
**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE
APPLICATION BY SCS CARBON
TRANSPORT LLC FOR A PERMIT TO
CONSTRUCT A CARBON DIOXIDE
TRANSMISSION PIPELINE**

HP22-001

**DR. JOHN ABRAHAM
INITIAL PRE-FILED TESTIMONY
IN SUPPORT OF LANDOWNER
INTERVENORS**

Q: Please state your name and purpose for providing testimony in these proceedings.

A: My name is Dr. John Abraham. The purpose of my testimony is to provide the PUC information helpful when considering Summit's proposed hazardous carbon dioxide pipeline through South Dakota.

Q: How did you become involved in these proceedings?

A: I was contacted by Brian Jorde who represented himself as legal counsel for many concerned South Dakota citizens and landowners. Mr. Jorde asked if I would opine as to the veracity, accuracy, and reliability of PHAST or Phast software modeling, and render an opinion to a reasonable degree of scientific certainty or whether or not Phast generated Plume Modeling and resultant buffer distances contains accurate information that the PUC can rely upon. Specifically, when considering risks, and safety, land use and development considerations, economic, environmental, social and general welfare concerns for the directly affected landowners, persons and businesses in proximity to the proposed pipeline route, current and expected future inhabitants of the region, and the State of South Dakota, is the Phast modeling reliable and what weight should the PUC give to the data generated.

Additionally, I was told by Mr. Jorde that Summit has not shared their summary with the public or first responders or others as he was aware.

I will also discuss different approaches for calculating plumes from gas leaks. The calculations provide insight regarding how far a particular plume of gas may reach given environmental conditions and local topography. I will discuss the origins, strengths, and weaknesses of two competing approaches (PHAST modeling and CFD modeling), and why PHAST should not be used to assess risk from the rupture of a carbon dioxide pipeline.

Q: What experience, education, training, or background qualify you to provide opinions and your concerns as you have hearing?

A: In my professional capacity, I teach, consult with companies, and carry out research on a wide-range of engineering topics, in particular thermal-fluid sciences. The descriptor thermal-fluid sciences refer to the flow of heat and fluids (fluids include liquids, such as water; gases, such as air or other vapors; and supercritical fluids, such as supercritical carbon dioxide).

I teach courses to both undergraduate and graduate students on topics related to thermal sciences; among my regular teaching duties are Heat Transfer (a senior-level engineering course) and Advanced Thermal Design (a graduate-level course).

As a researcher, I have produced 272 scientific journal publications, given approximately 150 scientific presentations, written 37 book chapters, obtained 16 patents, with 5 applications in process. I have also edited 21 major works and written 3 books.

I am the Editor in Chief at two scientific journals (Numerical Heat Transfer part A and Numerical Heat Transfer part B) that specialize in numerical modeling of thermal fluid problems. I am the series editor of Advances in Heat Transfer, which is the most prestigious book series in heat transfer. I am also the series editor of Advances in Numerical Heat Transfer. As editor, my role generally relates to the assessment of incoming publications and determining whether they are suitable for

publication. I have won numerous awards that are listed in my CV, and I serve on multiple editorial advisory boards.

My education, experience, training, and background is fully described in my CV of which a true and accurate copy is found in **Attachment No. 1**.

Additionally, I have been a consultant for industry for approximately three decades. In total, I have been retained by approximately 60 companies on a variety of subject matters in engineering, including the use of computational fluid dynamics (CFD). CFD refers to a technique of flow prediction. The process involves the placement of computational elements throughout the fluid region – then fluid parameters such as velocity, pressure, turbulence level, temperature, density, etc. are calculated at each of these computational elements. When the elements are reviewed as a whole, the picture of the real flow patterns becomes apparent. I have authored two recent books chapters on CFD modeling that provide a background to the method:

- *J.P. Abraham, S. Bhattacharya, L. Cheng, and J.M. Gorman, A Brief History of and Introduction to Computational Fluid Dynamics, in Computational Fluid Dynamics, edited by: Suvanjan Bhattacharya, published by IntechOpen, 2021.*
- *J. Gorman, S. Bhattacharya, J.P. Abraham, L. Cheng, Turbulence Models Commonly used in CFD, in: Computational Fluid Dynamics, edited by: Suvanjan Bhattacharya, published by IntechOpen, 2021.*

I have also published many dozens of studies that use CFD; these studies are listed in my CV.

