Before the Nebraska Public Service Commission

In the Matter of the Application **of** **TransCanada Keystone Pipeline, LP for Route Approval of Keystone XL Pipeline Project, Pursuant to *Major Oil Pipeline Siding Act***	**Application No: OP-003** **Direct Testimony of Thomas David Hayes**

State of Texas)
) ss.
Travis County)

Q: Please state your name.

A: My name is Thomas David Hayes.

Q: Briefly describe for the Commissioners please your educational background starting with your undergraduate work and all degrees and any relevant certifications earned or held by you.

A: I earned my B.A. (Biology, 1975) from Rice University, Masters of Forest Science (Ecosystem Biology, 1977) from Yale University, and Ph.D. (Biogeochemistry and Conservation Biology, 2002) from the University of California, Berkeley.

Q: Tell the Commissioners about your current employment and about your relevant work experience over the past ten years.

A: Since 2011, I have been employed as Lead Scientist and Executive Director by Texas Conservation Science (TCS), a 23-year old nonprofit [501(c)(3)] corporation based in Austin, TX. TCS provides research and technical services to the conservation community, including public agencies, nonprofit organizations, and private businesses and landowners. TCS services include environmental and ecological research, land and water stewardship, biodiversity and ecosystem management, rare species conservation, environmental impact assessment, and sustainable development.

During 2008-2011, I worked as the Science Director for the Greater Edwards Aquifer Alliance, Austin, TX. My primary focus was conservation of a regional aquifer and associated springs, streams, endangered species, and watersheds. My independent research during this period quantified environmental flows to sustain floodplain habitats in east Texas, and addressed riparian conservation issues in the Mojave Desert of Nevada.

Q: **Summarize for the Commissioners your prior work experience that may be relevant.**

A: For 40 years, I have worked as a research ecologist, land-water resource manager, conservation biologist, and environmental consultant. After my Master's degree in 1977, I worked for over six years for an environmental engineering firm, for the most part assessing impacts and mitigation requirements for vegetation and wetlands, due to mining, reservoirs, pipelines, and other development. During 1985-1989, I was employed by the Texas Parks and Wildlife Department (TPWD), first to implement habitat restoration in various state parks, and then for over four years as a regulatory and research biologist in the Environmental Protection Division, preparing official TPWD comments for permit applications and other projects impacting wetlands, water resources, and endangered species. During 1989-1992, I was hired as the Texas State Stewardship Ecologist by The Nature Conservancy, for which I designed and managed TNC preserves and private-lands conservation initiatives throughout the state.

From 1993 to 2002, I researched above- and below-ground carbon and nitrogen cycling within disturbed old-growth forests of the Pacific Northwest. During this effort, I held dual appointments as a part-time Ph.D. candidate at U. California-Berkeley and as research faculty at Oregon State U.-Corvallis. For my subsequent 2003-2005 post-doc at U. Wisconsin-Madison, I researched carbon cycling and storage processes within northern hardwood forests. And in 2005-2008, I taught forestry and ecology, and managed school forests, for U. Wisconsin-Stevens Point.

Q: **Is the resume that you submit with this testimony true and accurate as of today's date?**

A: Yes, my submitted resume is accurate and up-to-date.

Q: **Have you noted inaccuracies or biases in the Keystone XL PSC Application's (2/16/17) comparison of the Preferred Route with the alternative routes?**

A: The Keystone XL PSC Application (2/16/17) presents false and biased reasoning that the Preferred Route is more beneficial, more preferable, and less adverse relative to the Keystone Mainline Alternative Route (see pp. 8 & 61, KXL PSC Application, 2/16/17). These two pages include the incorrect statements that the Keystone Mainline Alternative Route increases the crossing of the ranges of federally-listed threatened and endangered species. This statement is false based on the application's own numbers (Table 2-1, pp. 9-12). As shown in my Table 1 (below), the Keystone Mainline Alternative Route's impact upon federally listed species is significantly less than that of the Preferred Route, primarily due to the Keystone Mainline Alternative Route impacting 84.6 fewer miles of whooping crane habitat, compared to the Preferred Route.

Q: Did you discover additional inaccuracies in the KXL PSC Application's assessment of impacts to natural resources due to the Preferred Route, compared to impacts of the alternative routes?

A. These two pages (pp. 8 & 61) in the KXL PSC Application are also incorrect in stating that the Preferred Route crosses fewer highly erodible soils, compared to the Keystone Mainline Alternative Route. Again, based on the application's Table 2-1 (pp. 9-12), the Keystone Mainline Alternative Route actually crosses 24.4 and 3.6 fewer miles, respectively, of Highly Water Erodible Soils and Highly Wind Erodible Soils, again compared to the Preferred Route (attached Table 1).

Furthermore, crossing distances for soils listed in the KXL PSC Application should be reconciled with corresponding numbers in the Table 3.2-1 of the FSEIS. For example, the FSEIS Table 3.2-1 lists 178.0 miles of Highly Water Erodible Soils crossed by the Preferred Route in Nebraska, while Table 2-1 in the KXL PSC Application lists only 57.4 miles of these soils being crossed by the Preferred Route.

Q: In your opinion, does the KXL PSC Application include other inaccuracies or biases in regard to its assessment of impacts to natural resources, due to the Preferred Route compared to the alternative routes?

A: I noted that the KXL PSC Application downplays the measurable benefits of co-locating the Keystone Mainline Alternative Route. With 88.3 and 102.2 more miles, respectively, of pipeline and total co-location, compared to the Preferred Route, the Keystone Mainline

Table 1: Summary Comparison of Preferred Route and Keystone Mainline Alternative Route
Keystone XL PSC Application, 2/16/17

Feature	Measure	Preferred Route *	Keystone Mainline Alternative Route *	Relative Difference: Keystone Mainline Alternative Route vs Preferred Route	Advantage
Whooping Crane Habitat	Crossing Length (miles)	250.9	166.3	84.6 (Decrease)	Keystone Mainline Alternative Route
Highly Water Erodible Soils	Crossing Length (miles)	57.4	33.0	24.4 (Decrease)	Keystone Mainline Alternative Route
Highly Wind Erodible Soils	Crossing Length (miles)	47.1	43.5	3.6 (Decrease)	Keystone Mainline Alternative Route
Perennial Stream & River Crossings	Number of Crossings	21	31	10 (Increase)	Preferred Route
Intermittent Stream & River Crossings	Number of Crossings	229	205	24 (Decrease)	Keystone Mainline Alternative Route
Total Stream & River Crossings	Number of Crossings	250	236	14 (Decrease)	Keystone Mainline Alternative Route
Ecologically Unusually Sensitive Areas (HCA)	Crossing Length (miles)	2.2	4.4	2.2 (Increase)	Preferred Route
Co-Location: Pipeline Right-of-Way	Crossing Length (miles)	7.3	95.6	88.3 (Increase)	Keystone Mainline Alternative Route
Co-Location: Utility Corridors	Crossing Length (miles)	0.0	3.3	3.3 (Increase)	Keystone Mainline Alternative Route
Co-Location: Roads	Crossing Length (miles)	2.4	13.0	10.6 (Increase)	Keystone Mainline Alternative Route
Co-Location: TOTAL	Crossing Length (miles)	9.7	111 9	102.2 (Increase)	Keystone Mainline Alternative Route

* From Table 2-1, pp. 9-12, Keystone XL PSC Application, 2/16/17

Alternative Route substantially decreases its overall impact by reworking far more industrially impacted areas and, consequently, reducing impacts to relatively undisturbed land. As discussed below, in this manner, irreparable damage to important natural resources, including native soils and grasslands, is proportionally reduced.

Q: Before delving more deeply into the impacts of the proposed pipeline on soils, please summarize your experience in soil science.

A: I have researched and assessed soils throughout my career, starting with research for my Master's degree at Yale, and continuing with my doctorate and post-doctorate projects, which focused on carbon storage and nutrient cycling within soils. In addition to my graduate work, my professional employment in land management and impact assessment continues to emphasize soils, including during habitat restoration, vegetation inventories, wetland determinations, and mitigation planning.

Q: In your opinion, will the proposed Keystone XL pipeline significantly increase the impermeability of Nebraska soils?

A: The additional Keystone XL pipeline proposed for Nebraska will significantly damage the state's natural resources, largely due to decreased soil permeability and increased soil compaction in both natural areas and croplands. This pipeline effect is consistently documented by research, including Duncan and DeJoia (2011), Naeth et al. (1987), and Ramsey and Burgess (1985). The removal and stockpiling of topsoil exposes subsoil to heavy equipment during pipeline installation, which deeply compacts the soil causing a decrease in permeability that is difficult or impossible to restore. Soil compaction significantly decreases aeration, percolation and storage of water, drainage, root biomass, and plant productivity. Not only is the protection and careful replacement of topsoil important, but the same is true for subsoil and parent material, since the roots of economically important crops like soybeans and corn can reach a depth of six feet.

Q: How does soil disturbance during pipeline installation increase soil impermeability?

A: The mixing of surface and subsurface soil in both the trench and work areas commonly occurs during pipeline installation, despite the inclusion of best management practices in work plans. The careful scheduling of pipeline construction activities during dry summers and contract provisions for weather-related work cessation are critical, to avoid severe

compaction when soil moisture is at or near field capacity, which is when soil saturation prohibits normal farming activities.

However, work cessation seldom occurs in practice, at least not before field capacity is exceeded. Consequently, Batey (2014) found that prevention of severe subsoil compaction during pipeline construction was impractical, so payment for damages was common when drainage and crop production were negatively impacted. Though most studies address agricultural soils, working in native prairies of southern Alberta, Naeth et al. (1987) document an average increase in bulk density in surface soils of more than 50% following installation of a large-diameter pipeline similar to the proposed Keystone XL project.

Soil mixing compounds the damage due to physical compaction, by reducing soil organic matter content, which further increases bulk density, reduces water infiltration and storage, and decreases fertility. The reduction in available nutrients coincides with the loss of organic matter, largely due to lower cation exchange capacity and decreased nitrogen from mineralized organic matter.

Q: **In your opinion, how is agricultural productivity impacted by the compaction and impermeability of soil?**

A: Following land disturbance by heavy equipment, soil fertility, and plant production are often decreased by soil compaction and impermeability, which significantly reduces productivity, as explained above. In their review of pipeline construction research, Ramsey and Burgess (1985) found an average 33% reduction in crop yield due to significant decreases in soil organic matter in compacted soils following pipeline construction. In Ontario, corn, soybean, and cereal yields remained significantly depressed ten years following pipeline installation due to soil mixing, despite the remedial application of best farming practices (Culley and Dow 1987). In my experience, though unattainable in some instances despite energy inputs, infrastructure (drains, etc.), and soil amendments, the restoration of crop yield in agricultural soils is much easier to attain, compared to native prairie and wetland productivity, in which proactive invention such as deep tillage only degrades these natural areas further.

Q: **How can damage to agricultural soils be prevented?**

A: Through careful siting, pipelines should be routed on sandy well drained areas with high soil organic matter content, to increase resistance to compaction. Clayey, poorly drained soils must be avoided, due to likely long-term damage to crop production (Ramsey and Burgess 19985). As discussed above, pipeline installation should be scheduled for dry summer months, when cropland is not at or near field capacity.

In croplands, additional preventive measures before pipeline installation may reduce adverse impacts. For example, Batey (2014) recommends testing for soil-borne diseases to prevent spreading them to adjacent areas, and conducting drainage assessments followed by drain installation if necessary.

The rehabilitation of native prairie soils by physical methods such as drain installation and deep tilling is not an option, if the prairie ecosystem is to remain intact. Therefore, Neville's (2002) best management practices (BMPs) for pipeline construction in native prairies should be a requirement if a siting permit is granted. The KXL PSC application should require strict adherence to these BMPs in native prairies and rangeland, during the planning and construction stages, in order to minimize adverse and irreversible impacts to important natural resources (NE Major Oil Pipeline Siting Act, 57-1407(4)(b) and 57-1407(4)(c)).

Q: Can damaged agricultural soils be restored and what may be the long-term consequences to land use?

