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KLEINSCHMIDT LEADING THE TRANSITION TO REMOTE SENSING & AERIAL SURVEYS; USES eDNA TO TRACK SPECIES BY LOCATING TRACES OF THEIR DNA

For more than 50 years, **Kleinschmidt Associates** (Kleinschmidt, Pittsfield, ME) has provided engineering, regulatory, and environmental consulting services to energy companies and government agencies across North America. Kleinschmidt is an employee-owned company with now more than 160 employees. They have eight offices nationwide and two in Canada and have served clients in 45 of the 50 states and in six Canadian provinces.

Kleinschmidt is one of only a few engineering consulting firms in the United States specializing in servicing the hydropower industry and has been doing so for more than five decades. In the 1980s, they expanded into environmental and licensing services, and are now nationally known for this expertise, in addition to the engineering skills that have always been a hallmark of the company. In the 1990s, Kleinschmidt recognized the opportunity to expand their client base beyond hydro, and the company has excelled in ecosystem assessments, individual habitat and river restoration projects, watershed management, water supply reservoir management, dam removal, fish passage, and impact studies for wetlands.

Jon Christensen, President and Chief Executive Officer. Mr. Christensen has been with the firm for the past 32 years. He specializes in conducting economic studies and managing the planning, permitting, and licensing processes required for water resource and hydroelectric projects. He chaired the National Hydropower Association's task force on the Federal Energy Regulatory Commission (FERC) economics.

Scott Ault, Chief Technical and Operations Officer. In his current role, Mr. Ault's primary responsibilities include business development, technical oversight and direction, personnel management, and quality assurance. Scott specializes in the management and oversight of ecological services projects including assessing and mitigating the impact of hydropower operations on aquatic environments. Scott is a nationally recognized expert on American eel passage at hydroelectric facilities.

EBJ: How stable has the Natural Resources Management industry been over the past 5 years? What are your expectations for the near future?

Kleinschmidt: The forces that drive the Natural Resource Management industry are largely a combination of federal and state regulations that address minimizing human impacts to the environment and public sentiment on the intrinsic value of healthy, sustainable ecosystems. Both federal and state regulatory agencies are continually evolving the regulatory framework designed to avoid and/or minimize human impacts as the science to determine long-term effects of impacts continually

improves. Much of the improvements in science are a result of technology advancements in remote sensing techniques such as satellite imagery, drone data acquisition, and long-life remote photograph/videography. These techniques allow scientists to relatively easily collect large, robust data sets that provide compelling insights into human impacts to the environment on both a micro and macro scale. This has been particularly evident over the past 5 to 10 years and Natural Resource Management agencies have added new regulations or modified existing regulations accordingly.

Similarly, much of the data and conclusions that help shape regulatory policy

is also shaping public opinion and sentiment. The availability of information on the internet and the advent of communication through social media has effectively cast a spotlight on many human environmental impacts in almost "real-time" and has raised worldwide awareness to levels never seen before. The concern and debate over superstorms, clear air, the quality and quantity of clean water, burning of fossil fuels, the carbon footprint of our individual daily activities, melting of the polar ice caps, the plight of endangered species and their habitats, renewable electricity generation, and dozens of other topics all play out daily on internet blogs, discussion forums, Facebook, Twitter, and similar communication avenues. For the most part, this phenomenon has been a catalyst for the Natural Resource Management industry as concern by the public to reduce impacts to the environment increases with the availability of information. We believe this trend will continue for the foreseeable future.

EBJ: What are the trends in laws and regulations that pertain to Natural Resources Management?

Kleinschmidt: The political climate and administration have a significant impact on natural resource policy, compliance and enforcement. These shifts result in confusion and concern and we find that clients rely on us to be engaged in the highest levels possible to understand the consequences of changing laws and enforcing regulations. Any nexus to federal funding, permitting or federal lands requires at a minimum, compliance with the National Environmental Policy Act (NEPA).

There have been significant recent changes, and proposed changes, relating to water laws and the **U.S. Environmental Protection Agency's** (EPA) interpretation of the Clean Water Act. This includes what constitutes jurisdictional waters and how managers, owners and regulators are affected in terms of permitting and enforcement. The scope of Section 401 certifications is

under review, which could significantly affect future permitting requirements. There are similar trends in review regarding how government describes and analyses cumulative effects under NEPA, climate resiliency in natural resource management, and the identification and implementation of species management under Section 7 of the Endangered Species Act (ESA).

