and rates recorded in snapshot, daily or annual intervals in association with groundwater level data and the monitoring of Hands off Flow conditions (HoFs), providing the information that you need to stay in control. "Our clients know that we design cost effective and necessary monitoring networks, that meet the regulators expectations" says Mr Dodds. There is a definite need and willingness identified by all the stakeholders to come together to develop policy and collaborative solutions to sustainable water resources management in this rapidly evolving area. The NFU have laid out what they would like to see in England as a challenge to technology providers and policy makers alike:

- Development of a fully formed system that permits rapid sharing or trading of water between abstractors;
- Flexibility in permitting to enable farmers to capture and store water at any time of high flow (not just in winter);
- Give farmers access to real time information on river flows to help them with forward planning;
- Management of water discharges to benefit downstream abstractors;
- Development of contingency planning amongst all farmers to better understand risks to water supply disruption and how best to manage these risks;
- Development and promotion of precision farming and best practice for better management of soil to trap moisture;

And finally, the NFU would like to achieve all of the above whilst developing long-term multi sector plans to enable farmers to get their fare share of water, particularly where water is scarce and catchments where food is recognised as a priority for water use. A range of monitoring and data collection solutions to these challenges will be on display at the WWEM Exhibition in the UK on 25-26 May 2021 (https://www.ilmexhibitions.com/wwem/).

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