A: In general, chemical damage, such as nutrient loss and increased salinity, is more capable of being remedied, compared to physical damage such as compaction and impermeability leading to poor drainage. For example, to improve drainage in compacted agricultural soils, usual recommendations are to install subsurface drains, add gravel above existing drains, and/or loosen subsoil by deep tillage.

However, as pointed out by Fenton (2015), if an oil pipeline is already installed four feet deep across the fields, new drains can only be installed to a depth of two feet throughout the adjacent watershed. In this manner, drains are too shallow to restore drainage over a large agricultural area, extending up- and downslope from the buried pipeline. When

pipelines prevent the remediation of poor drainage in soils damaged during pipe installation, they cause irreparable loss of natural resources. In this manner, the pipeline may be an irreversible commitment of land and natural resources, in violation of Section 57-1407(4)(c) of the Nebraska Major Oil Pipeline Siting Act.

Q: **In your opinion, when comparing the 2017 KXL PCS Application and the 2014 KXL FSEIS, are there discrepancies in the quantification of soils affected by the proposed KXL pipeline?**

A: Yes, there are many unexplained discrepancies between the two documents in the quantification of pipeline-affected areas. One of the largest differences between the two documents is the affected area of Highly Water Erodible Soils. Crossing lengths for these soils are listed as 57.4 and 178.0 miles, respectively, in the KXL PCS Application (attached Table 1) and the KXL FSEIS (attached Table 2). This 120.6-mile difference translates to an affected acreage difference within construction-impacted 110-foot wide ROW of 1,602.5 acres.

Another difference between the two documents is their dissimilar approaches in the treatment of soils with distinctive Sand Hills characteristics. Page 3.2-5 of the 2014 FSEIS for the Keystone XL Pipeline states that the proposed pipeline route crosses approximately 88 miles of soils that tend to be highly prone to wind erosion and often consist of fragile eolian fine sands and loamy fine sands, which the FSEIS states are similar to the NDEQ-identified Sand Hills region. However, the KXL PCS Application (Table 2-1) only lists 3.9 miles of "Topographic Region Sandhills" as crossed by the Preferred Route, without mention of the similarly fragile soils identified in the FSEIS.

Q: **Based on your experience, how long will be required to restore the productivity of native prairie soils disturbed and compacted by heavy equipment during pipeline construction.**

A: My work to restore native tallgrass prairie and other disturbed plant communities indicates that full restoration of prairie soils, in order to support a diverse and productive assemblage of native species on severely disturbed soils, is likely impossible or at least takes centuries. Impacts of the proposed Keystone XL pipeline include soil damage during construction, along with chronic operational impacts, such as soil erosion, invasive weed species,

Table 2. Soils by National Inventory Grouping Crossed by Proposed Keystone XL Project Route in Nebraska*

Soil Grouping	Miles*	Acres	
		Construction	Operation
Total Affected Area	274.0	3,640.9	1,660.6
Highly Erodible Soils	48.1	639.1	291.5
Highly Erodible soils	178.0	2,365.2	1,078.8
Prime Farmland	175.8	2,336.0	1,065.5
Hydric Soils	47.1	625.9	285.5
Compaction-Prone Soils	169.4	2,251.0	1,026.7
Stony/Rocky Soils	40.5	538.2	245.5
Shallow Bedrock	0.3	4.0	1.8
Drought-Prone Soils	41.0	544.8	248.5

* Miles Crossed by National Inventory Grouping from Table 3.2-1, p. 3.2-4 Final Supplemental Environmental Impact Statement, Keystone XL Project, 2014

pollution, and higher soil temperature near the heated pipe. These effects have not been quantified, so that effective mitigation is not specified. Professor Wedin, in his 2010 testimony before the Nebraska Legislature's Committee on Natural Resources, also indicates that restoring and then maintaining diverse native prairie impacted by oil pipeline installation is impossible; especially with the presence of heated pipe.

Nannt (2014) estimates that 50 years are required to restore only half of the soil organic matter lost, following installation of a Keystone pipeline in Alberta mixed grass prairie. She found that the trench and work areas were significantly more compact than undisturbed prairie. The soil disturbance became chronic during pipeline operation resulting an invasion of non-native species extended 150 meters on both sides of the pipeline.

Shultz (2017), working on prairie restoration for 20 years with the Kansas Biological Survey at the University of Kansas, underscores the importance of carbon-rich water-stable aggregates that are protected from decomposition within native prairie soils. These carbon structures provide functions essential to prairie survival, including the rapid movement of water and air through soil, which sustains soil biota and plant species.

These carbon aggregates are part of a complex and fragile below-ground ecosystem, in which innumerable symbiotic connections form among mycorrhizal fungi and plant roots. This symbiosis is necessary for the survival of many late successional prairie plants. When pipeline construction destroys the plant and soil communities of a native prairie, Shultz (2017) calculates that restoration of stable soil aggregates, the soil community, and prairie vegetation takes many decades or centuries, and only if careful stewardship is maintained during and after the project life of the pipeline.

Q: **Based on your assessment of prairie restoration within and adjacent to oil pipeline installations, what is your prognosis for the long-term recovery and survival of native prairies impacted by the proposed Keystone XL pipeline in Nebraska?**

A: Along with others, I believe that construction of the pipeline will seriously deplete native prairie, so that the pipeline represents an irreversible commitment of land and natural resources. Unlike croplands, the delicate symbiotic connections between of prairie plants

and the soil ecosystem are not amenable to mechanical remediation or soil amendments. In this manner, the Preferred Route of the Keystone XL pipeline and available alternative routes may be subject to review according to Sections 57-1402(1) and 57-1407(4)(b) of the Nebraska Major Oil Pipeline Siting Act.

Q: What is your experience with freshwater wetlands, in terms of their conservation and restoration?

A: As demonstrated by my resume, stewardship and applied research in freshwater wetlands have been primary goals throughout my career. Riparian restoration research is the current focus of my nonprofit research group. Over the past eight years, our riparian research has quantified the environmental-flow requirements and related productivity relationships for both forested and emergent herbaceous communities. This year we are installing five more long-term riparian research stations, which increases our research network to 17 stations across Texas. The research is funded by several government agencies, along with some private organizations.

Q: How sensitive are wetlands to disturbance?

A: Within wetlands, including riparian types and those of the Rainwater Basin and Sand Hills regions, groundwater and surface water interconnect. Therefore, wetlands are especially sensitive to pipeline construction and operation, due to the increased potential for widespread impacts to biotic communities and water quality. The rapidity of these linkages means that even minor disturbances, such as rutting or vehicular spills, are unlikely to be contained.

Q: How does pipeline installation impact freshwater wetlands?

A: Pipelines in wetlands alter soils, vegetation, and water circulation both above and below the surface. During their research on the impacts of a large gas pipeline within emergent herbaceous wetlands in southeast Wisconsin, Olsen and Doherty (2012) documented a 63% increase in soil bulk density and a 19% decrease in soil moisture extending 12 meters on both sides of the pipeline. Within this zone, plant diversity was significantly lower compared to intact wetland. These negative impacts persisted for more at least eight years.

Q: Identify some of the important losses of wetland resources during oil pipeline construction and operation.

A: Routing an oil pipeline across emergent herbaceous and forested wetlands will cause many adverse impacts during both pipeline construction and operation, including permanent losses of wetland function and vegetation. Detrimental impacts during construction include direct wetland loss due to heavy equipment access, excavation, backfilling, and draining; soil mixing and associated soil organic matter loss and impermeability; turbidity and decreased water quality; and permanent reduction in water retention if water-impermeable substrate is breached, such as in depressional wetlands and prairie potholes.

Chronic reductions or losses in wetland resources during operation include soil impermeability and low fertility due to compaction, permanent vegetation loss within the operational right-of-way, weed invasion, reduced plant productivity, pipeline soil-heating changes reducing soil moisture and seasonal synchronicity with reproduction and pollinators.

Q: What is the best way to decrease wetland impacts during pipeline installation?

A: Due to the difficulty of restoring hydrologically connected wetlands, circumventing such areas is the best means of preventing impact. To avoid adverse impacts to quality wetlands with high species diversity, Olsen and Doherty (2012) conclude that siting surveys during pipeline planning must be used not only to avoid wetland occurrences, but also to guide planting and other proactive conservation measures following pipeline construction. If a pipeline is routed across quality wetlands, I recommend ambient monitoring of both surface and groundwater during pipeline construction and operation.

Q: Have you reviewed relevant portions of the Final Supplemental Environmental Impact Statement (FSEIS) prepared by the US State Department for the proposed route for Keystone XL (KXL FSEIS 2014) related to soils and vegetation?

A: Yes

Q: Have you reviewed relevant portions of the Environmental Impact Statement prepared by the US State Department for the route of Keystone I (KXL FEIS 2008) related to soils and vegetation?

A: Yes

Q: Are there significantly more areas of porous, sandy soils on the proposed KXL route than Keystone I?

A: Yes

Q: Is there a higher risk of contamination of groundwater in the construction process in areas with porous, sandy soils?

A: Yes

Q: Is there a higher risk of contamination of the groundwater from leaks and spills, if a high-pressure pipeline is routed through areas with porous, sandy soils?

A: Yes

Q: Would locating a high-pressure tar sands pipeline in areas with porous, sandy soils increase the likelihood of irreversible, irretrievable, and irreparable impacts to Nebraska's natural resources?

A: Yes

Q: Would locating a high-pressure tar-sands pipeline in areas with porous, sandy soils increase the likelihood of depletion of beneficial uses of natural resources?

A: Yes

Q: Would irreversible and irretrievable impacts to Nebraska's natural resources have a negative economic impact?

A: Yes

Q: Would depletion of natural resources have a negative economic impact to the State of Nebraska?

A: Yes

Q: Based on your education, research and study, after reviewing relevant documents regarding water resources and the statutory and regulatory criteria, do you have an expert opinion about whether the Public Service Commission should approve or deny the application for approval of this proposed route for KXL?

A: Yes, in my opinion, the Nebraska Public Service Commission should deny the application seeking approval for the proposed KXL route.

Q: If the PSC does approve TransCanada's application, is it your opinion that the Keystone I route would pose fewer risks to natural resources?

A: Yes

Q: If the PSC does approve TransCanada's application, is it your opinion that the Keystone I route would be less likely to cause irreversible and irretrievable impacts to Nebraska's natural resources?

A: Yes

Q: If the PSC does approve TransCanada's application, is it your opinion that the Keystone I route would be less likely to cause depletion of beneficial uses of Nebraska's natural resources?

A: Yes

Q: As of today's date, do you stand by your findings and conclusion as detailed in the above testimony?

A: Yes I do.

Witness Name

Subscribed and Sworn before me this 7th day of June, 2017.

Notary Public

NICK CARPENTER
Notary Public, State of Texas
Comm. Expires 01-15-2020
Notary ID 130497862

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PROFESSIONAL SUMMARY:

Tom Hayes earned his B.A. (1975) from Rice University, Masters of Forest Science (1977) from Yale University, and Ph.D. (2002) from the University of California, Berkeley. He has authored over 70 publications and technical papers (see below), plus conference and workshop presentations.

Since 2011, Dr. Hayes has been employed by Texas Conservation Science (TCS), a 23-year old nonprofit [501 (c) (3)] corporation. In 2015, the Environmental Conservation Alliance (ECA) changed its name to TCS. This nonprofit model provides scientific and technical services (consultation and research) to the conservation community, including public agencies, nonprofit organizations, and private businesses and landowners. TCS services include land and water stewardship, biodiversity and ecosystem management, rare species conservation, and sustainable development.

For 40 years, Dr. Hayes has worked as a land-water resource manager, research ecologist, conservation biologist, and environmental consultant. His direct experience encompasses ecological restoration, wetland determination, rare species conservation, environmental-flows research, habitat management plans, ecological and environmental monitoring, impact and mitigation assessment, reserve design and implementation, regulatory compliance, and issue-oriented research. His conservation and adaptive-management experience encompasses a broad range of animal and plant species and biotic communities; and their terrestrial, wetland, and aquatic habitats.