Finally, I have been involved in numerous litigations and have been recognized, multiple times, as an expert in CFD modeling of multi-species flows.

Q: What materials and data did you review and consider prior to rendering your expert opinions provided here and where you asked to accept as true any particular facts?

A: 2022-05-26 PHMSA Failure Investigation Report - Denbury Pipeline near Sartartia
2023-01-23 PHMSA 42023017NOPV_PCO_01312023_(21-199998)

2023-03-02 Denbury 42023017NOPV_Operator Response to Notice_03022023_(21-199998)

2023-03-24 PHMSA 42022017NOPV_Consent Agreement and Order_03242023_(20-176125)

2023-04-06 PST PR-4.6.22-Denbury-Enforcement_ES_KC_ES_Final3

2023-05-02 Entry for Satartia Rupture from PHMSA Accident Database

2013-10-01 PHMSA Failure Investigation Report Denbury Gulf Coast and Green Pipelines

2022-01-26 Weather data for Jackson MS and Satartia

2022-05-26 42022017 NOPV_PCO PCP_0526022_(20-176125) - Denbury Pipeline

Yes, I have been asked to assume that Summit, who has not yet publicly released its Plume/Dispersion modeling in South Dakota, has, like Navigator utilized the Phast Software model. I have been asked to assume that Summit and its agents, including Mr. John Godfrey in statements made to the Minnehaha County Commissioners regarding Summit have verified this fact.

I have also reviewed Navigator's "Heartland Greenway System Plume Modeling and Buffer Overview" as part of my involvement as an expert in that PUC Docket, but because that was provided to me confidentiality and is not directly relevant here, I do not discuss any specifics of those findings in this prepared testimony.

Q: What is the essence of your testimony here?

A: I testify her regarding shortcomings of the Phast Software model believed to be used in Summit's Plume/Dispersion Modeling and caution the PUC to rely upon conclusions drawn from Phast modeling specifically as it relates to the "buffer" distances Summit may also provide. My ultimate opinion is that Phast modeling is not the gold standard, should not be relied upon by the PUC for its review and decision making, and that it is not wise to rely upon Phast modeling to making decisions related to risk or safety or land use or effect on economic, environmental, social or general welfare concerns and doing so would be disserves to the people of

South Dakota. Relatedly I provide opinions concerning the diffusion of CO₂ following a leak or rupture or unintended release event.

Q: Please describe for the Commission Phast or PHAST modeling and its weaknesses as a predictive tool, if any.

A: PHAST modeling is a simplified approach to estimate where a plume travels following a rupture or a leak. The method is discussed in publications such as Witlox and Holt, (1999) and while parts of PHAST originated earlier than this publication, the 1999 paper provides a thorough discussion.

As revealed in the 1999 paper, the PHAST model is based on wind tunnel experiments from other researchers. These wind tunnel experiments were needed to obtain parameters that were used to force the model to match experimental results (termed “tunable parameters”). It is noteworthy that actual ruptures, such as the February 22, 2020, rupture of the Denbury pipeline near Satartia, Mississippi, are not in wind tunnels and so any wind-tunnel experiments would be irrelevant for Satartia or other real-world ruptures.

PHAST was also premised assuming a horizontal release – not a rupture like Satartia where a significant portion of the CO₂ was released vertically.

PHAST assumes that some plumes can take and maintain a perfectly spherical shape – and that other plumes can maintain circular cross sections as they move downstream, another feature that does not occur in real life.

Another weakness of PHAST is that it cannot account for changes in topography, which is an important factor for dense gases like CO₂ or for locations like Satartia that occurred in hilly topography.

Another feature of PHAST is that the cloud moves with a single velocity as it travels with the wind – this too is an unrealistic assumption. It is noteworthy that when Witlox and Holt compared their calculations with experiments, they found errors of ~ 500% less than half a mile from the release site – with PHAST dramatically underestimating the concentration of released gases.