A trend we expect to continue or increase is a higher degree of focus on climate resiliency in both regulating and analyzing impacts and managing solutions. We also expect an upward trend in managing water and conflicting uses as the demand for water management increases significantly, often occurring in less traditional geographic areas of the U.S. (i.e., mid-Atlantic and Southeastern United States).

These trends, while ever changing, offer exciting opportunities for the workforce tasked with regulating and managing natural resources.

EBJ: Kleinschmidt provides services for various types of clients, including power utilities, power and energy developers, governments, NGO's and water utilities. Could you provide some trends in the demand that those clients are having for natural resources management services?

Kleinschmidt: The **U.S. Fish and Wildlife Service** (USFWS) has listed or is reviewing several pollinating insects for

protection under the ESA. Our clients are particularly concerned about the potential listing of the monarch butterfly and are focusing on how they can proactively support the conservation of pollinating insects to prevent the need for future listings. This focus has led to conservation measures by our clients that include planting and managing a diverse mix of native plants on their properties to create habitat for these pollinating insects.

An emergent trend in the government sector is the restoration and reconnection of floodplains with natural channels to enhance habitat value while mitigating flood consequences. Performed at watershed or even basin-level scale, it is increasingly being viewed as a "win-win" solution that builds environmental value while allowing our river systems to function more naturally during extreme events.

EBJ: How is climate change affecting the type of work that you conduct?

Kleinschmidt: Our power clients are changing the way they generate electricity to renewable and low carbon sources. Just recently, one of our clients announced that they will cut their carbon emissions by 50 percent by 2030 and be net-zero by 2050. Changes like these are causing cascading effects on where electricity is produced, the distribution of that generation, how it is stored, and how it is brought to market. This has created a lot of work to adapt the grid.

With the back to back extreme weather years in the Gulf of Mexico and along the eastern seaboard, we are seeing large-scale planning efforts by flood authorities that anticipate larger and more frequent adverse weather events for this region. Our "what if" surface water modeling scenarios and "rain on grid" functions with intense weather events are being used to quantify impacts to the built environment and examine opportunities for changes to accommodate extreme events and enhance system-level resiliency.

One of our clients announced that they will cut their carbon emissions by 50 percent by 2030 and be net-zero by 2050.

EBJ: Do you think that there will be an increase in National Resources Management Work in the near future due to climate change?

Kleinschmidt: The development of renewable energy has come with challenges to manage natural resources. In many cases, solar companies are trying to develop as quickly as possible and avoid as many conflicts as possible with protected natural resources in the process. These developments are creating large areas of infrastructure that traditionally do not provide high quality habitat. For example, some solar companies are creating prairie habitats that are compatible with their infrastructure to benefit pollinating insects or grassland birds.

Perhaps one of the stronger market signals reflecting government priorities related to climate change comes from the state of California's 2018 Water Plan Update. Fifty-year stated budget needs exceed

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\$85 billion to address two of the plan's complementary goals of strengthening infrastructure resiliency and restoring critical ecosystem functions. With over \$580 billion of assets at risk (i.e., crops, property, public infrastructure), this represents over 94 percent of the state's projected needs for water resources and natural resources-related funding.

EBJ: How are you using technology while conducting services like wetland and habitat investigations, endangered species assessments and remote sensing? How do you think that these services will be performed differently in the near future due to changes in technology?

Kleinschmidt: Kleinschmidt has investigated the use of state-of-the-art technologies for performing wetland and habitat investigations, and when conducting rare, threatened and endangered (RTE) species assessments. Remote sensing provides the opportunity to sample these communities and ecosystems from afar without disturbing the species, resulting in observing them without introducing bias. With remote sensing, it is also possible to collect large volumes of data at a fraction of the cost of traditional boots-on-the-ground surveys. When we combine remotely sensed images and point clouds with robust training data, our geospatial professionals can identify and quantify these communities using machine learning algorithms. It is also possible to assess changes in community structure with repeated aerial surveys.

As more remote sensing surveys are conducted, validated and accepted by natural resource agencies, we believe there will be a paradigm shift in terrestrial surveying where large-scale rapid-assessment and qualitative boots-on-the-ground surveys will be replaced in favor of targeted small-scale quantitative training data surveys coupled with large-scale aerials surveys conducted with unmanned aerial vehicles (UAVs) or collected by satellites. The ability to infer what is on the ground from remotely acquired images and data will improve as new and more advanced sensors, and more powerful software are acquired, increasing our institutional knowledge.