Dr. Hayes' technical experience includes:

- Ecological and environmental studies: baseline inventory and impact analyses
- Habitat conservation plans: endangered species and sustainable landscapes
- Flow analyses to sustain and restore riparian, wetland, and estuarine habitats
- Habitat management and trend analyses: endangered and rare species, and biotic communities
- Water resource analyses: surface and ground water, rural and urban, land-use effects on water quality
- Biogeochemistry: nutrient cycling and ecosystem processes
- Wetland determination: implementation, permitting, mitigation
- Conservation easements and other permanent-protection planning and implementation
- Expert testimony: judicial and administrative, hearings and proceedings
- GIS and remote-sensing: project management, habitat analysis, and environmental assessment
- Land and wildlife management, including related agricultural tax valuations
- Environmental forestry: urban and rural management plans, implementation, and policy
- Low-impact development, including best management practices
- Species inventories and monitoring, including adaptive management

EDUCATION:

Ph.D.	Biogeochemistry and Conservation Biology, Dept. of Integrative Biology, Univ. of California, Berkeley, CA, 2002.
M.For.Sci.	Ecosystem Biology, School of Forestry and Environ. Studies, Yale Univ., New Haven, CT, 1977.
B.A.	Biology, Cum Laude, Rice Univ., Houston, TX, 1975.
Diploma	McClellan High School, Mabelvale, AR, 1971.
Diploma	Marine Biology and Higher Mathematics, National Science Foundation Summer Fellow, Humboldt State Univ., Arcata, CA, 1970.

WORK EXPERIENCE:

Executive Director and Senior Scientist, Texas Conservation Science, Austin, TX, 2011-present.
Science Director, Greater Edwards Aquifer Alliance, Austin, TX, 2008-11.
Research Ecologist (3-mo grant), Lower Colorado River Habitat Conservation Project, Marine Sciences Institute, U. of California, Santa Barbara, 2008.
Vallier Resident Ecologist & Associate Scientist (3-year grant), Treehaven Environmental Learning Center, Tomahawk, WI, & College of Natural Resources, U. of Wisconsin - Stevens Point, 2005-08.
Project Manager (post-doc), Flambeau Experiment, Forest Landscape Ecology Laboratory, Dept. of Forest Ecology & Management, U. of Wisconsin, Madison, 2003-05.

WORK EXPERIENCE: concluded

Research Faculty (adjunct), Dept. of Forest Science, Oregon State U., Corvallis, 1996-2003.
Ph.D. Candidate (part time), Dept. of Integrative Biology, U. of California, Berkeley, 1993-2002.
State Stewardship Ecologist, The Nature Conservancy of Texas, San Antonio, 1989-92.
Biologist III, Habitat Assessment, Resource Protection Div., Texas Parks & Wildlife Dept, Austin, 1986-89.
Biologist II, Resource Management, Parks Div., Texas Parks & Wildlife Department, Austin, 1985-86.
Project Manager/Conservation Biologist, Espey, Huston & Associates, Austin, TX, 1978-84.
Research Assistant, Hubbard Brook Exp. Forest, USDA Forest Service, in cooperation with School of Forestry & Environmental Studies, Yale U., New Haven, CT, 1976-77.
Research Assistant, Biology & Environmental Engineering Depts., Rice U., Houston, TX, 1972-75.
Biological Technician, Southwest Research Institute, Houston, TX, 1973-74.

OTHER QUALIFICATIONS:

Technical Skills:

Environmental and ecological inventory and monitoring, environmental-flows analysis, estuarine bioaccumulation and bioassay, forestry, habitat typing and restoration, invasive species control, project coordination and consensus building, regulatory compliance, land protection (reserve design, conservation easements), wetland determination.

Selected Honors/Committees:

Urban Forestry Board, Vice Chair, City of Austin, TX. 2011-14.
Biological Advisory Team, Member, Southern Edwards Plateau Habitat Conservation Plan, US Fish & Wildlife Service, San Antonio, TX, 2010-12.
Science Advisory Board, Member, Hill Country Alliance, Austin, TX, 2009-present.
Vallier Foundation Fellowship, Treehaven Field Station, UW-Stevens Point, Tomahawk, WI, 2005-2008.
Post-Doctorate Fellowship, Forest Landscape Ecology Laboratory, Department of Forest Ecology and Management, University of Wisconsin-Madison, 2003-2005.
STAR Graduate Fellowship, Environ. Sci. Res. Div., US Environ. Protection Agency, 1997-2000.
National Network for Environ. Manag. Studies, Fellow, US Environ. Protection Agency, 1994-96.
Texas Organization for Endangered Species, Communities Committee Chair/Steering Committee, 1991-92.
Texas Academy of Science, Conservation Section Chair, 1989-1990.
Texas Organization for Endangered Species, Plant Committee Chair/Steering Committee, 1982-1984.
Phi Beta Kappa, Rice University, Houston, TX, 1975.
President's Honor List, Rice University, Houston, TX, 1971-1975.
National Science Foundation Fellowship, Humboldt State University, Arcata, CA, summer 1970.

PRIOR WORK HISTORY:

Throughout his undergraduate and graduate studies at Rice and Yale, respectively, Dr. Hayes was at the same time employed in environmental and ecological studies of stream runoff, aquatic and estuarine ecosystems, and biogeochemical processes within disturbed landscapes.

Upon earning his Master's degree in 1977, Dr. Hayes worked for Espey, Huston, and Associates (EH&A), Austin, TX, first as manager of an estuarine bioassay/bioaccumulation laboratory in Galveston, TX, and subsequently at the EH&A headquarters in Austin, as senior biologist and project manager for aquatic and terrestrial impact assessments and mitigation, wetland determinations, rare and endangered species, habitat restoration, and Section 404/10 and water-rights regulatory compliance.

In 1985, Dr. Hayes gained employment as Biologist II with the Resource Management Section, Parks Division, Texas Parks & Wildlife Department (TPWD), Austin. He primarily trained and organized resource-management teams throughout the State Park System, to lessen human impacts and proactively restore native terrestrial and aquatic habitats. He also completed special projects, including large volunteer restoration efforts, regulatory and endangered-species assessments, and water-rights testimony.

Upon his promotion to the Resource Protection Division (1986-89), TPWD, Austin, Dr. Hayes continued to oversee regulatory assessments (CWA Sections 404 & 10, etc.), water-rights studies, community outreach, and related mitigation implementation. Notable projects included wetland determinations and in-stream flows analyses in support of regulatory hearings for floodplain and coastal development and for state water rights, including proposed wetland development and reservoir projects. He was also the primary TPWD liaison to the U.S. Forest Service, coordinating and writing the formal State responses to 10-year plans and other activities concerning all National achieved permanent protection on federal lands in 17 states for the endangered Red-cockaded Woodpecker.

PRIOR WORK HISTORY: concluded

Later, as the first State Stewardship Ecologist for The Nature Conservancy of Texas (TNC), his projects included acquisition and restoration of coastal and inland habitats, such as the Mad Island Marsh Preserve and WMA near Palacios, the Diamond Y Springs Preserve near Fort Stockton, Dolan Falls Preserve in Val Verde County, Caddo Lake WMA near Jefferson, and many other conservation projects.

Returning in 1993 to academic research at the University of California-Berkeley (UCB) and Oregon State University (OSU), Dr. Hayes managed a long-term field and lab study of the biogeochemical impacts of landscape-scale old-growth forest disturbance. Upon completing concurrent Ph.D. (UCB) and research-faculty (OSU) appointments in 2003, he continued his research on disturbed ecosystem processes, along with teaching duties, at two University of Wisconsin campuses: Madison and Stevens Point. In 2008, Dr. Hayes accepted a 3-month grant with the Marine Sciences Institute, University of California-Santa Barbara, to help design a wetlands and riparian restoration project, spanning the Mojave Desert in southern Nevada and portions of three adjacent states.

In October 2008, Dr. Hayes returned to applied conservation and impact assessment in Texas (see above).

SELECTED PUBLICATIONS AND TECHNICAL REPORTS:

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Hayes, T. 1981. An Assessment of the Impacts of Surface Lignite Mining in the Vicinity of an Ecologically Sensitive River System in Northwestern Louisiana. Southwestern Electric Power Company, Shreveport, LA. EH&A Doc. 81096.

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Hayes, T. 1982. Determination of Regulatory Wetlands Within a 54,000-Acre Tract in East-Central Louisiana. Fisher Lumber Company, Detroit, MI. EH&A Doc. No. 82253.

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Hayes, T. 1982. Alternative Route Analysis and Environmental Assessment for the Fayetteville-Salem 345-kV Transmission Line – Vegetation. Prepared for Lower Colorado River Authority, Austin, TX. EH&A Doc. No. 82522.

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Hayes, T. 1990. Reclamation Plan and Surface Use Agreement for Oil and Gas Operations at Diamond Y Spring Preserve, Pecos County, TX. The Nature Conservancy, San Antonio, TX.

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Diaz, P., K. Anderson, S. Ramirez, and T. Hayes. 2013. Land Use Data for the Central Texas Urban Intensity Index, Phase 1. US Fish and Wildlife Service, San Marcos, TX, and Save Barton Creek Association, Austin, TX. ECA project # 2013-01.

Heger, N., and T. Hayes. 2013. Change in available Golden-cheeked warbler habitat through time: An assessment of change in mature Central Texas juniper-oak woodlands. Golden-cheeked Warbler Symposium. Lady Bird Johnson Wildflower Center, Univ. of Texas, Austin.

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Hayes, T. 2014. Strategy and Cost Estimate to Revise Austin's Urban Forest Plan as a Comprehensive Plan including Private and Public Trees. submitted to City Council, Austin, TX. ECA project # 2014-02.

Trungale, J., and T. Hayes. 2014. Response to Region C's Quantitative Impact Analysis of Marvin Nichols Reservoir on Natural Resources. Prepared for Trungale Engineering and Science, Austin, TX, submitted to Ward Timber, Linden, TX. ECA project # 2014-03.

Hayes, T. 2014. Jurisdictional Wetlands Determination: Schlenker School Outdoor Education Center, Houston, TX. Prepared for Congregation Beth Israel, Houston, TX. ECA project # 2015-04.

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Hayes, T., and R. Lowerre. 2015. Supplemental comments and hearing request of Stop Post Oak Dump on Permit Application Number SWF-2011-00192 by Post Oak Clean Green, Inc. Prepared for Frederick, Perales, Allmon & Rockwell, Austin, TX. Submitted to U.S. Army Corps of Engineers, Fort Worth, Regulatory Branch, and Texas Commission on Environmental Quality. ECA project # 2015-01.

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Hayes, T. 2015. Jurisdictional Wetlands Impact Assessment: Proposed Old River Road RV Park, Center Point, TX. Prepared for Naylor Ranch, Center Point, TX. Texas Conservation Science (TCS), Austin, TX. TCS project # 2015-05.

Hayes, T. 2015. Preliminary Inventory of Wetlands and Plant Species, Naylor Ranch, Center Point, TX. Prepared for Naylor Ranch, Center Point, TX. TCS project # 2015-06.

Hayes, T. 2015. Pre-filed Testimony, Application by Post Oak Clean Green Inc., for a New Type I Municipal Solid Waste Landfill in Guadalupe County, TX. TCEQ Docket No. 2012-0905-MSW, before the State Office of Administrative Hearings. Prepared for Stop Post Oak Dump, Luling, TX. TCS project # 2015-07.

Hayes, T. 2016. Pre-filed Testimony, Application of the Guadalupe-Blanco River Authority for a New Water Use Permit No. 12378 in Gonzales County, TX. SOAH Docket No. 582-15-2477, State Office of Administrative Hearings, 05/22/16. Prepared for National Wildlife Federation, Austin, TX. TCS project # 2016-02.

Hayes, T. 2016. Riparian Productivity along the Lower Brazos River. Final report, 07/18/16. Prepared for Texas Parks and Wildlife Dept., Austin, and Texas Water Development Board, Austin. TCS project # 2016-03.