Other studies confirm that PHAST cannot be used to provide high fidelity plume calculations. In Witlox, Harper, and Oke, (2012), the calculations diverged from experiments after a distance of only ~ 30 m. Clearly, PHAST would be unable to calculate concentrations for a very different situation, over long distances (~1000m).

Based on my review of the enforcement documents prepared by the Pipeline and Hazardous Materials Safety Administration (PHMSA) for the Satartia rupture that a PHAST calculation was performed by Denbury prior to the Satartia rupture to determine if its pipeline posed a risk to the village. In its March 24, 2023 Consent Agreement with Denbury (available at:

[https://primis.phmsa.dot.gov/Comm/reports/enforce/documents/42022017NOPV/42022017NOPV_Consent%20Agreement%20and%20Order_03242023_\(20-176125\).pdf](https://primis.phmsa.dot.gov/Comm/reports/enforce/documents/42022017NOPV/42022017NOPV_Consent%20Agreement%20and%20Order_03242023_(20-176125).pdf)), PHMSA reported that “the earlier PHAST dispersion analysis was wrong.” Denbury’s reliance upon a dispersion model is also confirmed in

PHMSA’s May 26, 2022 Notice of Probable Violation (available at:

https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2022-05/42022017NOPV_PCO%20PCP_0526022_%2820-176125%29%20-%20Denbury%20Pipeline.pdf), and in PHMSA’s May 26, 2022 Failure

Investigation Report (available at:

<https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2022-05/Failure%20Investigation%20Report%20-%20Denbury%20Gulf%20Coast%20Pipeline.pdf>).

Consequently, from the information available to me, I conclude that Denbury – and unfortunately, every community where this particular pipeline was located - inappropriately relied upon a calculation approach that was known by Denbury, and its consultants, to be unable to incorporate critical factors necessary to determine the risks that its pipeline posed to Satartia and was also known to vastly under-predict downstream gas concentrations.

Q: Is there a superior or preferred alternative to PHAST that is more accurate and reliable, and if so, please describe that superior modeling technique.

A: Yes, there is. The gold-standard and more accurate modeling technique and tool is known as CFD, the computational fluid dynamics modeling referenced previously. CFD is becoming increasingly turned to for dispersion calculations (Huiru et al., 2021). This method has been effectively used and is able, for example, to handle different terrains (Godbole et la., 2018; Woolley et al., 2014; Mack and Sprujit, 2013; Liu, Godbole, Lu, and Michal, 2017).

CFD does not suffer the same weaknesses as PHAST. There are no tunable parameters that need to be carefully set. It can handle terrain and leaks that are not horizontal; it is able to simulate plumes that are not perfectly spherical or that have non-circular cross section. With CFD, the cloud does not move with a single velocity. Without these simplifications, CFD can yield more accurate calculations. Advantages of CFD over PHAST are known in the scientific community and are expressed, for example, by Liu et al., 2015.

The above studies represent examples of the application of the three categories of dispersion models—Gaussian-based, similarity-profile and CFD-based. In general, CFD models are the most adaptable and are able to produce better prediction, as they use more detailed mathematical descriptions of the conservation principles. This allows the simulation of complex physical processes involving heat and mass transport in complicated computational domains (Pontiggia et al. 2009). The main drawback of CFD models is that they are often difficult and time-consuming to set up and run. Furthermore, detailed meteorological measurements and topographic data, which are essential inputs to the CFD model, are often unavailable. Gaussian and similarity-profile models are unable to model the flow over obstacles or across complex terrains (Sklavounos and Rigas 2004). However, their main advantage is that they are relatively easy to use and provide quick estimates of dispersion.

From Liu et al., 2015

Q: Given that Summit is requesting PUC approval to for the perpetual location of their proposed hazardous CO2 pipeline, do you have an opinion as to if the Commission should rely upon PHAST modeling data and its generated buffer areas when deciding on the Summit Application, and if so, what is your opinion?