We also recognize that remotely sensed data should not be limited to images and

point clouds. Advances have been made in environmental DNA (eDNA) allowing us to track mobile species, without observing them, in terrestrial and aquatic environments by locating traces of their DNA in the environment.

EBJ: Kleinschmidt provides substantial amount of work in the area of Fish Protection and Fisheries. Please provide information on trends related to the following:

- Species Restoration and Restoration Planning

With major advancements in aquatic biotelemetry including miniaturization of tag electronics, fisheries biologists can tag and track a variety of sizes of migrating fish to understand their use of habitat and their response to altered flow regimes. For large-scale whole-river migration projects, we routinely deploy radio telemetry technologies; while for small-scale habitat use and infrastructure efficiency projects, acoustic tagging technologies that produce fine-scale, three-dimensional positions in time are being utilized.

The voluminous information produced by these technologies can be analyzed with advanced algorithms for large datasets to determine how and why fish move with respect to hydroelectric station operations and other environmental parameters. We anticipate that study demands will grow over time with requirements for more complex whole-river telemetry networks designed to assess cumulative effects on fish migration and small-scale infrastructure efficiency projects to determine how individual fish react to near-field hydraulics.

Having the architecture and institutional knowledge necessary to assess the voluminous datasets produced by these technologies will become key for the success of these projects in the future.

- Agency Consultation

We believe that close consultation with natural resource agencies is a key to project success. As our knowledge of fisheries and our understanding of our impacts on fisheries increases, the questions that are being asked by resource agencies are in-

creasing in complexity. By working closely with agencies during study planning, consultant biologists and regulatory personnel can strike a balance between answering key regulatory questions with sound statistical assessments that preserve the client's interests through proper scoping. Following the completion of large-scale telemetry projects, our data scientists assess habitat use, movement and migratory success with state-of-the-art statistical techniques and machine learning algorithms.

- Mapping

Kleinschmidt's geospatial professionals are at the forefront of incorporating remotely-sensed data into our mapping projects. UAVs offer the ability to quickly sample large areas of riverine or lacustrine habitat. The resulting orthomosaic images, synthetic LiDAR point clouds, and photogrammetric models can be further analyzed to quantify existing habitats and draw insight into their use. Assuming that optimal conditions exist, it is even possible to map substrate types and woody habitat features with UAV images. When these data are combined with water velocities produced by acoustic doppler current profilers, and bathymetry from multi-beam SONAR, we have the ability to map habitat with stunning accuracy and detail. As agency questions become more complex and focused, we foresee the need to map habitat with high accuracy increasing over time.

- Engineering Design

One trend in field of engineering is the use of Computational Fluid Dynamics (CFD) modeling to enhance and inform the design of fish passage and protection facilities. CFD modeling uses applied mathematics, physics and computational software to visualize how water flows. CFD modeling allows biologists and design engineers to understand and illustrate the flow fields that fish navigate to move through the fish passage facilities that were designed and constructed to allow them to freely move around barriers (i.e., dams) in their migrations. This type of modeling allows optimization of the efficiency and effectiveness of the fish passage layout.

Another trend in field of engineering for fish passage facilities is a movement to-

ward the use of nature-like approaches to provide fish passage at migratory barriers (i.e., dams), as opposed to the more traditional approach of providing “technical fishways” that have historically been constructed of engineered materials like concrete and steel. We are seeing an increased inclination of fisheries resource agencies to select or recommend the use of nature-like fishways as solutions for fish passage.

While nature-like fishways are still engineered, they are constructed of natural materials that include boulders, large stone, gravel and geotextiles. Nature-like fishways typically fall into one of two major categories; rock ramps or natural channel bypasses. Rock ramps utilize stone and boulders to provide a sloping approach for fish to ascend over the top of a barrier. This could be a somewhat disorganized array of stone and boulders to create an ascending riffle, or a more organized series of stone weirs to create rapids and pools to allow fish to ascend above the barrier. The natural channel bypasses provide a nature-like route of passage around a barrier.