Hayes, T. 2016. Riparian Assessment on the Guadalupe and Brazos Rivers. Final report, 07/18/16. Prepared for Texas Parks and Wildlife Dept., Austin, and Texas Water Development Board, Austin. TCS project # 2016-04.

Hayes, T. 2016. Riparian Assessment on the Middle and Lower Brazos River. Final report, 10/24/16. Prepared for Texas Parks and Wildlife Dept., Austin, and Texas Water Development Board, Austin. TCS project # 2016-01.

Hayes, T. 2016. Big Cypress Bayou Monitoring Network: Forest Plot Results 2012-2016. Final report, 12/31/16. Prepared for Caddo Lake Institute, Austin. TCS project # 2016-05.

SELECTED SPECIAL PROJECTS: Geography Dept., Texas State U.-San Marcos.

Analysis of Endangered Golden-cheeked Warbler Habitat Change from 2005 to 2010, Twelve Central Texas Counties. Fall 2010 semester, Four-student class project (GEOG 4427, Prof. A. Giordano), Advisor: T. Hayes (GEAA).

Mapping Wastewater Pipelines on the Recharge Zone of the Southern and Barton Springs Segments of the Edwards Aquifer, TX. Spring 2011 semester, Four-student class project (GEOG 4427, Prof. Y. Lu), Advisor: T. Hayes (GEAA).

Determination of Tree-Shade Indices for Streets and Trails, City of Austin, TX. Fall 2011 semester, Six-student class project (GEOG 4427, Prof. A. Giordano), Advisors: T. Hayes (ECA) and A. Hanson (City of Austin).

Watershed analysis: Spatial Correlations Among Tree-Canopy Cover, Land Use, and Water Quality, City of Austin, TX. Spring 2012 semester, Four-student class project (GEOG 4427, Prof. Y. Lu), Advisors: T. Hayes (ECA) and A. Hanson (City of Austin).

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Application of TransCanada Keystone Pipeline, LP, for route approval of the Keystone XL Pipeline Project pursuant to the Major Oil Pipeline Siting Act	))))	Application No. OP-0003

NOTICE OF SUBMISSION OF CORRECTION

The Bold Alliance (Bold), the Sierra Club, Nebraska Chapter (Sierra Club), hereby jointly provide notice of submission of correction of the written testimony of Paul A. Johnsgard, Ph. D. This submission of correction of evidence is subject to continuing objections on limitations on the scope and nature of evidence and number of witnesses previously filed by Bold and the Sierra Club in this matter. Submission of evidence at this time does not waive these objections, nor any other objections or procedural motions before the Commission nor any other objections or motions which may be filed during this proceeding.

CERTIFICATE OF SERVICE

Pursuant to 291 Neb. Admin Code § 015.0 (b) and the rulings of the Hearing Officer in this matter regarding service, copies of the correction described above were served upon all parties of record to this proceeding or their attorneys of record electronically using the service list provided by the Commission on this 28th day of June 2017.

BOLD ALLIANCE
SIERRA CLUB, NEBRASKA CHAPTER

By: _____

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BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Application of TransCanada Keystone Pipeline, LP, for route approval of the Keystone XL Pipeline Project pursuant to the Major Oil Pipeline Siting Act	))))	Application No. OP-0003 Correction to Testimony of Paul A. Johnsgard, Ph.D.

State of Nebraska)
) ss.
County of Lancaster)

Q: What is your name?

A: Paul A. Johnsgard.

Q. Did you submit testimony in this matter?

A: Yes.

Q. Are you aware of a correction that needs to be made to that testimony?

A: Yes. Actually, I attempted to correct the testimony prior to it being filed but the communication about this correction apparently was not received by the person preparing the testimony.

Q: What is the correction?

A: On page 5, in the last paragraph, "four eggs" should be corrected to "two eggs".

Q: Is the remainder of your statement true and correct to the best of your knowledge and belief?

A: Yes.

Signed and sworn before me this 27 day of June, 2017.

Paul A. Johnsgard

Notary Public

GENERAL NOTARY - State of Nebraska
LINDA S. TROUBA
My Comm. Exp. August 22, 2020

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Application of TransCanada Keystone Pipeline, LP, for route approval of the Keystone XL Pipeline Project pursuant to the Major Oil Pipeline Siting Act	))))	Application No. OP-0003 Testimony of Paul A. Johnsgard, Ph.D.

State of Nebraska)
) ss.
County of Lancaster)

Q: What is your name?

A: Paul A. Johnsgard.

Q: Where do you reside?

A: I currently live in Lincoln, Nebraska.

Q: What is your education and professional training?

A: I earned my M.S. in Wildlife Management from Washington State University, and my Ph.D. in Vertebrate Zoology at Cornell University, with Postdoctoral Fellowships (National Science Foundation & Public Health Service) at Bristol University in England. For 40 years I worked at the University of Nebraska-Lincoln, where in 1980 I was named a University of Nebraska Foundation Professor of Biological Sciences (and received the most teaching and research awards of any UNL professor in history, including an honorary Doctor of Science degree). I am now Professor of Biological Sciences Emeritus following my retirement in 2001.

Q: Have you focused your research in specific areas?

A: I have concentrated my research on the comparative biology of several major bird groups of the world, having published nine world monographs (waterfowl; grouse; cranes; shorebirds; pheasants; quails, partridges & francolins; bustards, hemipodes &

sandgrouse; cormorants, darters & pelicans, trogons & quetzals) and six monographs on various North American bird groups (waterfowl; grouse & quails; auks, loons & grebes; owls; hawks, eagles & falcons; hummingbirds). As of 2017 I had published 85 books, some with the most prestigious publishers of the world (Smithsonian Institution Press, 8 books, Oxford University Press, 4 books, Cornell Univ. Press, one book, *etc.)*

Q: Have you written other publications about your research?

A: Yes. Besides my 85 books (the most of any non-fiction author in history, I believe; certainly the most of any scientist), I have published over 150 papers and biological articles, mainly on birds. Much of my work has focused on the migratory birds of the Great Plains, and I have published four books/monographs on cranes, and about ten on migratory waterfowl and the habitats they rely on, especially essential wetland areas. I have attached my *curriculum vitae*, which provides a list of the books and articles I have published to 2017. Several (underlined) are especially pertinent to the impacts of proposed route of the Keystone XL pipeline on cranes, including the following books:

- *The Cranes of the World.* 1983. Indiana Univ. Press, Bloomington.
- *Crane Music: A Natural History of American Cranes*. 1991. Smithsonian Institution Press, Washington, D.C. Reprinted in 1997, Univ. of Nebraska Press, Lincoln.
- *This Fragile Land: A Natural History of the Nebraska Sandhills*. 1995. U. of Nebr. Press, Lincoln.
- *Prairie Birds: Fragile Splendor in the Great Plains*. 2001. Univ, Press of Kansas, Lawrence.
- *The Nature of Nebraska: Ecology and Biodiversity.* 2001. U. of Nebraska Press, Lincoln.
- *Great Wildlife of the Great Plains.* 2003. Univ. Press of Kansas, Lawrence.
- *Faces of the Great Plains: Prairie Wildlife*. 2003. With photos & photographic notes by Bob Gress. Univ. Press of Kansas, Lawrence.
- *The Sandhill and Whooping Cranes: Ancient Voices over the America's Wetlands*. 2011. Univ. of Nebr. Press, Lincoln.

- *A Nebraska Bird-finding Guide*. Lincoln, NE: Zea E-Books & Univ. of Nebraska-Lincoln Libraries. 2011. 166 pp. http://digitalcommons.unl.edu/zeabook/5/
- *Wetland Birds of the Central Plains: South Dakota, Nebraska and Kansas.* 275 pp. pp. 2012. Lincoln, NE: Zea E-Books & Univ. of Nebraska Digital Commons http://digitalcommons.unl.edu/zeabook/8/
- Nebraska's Wetlands: Their Wildlife and Ecology. 2012. Lincoln, NE: Conservation and Survey Division, Inst. of Agriculture & Natural Resources, Univ. of Nebraska–Lincoln.
- *Birds of the Great Plains: Breeding Species and their Distribution.* Revised ed, with a Literature Supplement and revised maps. 2009. http://digitalcommons.unl.edu/ bioscibirdsgreatplains/1/
- *A Chorus of Cranes. The Cranes of North America and the World.* 2015. Boulder: U. Press of Colo. 242 pp.
- The following shortee\r publications are also relevant:
- *The Status of Cranes of the World in 2008*: A Supplement to Crane Music. URL: http:// digitalcommons.unl.edu/biosciornithology/45/
- Sixty-five years of Whooping Crane records in Nebraska. *Nebraska Bird Review* 45:54-56. (with Richard Redfield)
- The ornithogeography of the Great Plains states. *Prairie Naturalist,* 10:97-112.
- The breeding birds of Nebraska. *Nebraska Bird Review*, 47:3-14.
- A century of ornithology in Nebraska: A personal view. Pp. 329-55, in *Contributions to the History of North American Ornithology,* Vol.. II. (W. E. Davis & J. A. Jackson, eds.) Nuttall Ornithological Club, Boston, Mass.
- Nebraska's sandhill crane populations: Past, present and future. *Nebraska Bird Review* 70:175-178.
- Habitat associations of Nebraska birds. *Nebraska Bird Review,* 73:20-25. (with John Dinan)
- Review of *Endangered Birds. Science*, 203:428-429.
- "Whooper recount." *Natural History*, February, p. 70-75.
- Review of *Cranes: A Natural History of a Bird in Crisis*. *Great Plains Research* 20:1 (Spring 2010), p. 137.
- "The whooping cranes: Survivors against all odds." *Prairie Fire*, Sept., 2010, pp. 12, 13. 16, 22. (with K. Gil-Weir). http://www.prairiefirenewspaper.com/2010/9/ the-whooping-cranes-survivors-against-all-odd

Q: Have you received awards for your literary work?

A: Literary awards that I have received include the Wildlife Society's annual award for the outstanding book (*Grouse and Quails of North America*) or monograph in the field of terrestrial wildlife biology, and the Library Journal's selection of *Waterfowl: Their Biology and Natural History* as one of the most outstanding books of the year in science and technology. I am an honorary life member of the Nebraska Ornithologists' Union since 1984, and an elected Fellow of the American Ornithologists' Union since 1961. I have also been a Guggenheim Fellow, and held postdoctoral fellowships from the National Science Foundation and the U.S. Public Health Service.

Q: Have you received other honors and awards for conservation or environmental protection efforts?

A: In 2001 I was honored by the Nebraska section of the National Audubon Society with their Fred Thomas Nebraska Steward Award, and in the same year the Nebraska Wildlife Federation presented me with a Lifetime Achievement Award. In March, 2005, I received the National Wildlife Federation's National Conservation Achievement Award (Science), given annually to a scientist who has performed conservation work of national significance. In March, 2008, the National Audubon Society awarded me their Charles H. Callison Award, their highest honor that they bestow for volunteer conservation work. Most recently (2017), the Center for Great Plains Studies awarded me a Lifetime Achievement Award, which is given to persons whose lifetime of work has greatly impacted and bettered the Great Plains. I am the first recipient of this award.

Q: Have you spent a great deal of your life studying and writing about whooping cranes?

A: Yes. I have spent much of my life studying the whooping crane and other migratory bird species in the Great Plains, and plan on continuing to study these species and write

books and articles about them. I have continued to follow the efforts to protect the whooping crane and migratory birds throughout my career.

Q: Aren't whooping cranes are on the endangered species list?

A: Yes.

Q: Why are whooping cranes on the endangered species list?

A: In 1941 there were only 22 whooping cranes known to exist. Following decades of recovery efforts, the population of whooping cranes in 2006 was merely an estimated 338 birds: 215 in the wild and 123 captive-raised birds that have been released in Florida in an attempt to rebuild the eastern United States' population. The Fish and Wildlife Service's most recent available estimates put the population at 350 or fewer birds. Studies have found that in order to be genetically viable, the population needs to reach at least 1,000 individuals. The number of whooping cranes is far below the number considered necessary to be genetically viable.

Q: Has there been a great deal of effort to save the whooping crane as a species?

A: Yes. The fact we have around 350 cranes represents major efforts by scientists, conservationists and policy makers. The Platte River Recovery Project in Central Nebraska, which provides many benefits, including supporting the water supplies for the cities of Lincoln and Omaha by maintaining flows in the Platte River, was established largely to protect the whooping cranes.

Q: Do whooping cranes reproduce quickly?

A: No. Whooping cranes are monogamous, forming pairs at around 3 years of age and typically begin breeding around 5 years of age. Though four eggs are laid on average per pair, the survival rate of chicks per pair is generally less than one chick annually. This

slow reproductive potential has been a major issue in trying to recover whooping crane populations.

Q: Do whooping cranes migrate along the same route every year?

A: Yes, whooping cranes generally follow the same migration route year after year.

Q: Are you familiar with the proposed route of the Keystone XL Pipeline?

A: I am familiar with the proposed route of the Keystone XL Pipeline, which is the subject of this proceeding.

Q: Does the proposed route of the Keystone XL pipeline generally follow the migration route of the whooping cranes?

A: Yes, the proposed route generally follows the migration route of the whooping cranes. A significant portion of the proposed route in Nebraska crosses directly over the migration corridor of the whooping cranes.

Q: Do you have concerns about the impact the proposed route of the Keystone XL pipeline may have upon whooping cranes?

A: Yes, I have several concerns about the impact the proposed route may have upon whooping cranes. I am very concerned that the destructive impacts of the Project have not been adequately analyzed, and that relevant literature has not been considered in the analysis of whether this project is in the public interest. It is also my understanding that TransCanada is developing a migratory bird conservation plan under the Migratory Bird Treaty Act; however, this plan has not been completed, and has not been made available for review.

Q: Are there specific aspects of the proposed route that cause particular concern?

A: I am particularly concerned about the potential harm to whooping cranes from power line collisions. The Final Environmental Impact Statement prepared by the US State Department found there would be 377 miles of transmission lines for pump stations for pump stations, including 68 miles of transmission lines in the State of Nebraska.

Q: Why are you concerned about power line collisions?

A: Several studies, including some of my own work, discuss adverse impacts to whooping cranes from collisions with power lines. *See* Johnsgard, P. A., and R. Redfield, Sixty-five years of whooping crane records in Nebraska, *Nebraska Bird Review,* 45:54–56 (1977). Of all the known threats to whooping cranes, collisions with power lines are the primary cause of mortality. Indeed, the principal recovery strategy for whooping cranes is to augment and increase the wild population by reducing threats, including the potential for power line collisions. Yet, the Keystone XL Project would dramatically increase the number of power lines within the central migration corridor in areas where whooping cranes would be roosting and feeding, and thereby significantly increase the threat of mortality from collisions.

Q: Why do whooping cranes collide with power lines?

A: Whooping cranes rely on sight to avoid obstacles they may encounter along their migration route, particularly those encountered at take-off and landing. Cranes and other birds apparently collide with lines because they do not see them in time to avoid them and suffer traumatic injury from the collision itself, or from the resulting impact of falling to the ground. Encounters with power lines usually occur as whooping cranes are making short, low altitude flights between foraging and roosting areas, which frequently occur near sunrise and sunset when light levels are diminished.

Q: Based on your research, study and knowledge of this issue, is it your opinion that the proposed route of the Keystone XL pipeline would lead to the loss of whooping cranes?

A: Yes. Given the proposed route in the crane migration corridor and the increased risk of collisions from the number of planned power lines, the loss of whooping cranes over the 50-year lifespan of the proposed project is likely.

Q: If whooping cranes were killed by collisions from power lines, what would be the impact from the loss of these whooping cranes?

A: The loss of even a few, and even one, breeding adult could jeopardize the continued existence of this protected species. This is an unacceptable risk to this iconic species.

Q: Are you familiar with measures intended to mitigate impacts to cranes from power lines?

A: I am familiar with the measures intended to mitigate impacts to cranes from power lines, such as marking of power lines and installation of bird diverters.

Q: Are these mitigation efforts likely to be successful?

A: Although these efforts may reduce the number of collisions, they do not eliminate them altogether, as environmental conditions such as fog and high winds as well nocturnal flight patterns would render them effectively meaningless at certain times. Most studies have found that bird diverters are around 50-60% effective, and thus do not come close to eliminating the collision risks for whooping cranes.

Q: Do you have other concerns about the proposed route of the Keystone XL pipeline?

A: Yes, I am also concerned that Keystone XL would be located adjacent or directly through several Audubon-designated Important Bird Areas (IBA), including the Rainwater Basin IBA in Nebraska, which attracts millions of shorebirds, water birds, and

waterfowl each year, and is an important stopover area for whooping cranes. These areas are essential for migratory bird species, and I am very concerned that the Department of State's EIS and Biological Assessment, as well as Fish and Wildlife studies, do not adequately analyze the impacts that this proposed route would have on these Important Bird Areas, including construction-related disturbance and habitat loss, as well as contamination from pipeline spills and leaks.

Q: Based on your research, knowledge and experience, has there been sufficient analysis to ensure the proposed route does not pose a threat to the continued existence of the whooping cranes?

A: I am very concerned there has not been sufficient analysis to ensure that the proposed route of the Keystone XL pipeline does not pose a threat to the continued existence of the whooping cranes, and to assess the potential for harm to other migratory bird species and the habitats that they rely on.

Q: Hopefully whooping cranes will continue to survive as a species far into the future. However, what would the loss of whooping cranes as a species mean to people around the world?

A: I fervently hope that whooping cranes will survive and grow and thrive as a species far into the future. Loss of the whooping cranes as a species would be a huge loss to humanity as a whole and to biological diversity on this planet. It would be a devastating blow to the millions of people who care about this beautiful and majestic bird. It would be an incredible loss to scientists, conservationists and bird-lovers. It would also mean that millions of dollars and countless hours spent by scientists and conservationists to

bring this iconic species back from the brink of extinction would have been wasted. We need to reduce the threats to this magnificent bird, not increase them.

Q: In addition to their value for researchers and conservationists, do whooping cranes have economic value to the State of Nebraska?

A: Yes. Thousands of people (at least 20,000 in 2016) come to Nebraska every year to see the sandhill cranes, resulting in millions of dollars of income for Nebraska residents as well as revenues to the state and local political subdivisions from tax revenues. Many of these tourists hope to get a chance to see a whooping crane. If the species is further endangered, it could result in the reduction of these economic benefits from environmental tourism.

Q: Based on your education, research and experience, do you have an opinion about whether the current proposed route of the Keystone XL pipeline should be approved or denied.

A: Yes. It should be denied because of the threats the current proposed route pose to the continued existence of the endangered whooping crane as a species as well as threats to other migratory bird species.

Q: Based upon the above concerns what is your opinion about whether the proposed route for the Keystone XL pipeline is in the public interest?

A: Based on my lifetime of study, research, experience and writing, it is my opinion that the proposed Keystone XL pipeline is not in the public interest of the State of Nebraska.

Signed and sworn before me this 7th day of June, 2017.

Paul A. Johnsgard

Notary Public

GENERAL NOTARY - State of Nebraska
SONYA M. BRAKEMAN
My Comm. Exp. Nov. 24, 2020

MAP SHOWING WHOOPING CRANE MIGRATION CORRIDOR IN COMPARISON TO KEYSTONE I AND KEYSTONE LX PIPELINE ROUTES

Current Range and Migratory Corridor of the Whooping Crane

Current range and migratory corridor
Historical range
Oil sands deposits

Breeding and wintering areas and primary migration pathway of the Aransas-Wood Buffalo Population of the Whooping Crane

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Application of TransCanada Keystone Pipeline, LP, for route approval of the Keystone XL Pipeline Project pursuant to the Major Oil Pipeline Siting Act	))))	Application No. OP-0003

NOTICE OF SUBMISSION OF EVIDENCE

The Bold Alliance (Bold), the Sierra Club, Nebraska Chapter (Sierra Club), hereby provide notice of submission of written testimony in this matter. Bold and Sierra Club jointly submit the testimony of Paul A. Johnsgard, Ph. D., Thomas David Hayes, Ph. D. and Joseph F. Trungale, Jr., along with exhibits related to such testimony. This submission of evidence is subject to continuing objections on limitations on the scope and nature of evidence and number of witnesses previously filed by Bold and the Sierra Club in this matter. Submission of evidence at this time does not waive these objections, nor any other objections or procedural motions before the Commission nor any other objections or motions which may be filed during this proceeding.

Bold and Sierra Club submit such evidence, subject to the previously stated objections, on behalf of Formal Intervenors designated as Natural Resources Petitioners by the Hearing Officer.[1] The testimony of Dr. Paul A. Johnsgard and Joseph F. Trungale, Jr, is submitted pursuant to the order of the Hearing Officer of May 10, 2017, granting Natural Resources Intervenors two witnesses. The testimony of Dr. Thomas Hayes is submitted pursuant to the

[1] The Hearing Officer's order of March 31, 2017 designates Bold, Sierra Club, Oil Change International, 350.org, and approximately thirty-five individuals collectively as "Natural Resource Petitioners." Bold and Sierra Club do not have working relationships with the individual Natural Resource Petitioners and do not purport to fully represent their interests. Thus, Bold and Sierra Club have not coordinated these submissions with the other "Natural Resources Petitioners".

provisions of the order of the Hearing Officer of March 31, 2017 granting an additional witness regarding the Keystone I alternate route.

CERTIFICATE OF SERVICE

Pursuant to 291 Neb. Admin Code § 015.0 (b) and the rulings of the Hearing Officer in this matter regarding service, copies of the testimony and exhibits described above were served upon all parties of record to this proceeding or their attorneys of record electronically using the service list provided by the Commission on this 7th day of June 2017.

BOLD ALLIANCE
SIERRA CLUB, NEBRASKA CHAPTER

By: _____

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Before the Nebraska Public Service Commission

In the Matter of the Application **of** **TransCanada Keystone Pipeline, LP for Route Approval of Keystone XL Pipeline Project, Pursuant to *Major Oil Pipeline Siding Act***	**Application No: OP-003** **Direct Testimony of Joseph F. Trungale, Jr.**

State of Texas)
) ss.
County of Travis)

Q: Please state your name.

A: My name is Joseph F. Trungale, Jr.

Q: Is Attachment No. 1 to this sworn statement a true and accurate copy of your most recent CV or Resume?

A: Yes it is.

Q: Briefly describe for the Commissioners please your educational background starting with your undergraduate work and all degrees and any relevant certifications earned or held by you.

A: I received a Bachelor of Arts degree in Literature from Georgetown University in 1990 and a Master of Science degree in Civil Engineering from the University of Washington in 1996. Between 2004 -07, pursuing a Ph.D. candidacy in Aquatic Biology at Texas State University, I completed required course work. My area of specialty is hydrology with a focus on in-stream flows.

Q: **Tell the Commissioners about your relevant work experience over that past ten (10) years and about your current employment.**

A: After several years working for public resource agencies and at a large consulting firm, I began Trungale Engineering and Science in 2004. My work often involves quantifying the effects of changing flows and flow patterns, aquatic habitat and other conditions in Texas rivers. I have provided expert testimony in state and federal court on issues related to water rights permits, sand and gravel mining and impacts of altered freshwater inflows on endangered species. I have been a member of the several of the state of Texas Senate Bill 3 Bay and Basin Expert Science Teams, and was the lead hydrologist on the Lower Colorado River Aquatic Habitat study. This is the most comprehensive instream flow evaluation that has been conducted in Texas to date. I have also worked extensively on San Antonio and Galveston Bay evaluations of salinity and produced an instream flow report on the Brazos River.

Q: Are you familiar with the Nebraska Public Service Commission's (NPSC) Natural Gas Pipeline Rules and Regulations and the proposed Keystone XL pipeline (KXL pipeline) application?

A: Yes, I have reviewed these documents as wells as sections of the Final Supplemental Environmental Impact Statement (FSEIS) for the Keystone XL Project prepared by the U.S. Department of State and the Final Evaluation Report prepared by the Nebraska Department of Environmental Quality (NDEQ).