- Fisheries and Aquatic Organism Assessments

We foresee a number of advancements in how fisheries and aquatic organisms are sampled and assessed. While we still employ traditional survey techniques to sample aquatic organisms, we have conducted eDNA studies, where we sample the environment (i.e., water) rather than collecting aquatic species. By taking water samples and looking for trace DNA cues left in the water column, it is possible to identify the presence of a variety of fish species (RTE species as well as invasive species). Labor intense fish assemblage surveys could soon be replaced by eDNA sampling.

The use of radio and acoustic telemetry technologies that track the movement of aquatic organisms is increasing. Our statistical models are improved through large sample sizes. These projects produce tremendous amounts of data and we have developed advanced algorithms capable of managing, cleaning and analyzing these large datasets.

EBJ: What activities and industries are having an increased demand of Fish

Protection services?

Kleinschmidt: Reissuance of Section 316(b) of EPA’s Clean Water Act has established new performance requirements for over a 1,000 water withdrawal facilities nationwide including the electric generating, chemical and petroleum industries that withdraw at least 2 million gallons per day of cooling water from lakes and rivers. Section 316(b) requires each facility to conduct monitoring and an assessment of fisheries-related impacts and to propose best technology available (BTA) mitigation to reduce cooling water impacts, primarily mortality, to all life stages of fish that inhabit the water body where water is withdrawn.

During National Pollutant Discharge Elimination System (NPDES) permit renewal (occurs every five years), facilities must demonstrate that their compliance

option represents 316(b) BTA and meets the performance standard for reducing impingement and entrainment mortality. As a result, permittees will be required every five years to re-evaluate BTA and further restrictions can be required.

The emergence of the renewable energy industry including hydrokinetics, wave energy and offshore wind have provided increased demand for fish protection services that include field collections, impact assessment and mitigation actions to offset impact to habitat and species of interest.

EBJ: Can you provide an overview on how the following regulations drive Fish Protection and Fisheries services?

- Endangered Species Act (ESA)

The ESA requires that federal agencies consult with the USFWS and/or **National Oceanic and Atmospheric Administra-**

Kleinschmidt’s STEM Center

The Kleinschmidt Science, Technology, Engineering and Math (STEM) Center web-page provides an easily searchable and educational resource that explains how Kleinschmidt is working to make the future more sustainable. We provide resources (financial support and paid volunteer days) that help our employees reach out to middle- and high-school students. We also work directly with young adults (college) and early-career technical professionals to help them succeed in their chosen professions.

Kleinschmidt regularly participates with educational institutions on career days and during engineering week. In addition to demonstrating key engineering and environmental principals, our staff provides demonstrations on how hydro projects work (using turbine-generator kits), how we develop habitat restoration projects, and how fish-passage projects combine engineering and science to ensure safe passage of fish past dams. We sponsor (and volunteer for) robotics competitions, and recently sponsored a middle school that raised Atlantic salmon and released them into the wild (under the supervision of state officials).

Kleinschmidt’s flagship event over the last several years has been sponsoring the Kleinschmidt Windstorm Challenge in partnership with the **University of Maine**. This event brings together over 600 science and math students throughout Maine to design floating platforms to support an offshore wind turbine. Teams from middle and high schools compete by installing a scale-model wind turbine aboard the platforms they design for testing under simulated ocean conditions in University of Maine’s state-of-the-art hydraulic test lab.

Kleinschmidt is involved with groups that provide college scholarships, and several employees are (have been) advisors for college programs and for on-campus chapters of important industry organizations like **Society of American Military Engineers (SAME)** and **American Society of Civil Engineers**. A unique program run by SAME offers scholarships for high-school students to attend camp at a military installation where they are exposed to STEM and leadership challenges. Kleinschmidt also offers internships to students who are interested the hydro field. □

tion (NOAA) Fisheries about proposed actions (projects) they license or permit to ensure these actions do not jeopardize the continued existence of listed threatened and endangered species or adversely modify designated critical habitat. Consultation occurs under Section 7 of the ESA and usually begins informally with background research and, for projects affecting surface waters, new or updated fish and aquatic species surveys to establish whether listed species are present and may be affected by the project.

Formal ESA consultation entails the preparation of a Biological Assessment.