Q: What is your understanding of the NPSC rules as related to the KXL pipeline application?

A: It is my understanding that NPSC shall approve the application if the proposed route if it is determined in the public interest. The applicant has the burden of proof to establish that the proposed route would serve the public interest and that in making its determination the NPSC may consider "Evidence of the impact due to intrusion upon natural resources and not due to safety of the proposed route of the major oil pipeline to the natural resources of Nebraska, including evidence regarding the irreversible and irretrievable commitments of land areas and connected natural resources and the depletion of beneficial uses of the natural resources" and

"Evidence of methods to minimize or mitigate the potential impacts of the major oil pipeline to natural resources."

Q: Do you have concerns as to whether the application is in the public interest?

A Yes I do.

Q: Can you please summarize these concerns?

A: My concerns are primarily related to the impacts on natural resources at stream crossings. Specifically, in my opinion, the applicant has failed to provide sufficient, or really any, site specific information related to the likely to physical, chemical and biological impacts associated with the construction of pipelines at stream channels. I am also concerned that the applicant has failed to provide any site-specific information related to stream channel erosion and migration so methods to minimize or mitigate the potential impacts could be evaluated or if necessary alternative routes could be considered. Finally, I am concerned that the proposed route would pass through areas with shallow aquifers which could directly impact these systems as part of the construction process and that the pipeline could alter groundwater flow paths potential impacting springs.

Q: Can you explain how the application proposes to cross water bodies along the pipeline route?

A: The most recent proposed Project route would include 281 waterbody crossings in Nebraska. Waterbodies would be crossed using one of four different open-cut methods or the HDD method. (FSEIS 2.1-63). Non-flowing segments will be crossed using Non-Flowing Open-Cut Crossing Method, while flowing streams will be crossed using Flowing Open-Cut Crossing Method, or for environmentally sensitive rivers one of two methods which temporarily isolate the segment of river channel in which the pipeline trench is to be excavated, Dry-Flume Open-Cut Method and Dry Dam-and-Pump Open-Cut Method or the Horizontal Directional Drilling (HDD) Method.

Q: Can you determine from the application or other documents which of these stream crossing methods will be employed at each of the 281 water body crossings?

A: Per the NPSC application "Keystone currently plans to use the HDD method of construction to avoid impacts to five waterbody crossings along the Preferred Route." According the FSEIS these five were selected based "on stream width, adjacent topography, adjacent infrastructure, best management practices, permitting, and sensitive environmental areas," though I could find no details as to how these criteria were applied nor whether any of the remaining 276 crossings meet any or all of these criteria. In fact, the application and the FSEIS are largely devoid of any site-specific information that the NPSC or anyone else would use to evaluate whether any effort had been made to determine if the appropriate crossing methods to "minimize or mitigate the potential impacts of the major oil pipeline to natural resources" are going to be applied at the overwhelming majority of the waterbodies that the route encounters.

Q: What does the application say with respect to water bodies cross where HDD has not been identified as the method that will be used?

A: The FSEIS states that "Where the HDD method is not used for major waterbody crossings or for waterbody crossings where important fisheries resources could be impacted, a site-specific plan addressing proposed additional construction and impact reduction procedures would be developed (see CMRP, Appendix G)."

Q: Does this statement satisfy the requirement that the application include methods to minimize or mitigate the potential impacts of the major oil pipeline to natural resources?

A: I do not believe so. I have several concerns regarding this statement. First, a permit application which essentially says "grant the permit first and later we'll tell you how we're going to implement it" makes meaningless the application review and approval process. Second, the determination of whether a stream crossing contains "important fisheries resources" that "could be impacted" is not a determination that

could or should be made solely during the construction phase of the process. While site visits should be part of this determination, and these should be conducted and data from them analyzed, the determination of what constitutes an important fishery resources is necessarily a research activity which should include a literature and data survey to compile historical physical, chemical and biological data relevant to each crossing, review of range maps and species life history information and development of screening and analysis tools to access likely impacts of disturbances on these natural systems. Finally, the reference to see CMRP, Appendix G, might suggest that this section contains some information related to where important fisheries resources could be impacted, or what components might constitute a site-specific plan to address these impacts. This is not the case; there is no information in Appendix G that discusses how important fisheries resources might be identified nor, with the exception describing each of the five trenching methods, sufficient information for the NPSC to determine how site plans would address additional construction and impact reduction procedures.

Q: Is there any reason that you would be more concerned about flowing open cut crossing methods over one of the temporary isolation or HDD methods?

A: All instream construction activities may adversely impact natural systems. In my opinion, the Flowing Open-Cut Crossing Method threatens immediate and irreparable harm to waters of the United States. Open-cut construction can impact water courses directly both physically and chemically, and these impacts may harm biological resources.

Instream open trenching impacts the physical channel morphology through the movement of sediments. These disturbances may affect water quality by altering total suspended solids (TSS), dissolved oxygen (DO), total dissolved solids, nutrients, water temperature and turbidity, as well as particulate total organic carbon, grain size, metals and polycyclic aromatic hydrocarbons (PAHs). Finally, this can impact fish and fish habitat by altering cover, channel morphology and

sediment deposition, fish health with changes in water quality, and ultimately fish abundance in response to the cumulative effects of these impacts.

Numerous studies have documented the effects of pipeline crossing construction on stream and river TSS, invertebrates and fish and association with elevated suspended solids and concentrations and increased sediment deposition. (Lévesque and Dubé 2007).

Q: Why is it important for the NPSC to consider this in its review of the application?

A: Site specific physical and biological conditions are an absolute requirement for informing a decision as to whether actions have been taken to minimize or mitigate the potential impacts of the major oil pipeline to natural resources. With the information, currently available, I do not believe it would be possible for the NPSC or anyone else to determine that Keystone has demonstrated that appropriate "methods to minimize or mitigate the potential impacts of the major oil pipeline to natural resources" are being applied. With the possible exception of the five sites identified for HDD, there is no site-specific information on the physical, chemical or biological conditions at the stream crossings and, as a result, no specific plan as to how the pipeline will minimize impacts these natural resources.

Q: What would be required to demonstrate that the proposed pipeline construction does not cause irreversible and irretrievable commitments of land areas and connected natural resources and the depletion of beneficial uses of the natural resources?

A: While it is possible that the not all crossings will result in irreversible and irretrievable damage to Nebraska's natural resources, in my opinion the application should include measures to properly monitor the effects of the pipeline construction on the natural resources. Quantification of the effect of the pipeline construction and operation on the natural resources and beneficial uses would be best determined by a Before-After-Control-Impact experimental design which would incorporate monitoring of physical, chemical and biological indicators before and after the

construction and at primary control site. This should include intensive monitoring during construction and until suspended sediments return to background levels.

Q: Can you please describe your second opinion regarding erosion and channel migration?

A: It is also my opinion that the application fails to provide information sufficient for the NPSC to determine that the preferred pipeline route has considered areas prone to erosion and/or scour during flood events resulting in exposure, which may reduce beneficial uses, including recreation and fish and wildlife habitat.

While the CMRP (FSEIS Appendix G) does include several schematic drawings, which provide a general conceptual description of the waterbody crossing approaches (detail 11-15 and 21), there is no site-specific information for associated factors related to channel erosion and scour, channel migration or potential for right of way (ROW) (i.e., surface and trench design) erosion. Without this basic site-specific data, it is not possible for the NPSC or anyone else to determine whether the preferred pipeline rout minimizes or mitigates effects on natural resources.

Q: Why is it important for the applicant to consider erosion potential in selecting a pipeline route which minimizes impacts to natural resources?

A: Estimates of channel erosion hazard areas are needed to determine burial depth and sag-bend set back distances for each crossing. As noted in the FSEIS

"Nebraska's rivers of the central High Plains typically flow through broad, flat valleys and deposit and rework sediments forming dynamic and unstable braided channel and transient depositional bars within relatively flat and broad valleys (Wiken et al. 2011)." FSEIS p 3.3-42.

and

"Blockage of channels by ice jams in some of the larger braided rivers such as the Elkhorn and Platte are triggered by relatively abrupt weather changes in mid or late winter (Mason and Joeckel 2007), and have the potential to cause significant lateral channel migration." FSEIS p 3.3-42

These conditions suggest unstable channels susceptible to scour and channel migration. Most alarmingly, this raises concerns over potential damage to the pipeline, as flood flows transport large rocks and debris over exposed pipelines, potentially resulting in catastrophic impacts on natural resources. However even in the absence of pipeline rupture, the exposed pipeline would result in depletion of beneficial uses of the natural resources, including rivers for recreation, instream habitat for fish and invertebrates and sediment transport.

Q: Is possible for the application to estimate potential for channel erosion and migration prior to construction?

A: Methods to minimize or mitigate potential impacts should rely on site specific information to determine the burial depths and sag-bend set back distances. Relevant information for each of the proposed crossings should include quantification of variables that control alluvial channel patterns including channel slope, discharge, valley confinement, sediment supply, sediment caliber, bank strength, and wood loading (Beechie and Imaki 2014). Based on this data screening, estimates of erosion potential can be calculated followed by site specific analyses at sites with high erosion potential. Alternative crossing locations could then be investigated to minimize or mitigate the potential impacts of the major oil pipeline to natural resources.

Q: Can you please describe your third opinion regarding the potential impacts to shallow aquifers?

A: I am concerned that the proposed route would pass through areas with shallow aquifers which could directly impact these systems as part of the construction process and that the pipeline could alter groundwater flow paths potential springs.

Q: Are there more places where the groundwater table is 10 feet or less from the surface on the proposed route of KXL than on the route of Keystone I?

A: Yes, by my calculations, based on well data that I acquired from the Nebraska Department of Natural Resources and pipeline route maps included in the FSEIS, there are 358 wells with 1 mile of the Keystone XL route, in Nebraska, were very

shallow water depth is likely with reported water level less than or equal to 10 feet bgs (below ground surface) and total well depth less than or equal to 50 feet bgs, while there are only 117 along the Keystone I route.

Q: Would this higher number of areas where the groundwater table is 10 feet or less from the surface on the proposed KXL route be cause for concern?

A: Yes

Q: Why would this cause concern?

A: As noted in the FSEIS (Section 4.3.3.1 – Groundwater Construction related impacts) there would be potential for spills and releases from equipment maintenance areas, camps, HDD locations, and pipeline placement areas. In shallow aquifers, any spills and leaks could flow directly into and pollute groundwater. More wells with the right of way would probably mean that more may need to be removed. There would likely be dewatering where groundwater is less than the burial depth of the pipe (typically, burial is 4 to 7 feet) during pipe-laying activities. Dewatering the excavation could generate substantial localized amounts of water to be discharged. The pipeline trench could potentially act as a conduit for groundwater migration and/or as a barrier to near-surface flow in areas of shallow groundwater (<7 feet below ground surface [bgs]). This could impact spring flows and the fish and wildlife species that depend on springs.

Q: Would locating a high-pressure tar sands pipeline through areas with shallow groundwater tables increase the likelihood of irreversible and irretrievable irreparable impacts to natural resources?

A: Obviously, the potential impact of spills and leaks is greater since the water in shallow aquifers has the potential to transport spills across a larger area, however simply placing the pipeline with a shallow aquifer could alter flow paths which could result in irreversible and irretrievable irreparable impacts on local springs.

Q: Would locating a high-pressure tar sands pipeline through areas with shallow groundwater tables increase the likelihood of depletion of beneficial uses of natural resources?

A: Yes, springs are natural resources which provide habitat for numerous species of fish and wildlife. In some systems, they provide a significant portion of the baseflow a river. If pipelines result in the dewatering or significantly alterations of flow paths to local springs this can impact river flows and species that are dependent on the habitats provided by these flows.

Q: Based on your education, research and study, after reviewing relevant documents regarding water resources and the statutory and regulatory criteria, do you have an expert opinion about whether the Public Service Commission should approve or deny the application for approval of this proposed route for KXL?

A: In my opinion the NPSC should deny the application because the pipeline would result in irreversible and irretrievable commitments of land areas and connected natural resources and the depletion of beneficial uses of the natural resources. The application is also deficient in providing evidence which demonstrate methods to minimize or mitigate the potential impacts of the major oil pipeline to natural resources. These include a failure to provide site specific analysis of aquatic resources and channel erosion hazard and the potential to impact groundwater flow paths through shallow aquifers.

Q: If the PSC does approve TransCanada's application, is it your opinion that the Keystone I route would pose fewer risks to natural resources?

A: Yes, based on my analysis the proposed route intersects stream flowline segments (National Hydrologic Dataset) 172 times as compared to 142 times along the Keystone I route. As discussed above the proposed route also includes more shallow groundwater wells. The likelihood of irreversible and irretrievable irreparable impacts to natural resources would be reduced if the pipeline were to insect these natural resources less frequently.

Q: If the PSC does approve TransCanada's application, is it your opinion that the Keystone I route would be less likely to cause depletion of beneficial uses of natural resources?

A: Yes, rivers and shallow aquifers, and the springs they support, provide a myriad of beneficial uses including water supply, instream habitat and recreation all of which would be less likely to be depleted if the existing Keystone 1 route were used instead of the proposed Keystone XL.

Q: Does this conclude your prepared testimony?

A: Yes, it does.

Joseph F. Trungale, Jr.

Subscribed and Sworn to before me this 7th day of June, 2017.

Shari D. Straight
Notary Public

SHARI D. STRAIGHT
Notary Public, State of Texas
My Commission Expires
April 04, 2019

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JOSEPH F. TRUNGALE, P.E.

Owner / Principal

FIELDS OF EXPERIENCE

Mr. Trungale is a professional engineer and the principal of Trungale Engineering & Science in Austin, Texas. He has over 20 years of experience working in water resource planning and environmental flow studies, including work for the river basin commission responsible for raw water supply for Washington D.C., as a consultant with HDR Engineering managing regional water planning and availability modeling and as the surface water hydrologist for the Texas Parks and Wildlife River Studies program. Mr. Trungale is currently an independent consultant with expertise in conducting instream flow studies to quantify the effects of changing flow regimes on aquatic habitat. His expertise extends to groundwater-springflow studies, freshwater inflows for bays and estuaries, and regional and state water planning including water availability analysis and water rights review. Mr. Trungale has an MS degree in Engineering from the University of Washington and has completed course work in pursuit of a PhD candidacy at Texas State University in Aquatic Biology.

EDUCATION

- Completed course work in pursuit of PhD candidacy, Aquatic Biology, Texas State University (San Marcos, Texas) 2010
- M.S. Engineering, University of Washington (Seattle, Washington), 1996
- B.A. English Literature, Georgetown University (Washington, D.C.), 1990

PROFESSIONAL/TECHNICAL AFFILIATIONS

- Texas State Board of Professional Engineers – Professional Engineer No. 92040
- Member of American Society of Civil Engineers

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Owner and Principal
2004 - Present Trungale Engineering & Science Austin, Texas

In 2004, Mr. Trungale established Trungale Engineering & Science and began working as an independent consultant. While continuing to conduct state of the science studies, he has brought his expertise in engineering and ecological science to broader contexts within the public policy and legal arenas. He works with diverse groups of stakeholders and scientists to develop innovative solutions to natural resource challenges that balance growing human needs for water with the need to protect and maintain sound ecological environments. In addition to addressing the needs of individual clients, he has also served on several science committees and testified as an expert witness in a number of precedent-setting decisions.

Gulf Flows Project - Texas Environmental Flows Initiative

Mr. Trungale is currently working as to support the Texas Environmental Flows Initiative (TEFI), a team of NGOs and university partners including the National Wildlife Federation, The Nature Conservancy, the Harte Research Institute, and the Meadows Center for Water and the Environment which is pursuing scientific and technical analyses to set the stage for one or more transactions to help permanently secure freshwater inflows for several Texas bay / estuary systems. The project is focused on three coastal watersheds, the Colorado-Lavaca, the lower San Antonio and the lower Trinity. Trungale Engineer supports this effort through the development of a Geospatial Database Tool which complies and

summarizes water right permit, use and availability and through the development and execution of water availbity models to test alternative water management strategies and estuarine circulation and salinity models to evaluate the benefits of these strategies.

Technical Evaluations of Guadalupe-Blanco River Authority and Lower Colorado River Authority Projects – National Wildlife Federation

Both the Guadalupe-Blanco River Authority (GBRA) and Lower Colorado River Authority (LCRA) are pursuing efforts to develop new off-channel reservoirs, or potentially aquifer storage and recovery projects, and divert water from the Guadalupe and Colorado rivers, respectively, into storage. These proposals would reduce instream flows in the river and freshwater inflows into the San Antonio and Matagorda Bay. TES was retained to assist NWF in assessing the reductions in instream flows and freshwater inflows expected from the proposed operations, understand the ecological significance of those changes, and support NWF advocacy efforts to mitigate those effects.

Caddo Lake/Cypress Basin Environmental Flows Study - Caddo Lake Institute

Since 2005, Mr. Trungale has worked with local, state and federal agencies and the Nature Conservancy to develop flow recommendations to protect the rivers and wetland surrounding Texas' only natural lake. Mr. Trungale conducts and reviews scientific studies related to wetland connectivity and instream habitat to determine ecosystem flow needs for Caddo Lake and associated wetlands. Implementing a consensus based decision-making process; he has led a science based stakeholder process to develop recommendations for subsistence, base and high flow targets and conducted field studies to address priority research issues. He worked closely with the U.S Army Corps of Engineers and the local water supply organization to develop approaches to implement environmental flow recommendations and is currently developing a monitoring and adaptive management program to assess the efficacy of these recommendations on maintaining the ecological health of this system.

SB3 work plans in Colorado and Guadalupe Basins. Texas Water Development Board

Mr. Trungale worked on two separate teams to evaluate various aspects of the environmental flow rules adopted by TCEQ. In the Colorado basin, he updated the state's salinity and circulation model of Matagorda Bay in order to investigate how the recent drought has affected salinity in the bay. In the Guadalupe basin, he worked with the San Antonio Bay Partnership to evaluate alternatives including acquiring existing water rights and storing them in underground aquifers to be used to supplement flows during times of low inflow.

Assessment of Impacts of Proposed Marvin Nichols Reservoir in the Sulphur River Basin. Region D Water Planning Group

Mr. Trungale recently completed a report assessing the adequacy of an analysis produced by Region C on the potential impacts of the proposed Marvin Nichols Reservoir on natural resources in the Sulphur River Basin. His GIS-based assessment considered the potential impacts of the loss of overbank flow to maintenance of bottomland hardwoods.

Evaluation of Brazos BBASC recommendations and review of TCEQ implementation of Brazos Rules into WAMs. National Wildlife Federation

Mr. Trungale attended a number of facilitated meeting of the Brazos Basin and Bay Advisory Stakeholder Committee as they deliberated over their recommendations to TCEQ regarding the BBEST Environmental Flow regime recommendations report. He provided analysis of the competing proposals and provided input on the BBASC minority report. After the rules were adopted, he evaluated their implementation into the Brazos WAM and provided comments to TCEQ. Finally, Mr. Trungale produced a technical analysis

of the implementation and evaluation, including costs, of alternative flow recommendations on hypothetical water development projects.

Lake Ralph Hall – Texas Conservation Alliance

Mr. Trungale conducted analysis of the costs of the proposed Ralph Hall reservoir, including a comparison of that project with other alternatives, and generated cost estimates for a new alternative. He provided expert report and testimony in support of protestant (TCA) in the matter of the Application of Upper Trinity Regional Water District for Water Use Permit No. 5821 (SOAH Docket No. 582-12-5332).

Analysis of the Lower Colorado River Authority Water Management Plan - Colorado Water Issues Committee of the Texas Rice Industry Coalition for the Environment

In response to the historic drought currently underway in central Texas the LCRA has applied for a number of emergency orders that allow them to completely curtail releases of water for rice irrigators. Mr. Trungale was retained by CWIC to analyze the proposed emergency order and develop alternatives that would achieve a more equitable balance among all of the water users in the basin. He reviewed the proposed, current and past water management plans, used LCRA's stochastic model to forecast future combined storage in the highland lakes assuming the proposed and alternative emergency orders and produced a technical report. Mr. Trungale testified as an expert witness testimony (TCEQ Docket No. 2-14-0124-WR / SOAH Docket No. 582-14-2123 (LCRA WMP Emergency Order)) describing his conclusions that the same level of protection for upstream interests could be achieved with a more moderate order.

Learning from Drought: Next Generation Water Planning for Texas – Texas Center for Policy Studies

Under a grant from the Meadows Foundation, Mr. Trungale co-authored a report that analyses the Texas regional and state planning process. The report includes: an analysis of the assumptions and methods employed to develop forecasts for municipal, irrigation and stream electric water demands; calculations of water available from existing supplies, including estimates of additional supplies that could be made available if drought contingency plans are incorporated; and a discussion of the need to provide water for the protection of a sound environment. The report includes several policy recommendations to develop a more sustainable water plan.

Effect of Diversions from the Guadalupe San Antonio River Basins on San Antonio Bay - The Aransas Project

Mr. Trungale produced a technical report on behalf of The Aransas Project, an alliance of citizens, organizations, businesses, and municipalities seeking responsible water management of the Guadalupe River Basin and bays. In 2011, TAP filed a federal lawsuit in the United States District Court for the Southern District of Texas, Corpus Christi Division, against several officials of the Texas Commission on Environmental Quality (TCEQ) in their official capacities for illegal harm and harassment of Whooping Cranes at and adjacent to Aransas National Wildlife Refuge in violation of the Endangered Species Act. Mr. Trungale testified as an expert witness in this trial describing how future changes in inflow are expected to alter salinity patterns in San Antonio Bay. His analysis focused on salinity thresholds for Blue Crabs, an important for source for the cranes, in the vicinity of the Aransas National Wildlife Refuge.

Instream Flow – Habitat Relationships for the Nueces River Basin and the Upper Rio Grande Basin

Mr. Trungale conducted extensive field data collections and developed instream habitat simulation models for selected locations in the Nueces and Upper Rio Grande River basins in order to develop predictive relationships which describe the response of instream available habitat over a range of flows. These relationships will be used to evaluate the flows that may be recommended by the Bay and Basin Expert Science Teams as part of their charge under the Senate Bill 3 Environmental Flows mandate.

Brazos River Instream Flow Study - Texas Rivers Protection Association & Friends of the Brazos River

Mr. Trungale analyzed the Brazos River Authority systems operation permit application and evaluated effects on instream flows to support environmental and recreation flow needs. Mr. Trungale characterized flow regimes under pre-development and currently modified management scenarios using a Water Availability Model (WAM) developed for the Brazos River Systems Operations Permit application which seeks to appropriate water from the Brazos River. He provided expert testimony in support of protestants (Friends of the Brazos River) in the matter of the application by Brazos River Authority for Water Use Permit No. 5851 (SOAH Docket No. 582-10-4184; TCEQ Docket No. 2005-1490-WR).

Llano River Sand and Gravel Mining Protest

Mr. Trungale conducted analysis of potential impacts from sand and gravel operations in the Llano River specifically with respect to compliance with 31 TEX ADMIN. CODE § 69.108 (c) including the evaluating sediment budget, erosion rates of the river segment to be mined, and the effect on coastal and receiving waters. He provided expert report and testimony in support of protestants (Peron and others) in the matter of an application of Joe B. Long and Mark L. Stephenson for a Sand and Gravel Permit (SOAH Docket No. 802-09-4552).

Colorado and Lavaca River Basins and Matagorda Bay and Basin Expert Science Team (BBEST) and Trinity and San Jacinto River Basins and Galveston Bay and Basin Expert Science Team (BBEST)

As a Texas Senate Bill 3 Expert Science Team member, Mr. Trungale developed science based flow recommendations for rivers and freshwater inflows. This included analysis of hydrology and hydraulics, biology, water quality and geomorphology to refine and validate hydrology based instream flow recommendations. He applied a salinity zonation approach to predict ecologically relevant salinity response to changes in freshwater inflows.