The USFWS/NOAA Fisheries then issues a Biological Opinion, which sets forth how best to proceed with the project and, if it is likely to jeopardize a listed species, what reasonable and prudent measures are necessary to minimize take (i.e., harassment, harm, killing) of the species. For example, water resource projects on rivers may be required to provide for minimum or seasonal flows to protect listed fish and mussel species habitat. Such requirements could drive the need for site-specific instream flow studies to determine the relationship between river flow and habitat suitability for the listed species.

- National Environmental Policy Act

NEPA drives fish protection and fisheries services for large energy, infrastructure and water management projects by requiring that federal agencies evaluate the environmental effects of proposed actions prior to making decisions about issuing licenses and permits. NEPA evaluations are prepared as Environmental Impact Statements (EIS) and Environmental Assessments (EA), which characterize the affected environment and assess the impacts of the proposed action and reasonable alternatives. The public scoping process identifies significant environmental re-

Examples of Innovation for Biodiversity

Technology	Data generated	Innovation and availability	Data Gap addressed	Key beneficiaries	Caveats
Nanopore DNA sequencing	DNA sequence data	Allows for the manufacture of desk-top DNA sequencers which are highly mobile, rapid at a much lower cost than more traditional techniques. Available now, but more research needed for full application	Genetic diversity, microbial diversity, monitoring and enforcement of wildlife trade (through sample identification)	Public sector, Private sector	Complementary DNA library and barcodes need to be developed to utilise effectively
Block chain	NA	The structure of a block chain database, should allow for the entire supply chain of a product to be accessible by the end-user, be that the consumer or retailers. Currently available	Supply chain sustainability, transparency of product origin. Useful for food, beverages, timber and other wildlife products	Public Sector, Private sector, Individuals	High energy use and not currently mobilised
Artificial intelligence (AI) and machine learning	Various	Remote sensing networks generate vast quantities of data (for example camera traps and acoustic monitoring). AI techniques can process this data into useful information which can then be used to monitor many dimensions of biodiversity (species occurrence, population dynamics, habitat disturbance)	State, pressures and responses	Public Sector, Private sector, Individuals	Availability of training data is low for many cases, creating training libraries is labour intensive
Citizen led data collection	Various	Democratises biodiversity data collection, currently utilised widely, most notably through GBIF. Allows for individual engagement with biodiversity	State of biodiversity	Public Sector, Individuals	Data generated is difficult to use and biased, requires more sophisticated analytical techniques than currently available (better developed AI for example)

Source: Biodiversity: Finance and the Economic and Business Case for Action. OECD, 2019. Report prepared for the G7 Environment Ministers' Meeting, 5-6 May 2019..

source issues for analysis in the EA or EIS. These issues often drive the need for studies to develop information on existing fisheries, such as species occurrence and abundance, habitat use, population attributes, recreational fisheries, listed threatened and endangered species, and invasive nuisance species. Habitat protection and restoration measures may also be evaluated as mitigation for adverse project effects.

- Clean Water Act (CWA)

Under Sections 316(a) and (b) of the Clean Water Act, EPA regulates cooling water intake structures for the effects of thermal discharges and fish impingement/entrainment, respectively. Section 316(b) has become a primary driver for fisheries sampling and evaluation of fish protection technologies as BTA for reducing the adverse effects of fish and shellfish impingement and entrainment at power plants and manufacturing facilities.

Organisms pinned against the intake screens represent impingement while eggs and larvae passing through the intake screens represent entrainment. All facilities must choose among pre-determined BTA compliance options for reducing impingement mortality. Facilities withdrawing larger amounts of cooling water must also evaluate the social costs and benefits of alternative entrainment control technologies. EPA then makes a site-specific determination of entrainment BTA, which may require the use of fine-mesh screens, closed-cycle cooling, water reuse or other protective measures.

- Federal Power Act (FPA)

FERC's regulation of over 1,700 non-federal dams in the United States represents a major area of fisheries and fish protection services. FERC issues licenses to projects for up to 50 years under the Federal Power Act (FPA). The licensing/re-licensing process engages federal and state agencies, stakeholders and the public in conducting studies needed to evaluate the effects of project operations and inform license terms and conditions.

These studies often include fisheries surveys, instream flow studies, protected species surveys and recreational use analy-

sis. Under Section 18 of the FPA, USFWS and NOAA Fisheries may condition a license by prescribing fishways. This mandatory authority, when exercised, drives the design, construction, operation, and monitoring of fishways/fish ladders for upstream and downstream passage of migratory fishes, such as salmon, river herring, American shad, and American eel. ■