Lower Colorado River Instream Flow Study – Lower Colorado River Authority/San Antonio Water System

Mr. Trungale developed models to evaluate the effects of flow alterations, specifically related to a proposed water development project to provide water from the Colorado River to the City of San Antonio. He was responsible for several components, which included performing reconnaissance to determine study sites, developing conceptual study flow charts, collecting physical and hydrologic data to model and characterize hydraulic habitat, analyzing results, recommending flow targets and preparing a final report.

Review of Desktop Methods for Establishing Environmental Flows in Texas Rivers and Streams – Texas Commission on Environmental Quality

Mr. Trungale provided technical support to the workgroup tasked with evaluating the current default method for determining instream flow needs, primarily for the purpose of defining special conditions within water rights permits. This included making comparisons between naturalized and gauged flows and between Lyons method and values derived from Indicators of Hydrologic Alteration (IHA) software as well as comparing estimates from desktop methods and recommendations from a comprehensive site specific study.

Kinney County Groundwater Management – Kinney Country Farmers and Ranchers Association

Mr. Trungale supported the coalition of ranchers and farmers to protect local wells and springs from excessive groundwater diversions and transfers. He evaluated previous and current studies, including Groundwater Availability Modeling (GAM) and provided support recommendations for springflow needs and approaches to meet these needs. Mr. Trungale provided affidavits to the Kinney County Groundwater Management District.

San Marcos River Foundation Instream Flow Permit Application – San Marcos River Foundation

Mr. Trungale provided technical guidance to the San Marcos River Foundation, a local non-profit which had applied for a permit for the protection of instream and freshwater inflows in the Guadalupe River. He also performed Water Availability Modeling (WAM) to support permit application, evaluated completed applications, and researched the TCEQ permitting policy to evaluate precedence and authority of the agency to grant such permits. Finally, Mr. Trungale evaluated state methodology to determine freshwater inflow needs for San Antonio Bay and continues to monitor activities to the Commission on Environmental Flows and their Science Advisory Committee. He provided affidavits in the matters of water rights applications from the San Marcos River Foundation and the Canyon Regional Water Authority.

Surface Water Hydrologist
1999 - 2004 Texas Parks and Wildlife Department San Marcos, Texas

Mr. Trungale's work at TPWD encompassed a large scope of projects including collecting and analyzing field data and developing hydraulic and habitat models to determine instream flow needs to support healthy ecosystems. In addition, he collected physical and biological data which included surveying stream cross sections and benchmarks with levels, total stations and GPS, measuring discharge with flow meters, collecting bathymetry with digital transducer and echosounder connected to GPS units, characterizing and mapping stream cover and substrate, collecting biological data, primarily fish, using seines, boat and backpack shockers, and also some limited collecting of chemical data primarily using automated data loggers. He performed statistical and time series analysis on hydrologic and hydraulic data, specifically calculating watershed and stream channel and flow statistics that have biological significance, e.g. Indicator of Hydrologic Variability (IHA) (central tendency, recurrence intervals, frequency and duration) and that may be used to develop or refine instream flow standards and requirements. Also Mr. Trungale developed and ran 1D and 2D hydrodynamic models including PHABSIM, River2D and SMS/RMA2, water quality models (SNTEMP and BASINS). He developed spreadsheet and GIS tools to analyze outputs of habitat preference and utilization. At TPWD, Mr. Trungale served as an agency expert on issues related to surface water hydrology in statewide permitting and planning including a review of major water rights applications, water availability modeling, reservoir yield calculations and departmental and state water planning processes.

Water Availability Models to Assess Alterations to Instream Flows

Mr. Trungale used water availability models to assess alterations to instream flows under current conditions and full authorized use assumptions. He developed monthly benchmark flow values at 72 sites throughout Texas based on a percentage of daily naturalized median flow (similar to the regulatory default method) and calculated the frequency of meeting or exceeding these benchmarks under natural and modeled assumptions. Finally, Mr. Trungale characterized the level of alteration based on the difference in percent of time targets met between natural conditions and full authorized use.

Guadalupe Instream Flow Study

Mr. Trungale was responsible for characterizing flow regime at three sites on the Guadalupe River by reviewing and comparing historical stream flow records, calculating flow statistics, and producing cumulative frequency graphs. He also collected physical and biological data at three sites on the Guadalupe River by several methods, including surveying cross section depths and water surface elevations, taking velocity measurements according to USGS protocol and calculating discharge, collecting bathymetry data using a boat mounted Echosounder/GPS system, and making substrate and cover calls and fish collections. Mr. Trungale developed 1D (PHABSIM) and 2D (SMS/RMA2 and River2D) hydraulic-habitat models including calculating stage-discharge relationship (rating curve), running and calibrating models and producing maps of model depths, velocities and habitat.

Regional Environmental Monitoring Assessment Program (REMAP)

Mr. Trungale's involvement in REMAP included collecting physical and biological data for small streams in East Texas including surveying cross section depths and water surface elevations, measuring velocity according to USGS protocol and calculating discharge. He also made substrate and cover calls, and developed spreadsheets to calculate summary statistics for more than 200 sites. The calculated statistics for each cross section included calculation of wetted width, maximum and median depth for current water surface elevations, bank full and flood prone areas. Mr. Trungale also summarized fish species collected at each site. Using GIS Software, Mr. Trungale calculated drainage areas for more than 200 sites using digital elevation models and land use density for each site according to Anderson scale and land use land cover data sets. Finally, Mr. Trungale developed programs to calculate the regionalized Index of Biotic Integrity (IBI) for fish and benthic macroinvertebrate metrics.

Evaluation of Spring Flows to Support the Upper San Marcos River Spring Ecosystem, Hays County, Texas

Mr. Trungale characterized flow regime by reviewing and comparing historical stream flow records, calculating flow statistics, and producing cumulative frequency graphs. He also developed a 1-D hydraulic-habitat model (PHABSIM) including calculating stage-discharge relationship (rating curve), by performing log-log regression between observed stage and discharge pairs at 28 cross sections, calculating velocities at each station within each cross section at a range of discharges using Manning's equation to solve for "n" at each station (in this context "n" acts as a roughness distribution factor across the cross section), calculating weighted usable area as a function of flow for target species (in this case five native plant species) by relating habitat suitability indices to modeled depths and velocities, and performing time series analysis to calculate weighted usable area over period of record to access historical variable and duration of "good" habitat conditions. In addition, Mr. Trungale developed a stream temperature model (SNTEMP) using results from hydraulic modeling and additional observed data to create inputs for a stream temperature model including latitude, elevation, travel time, stream width, shading data, and historical meteorological data (used for alternative scenarios). Finally, he modeled net heat flux = solar radiation + atmospheric radiation + vegetative radiation + evaporation + convection + conduction + friction-water's back radiation on a monthly time step, validated results against observed water temperatures, and predicted flow rates at which temperature thresholds might be violated.

Project Engineer
1997 - 1999 HDR Engineering, Inc. Austin, Texas

As a Project Engineer for HDR Engineering, Inc., Mr. Trungale developed water availability models and regional water plans. He was a principle programmer for state water availability models for the Guadalupe and San Antonio River Basins. Mr. Trungale was a project manager for new reservoir alternatives in the South Central Texas Regional Planning Study. He integrated long-range water supply plans for state sponsored regional planning studies based on demand projections, availability of new supplies, cost and environmental impacts. He modified reservoir yield simulation models for analysis and assessment of water supply alternatives on a daily time step. Models were evaluated for both the reliability of these alternatives to supply water as well as their impact on natural and aquatic resources downstream. Other projects included sizing and laying out potential pipeline routes and accessing costs for municipal water, sewer and drainage structures.

Guadalupe River Basin Water Availability Model

Serving as a Principle Modeler for the Guadalupe San Antonio Water Availability Model (GSA WAM), Mr. Trungale built a GSA water rights dataset which included reviewing permits, assigning priority dates and a diversion location to a geographical coordinate. He calculated monthly distribution factors, created storage area curves, and estimated historical evaporation rates. Mr. Trungale modified naturalized flow

sets including updated spring flow sets. Basin specific modifications were made to the WAM source code to calculate daily operations for Canyon Reservoir to meet FERC and hydropower daily flow requirements, including modifications to handle special permits (Braunig/Calveras/Victoria), and Medina/Diversion Lake leakage. Alternative scenarios were devised to evaluate changing return flow assumptions, exclusion of cancelable and term permits, and accounting for reservoir sedimentation. Model runs were performed to validate and present results.

South Central Texas (Region L) Water Planning

Mr. Trungale was a Project Manager for the SB1 Region L planning study for five new reservoir alternatives in the GSA. He managed a $20,000 budget and supervised the work of other project engineers. He calculated availability for water diversion into storage facilities with the constraints of meeting downstream senior water rights and bay and estuary flow requirements. He calculated reservoir yields subject to local evaporation and meeting a three-tiered environmental flow pass through, the impact of diversion at the site and at the mouth of the bay and the unit cost of water for the project. Mr. Trungale summarized yield estimates, costs and implementation/feasibility issues.

Environmental Criteria Refinement Study

Mr. Trungale modified the Texas Water Development Board's reservoir yield model (SIMDLYYD) to accept monthly flows, pass throughs for senior downstream water rights, bay and estuary flows, daily flows from a nearby reference gage, and to convert the daily values to monthly values. The model performs a mass balance on a proposed reservoir, passing flows to meet environmental targets based on triggers and iterating on storage to calculate evaporative losses. He calculated reservoir yield by increasing diversions until reservoir volume goes to zero. Options were also included for "stacking" pass throughs for instream flows on top of flows for bays and estuaries. Mr. Trungale performed this analysis on 7 proposed reservoirs in the South Central region. At one site, Sandies Creek, he made additional model runs to examine the effects of changing pipeline capacity. He compared resulting flows at the diversion site and the bay inflow with pre-project flow by calculating cumulative exceedance and monthly medians. Mr. Trungale ran fish production and salinity models to evaluate bay and estuary impacts.

Water Resource Systems Engineer
1996 - 1997 Interstate Commission on the Potomac River Basin Rockville, Maryland

During this period, Mr. Trungale managed raw water supply sources and planned for future water supply needs for the Washington, D.C. metropolitan area. He designed and maintained a hydrologic computer simulation model of the Potomac River Basin for use in long term planning of water supply needs. He issued monthly water supply outlook forecasts to alert Washington area water suppliers as to the likelihood of drought. He was responsible for scheduling water supply releases from storage facilities in the event that natural stream flow in the Potomac would be insufficient to meet current water supply demands. Mr. Trungale provided technical support and participated in planning efforts related to a range of water supply issues including yield analysis of current and future projects, management of water supply agreements across state lines, development of alternatives to meet future water supply needs, maintenance of historic flow and demand databases, development of local watershed groups and investigation of threats to future safety of area water supply.

Engineering Technician
1994 - 1996 ACT-ACF Comprehensive Water Resource Study Seattle, Washington

Serving as an Engineering Technician, Mr. Trungale developed a user-friendly computer simulation model to develop and analyze alternatives to manage water resources shared between three states and a wide range of stakeholders. He designed and programmed an object oriented computer simulation model

using Stella™ software for use by local and regional stakeholders, Alabama-Coosa-Tallapoosa (ACT) river basin. Mr. Trungale incorporated surface and ground water resources as well as findings from 14 concurrent studies. He met with public and private contractors and with representatives of environmental and planning departments from Georgia, Alabama, Florida and the federal government. Mr. Trungale consulted with these and other groups and developed measures of performance for municipal, industrial, and agricultural demands, hydro and thermal power production, environmental impacts on streams and reservoir lakes, and navigation and economic impacts. As a working group member, he had an extensive role interacting with stakeholders and making public presentations.

COMPUTER EXPERIENCE

- Surface Water Modeling (TxBLEND, WRAP, HEFR, RMA-2, River-2D, HEC-RAS)
- Statistical Software Packages (S-Plus, R, Conoco, Primer)
- Productivity (MS Excel, Word, Power Point)
- GIS (ArcView, Spatial Analyst, 3D Analyst)
- Database (Access, SQL)
- HTML, FORTRAN, VB, C