A: My opinion, which is provided to a reasonable degree of professional scientific certainty is that the Commission should not rely upon PHAST modeling or the data and buffers that flawed modeling provides. CFD modeling should occur, and that modeling should be further scrutinized. The Commission would be wise to take the more robust and accurate and dynamic CFD modeling into account before approving or denying Summit's Application. PHAST modeling is known to underestimate gas concentrations and is unable to deal with a number of critical factors including but not limited to topography and turbulence. Furthermore, newer, more accurate methods are available that can provide more accurate concentration calculations. Had such CFD modeling been performed prior to approval of the Denbury Satartia pipeline, the citizens, landowners, local and state governments,

and decision makers would have had more accurate data when reviewing the proposed location of the pipeline, whether to approve the route or not, whether to order additional conditions be included in an approved application, and the surrounding communities, first responders, and residents would have been empowered with the most reliable data and information to protect themselves, prepare for and mitigate the known and predictable risks of rupture, explosion, leak, and release from hazardous pipelines.

Had more accurate calculations been performed prior to the Satartia Mississippi CO2 incident, it is more likely than not true that leak risks and considerations, including advanced knowledge and awareness of the actual danger zones would have been more accurately known such that the negative fallout and effects on the residents and community would have been greatly minimized or prevented. Translating this to the current proposed Summit CO2 pipeline at issue here, the Commission, empowered with accurate data, may decide the actual risks associated with such a pipeline are simply too much for South Dakota and the residents, landowners, and businesses near the proposed route.

Q: Do you have an opinion as to buffer distances as generally determined by PHAST modeling and, if so, what are your opinions?

A: Yes, based on Phast modeling, it is more likely than not that all of Summit's stated buffer distances including, initial routing, design and operations, emergency response, and public awareness are under reported, inaccurate, and unreliable given the major decisions the Commission have to make.

Q: To the extent used by Summit, do you have an opinion as to concepts of "aspirational buffers" and "where feasible and practical" in relation to a pipeline companies proposed pipeline locating decisions, and if so, what are those opinions?

A: Buffer distances and setbacks should be driven by the best available scientific means and modeling – not corporate expediency or profit motive. If the goal is to consider the current existing residents, land uses, business, and other uses, the buffers and

setbacks should not be “aspirational” they should be grounded in science and enforced to best protect both the existing inhabitants and land uses but also those reasonably expected in the future. The concept of “where feasible and practical” in terms of a pipeline companies’ perspective is not the best practice. If the most accurate scientific methods are utilized and scrutinized, and if the Commission is to approve this project, I encourage them to do so only if the proposed route is located and sited in a manner to comply with all buffer zones and setbacks as dictated by the science not by corporate expediency or feasibility from the corporate lens.

Q: Have all of your opinions expressed herein been given to a reasonable degree of scientific professional certainty and been informed by your education, training, background, and experience?

A: Yes, they have, and I reserve the right to amend or modify these opinions upon presentation of any additional information that may justify such a change, if any.

Dated June 15, 2023

/s/ Dr. John Abraham

Dr. John Abraham

CV – DR. JOHN ABRAHAM

SUMMARY

Thermal science expert with experience in all aspects of heat transfer and fluid mechanics. Produced approximately 450 publications, books, book chapters, conference presentations, and patents in areas including biological heat transfer and fluid flow, biomedical device design, energy, burn injuries, climate change, fundamental heat transfer and fluid mechanics, and manufacturing processes. Author of approximately 350 popular press articles and has been in approximately 200 radio and television appearances.

APPOINTMENTS

University of St. Thomas, St Paul, MN

Professor	2013-Present
Associate Professor	2008-2013
Assistant Professor	2002-2008

EDUCATION

University of Minnesota - Twin Cities, Minneapolis, MN

Ph.D. , Mechanical Engineering (Thermal Sciences)	2002
M.S. , Mechanical Engineering, GPA 3.96/4.00	1999
B.S. , Mechanical Engineering, GPA 4.00/4.00, Minor : Mathematics	1997

PREVIOUS TEACHING EXPERIENCE

Adjunct Faculty , <i>University of St. Thomas, St Paul, MN</i>	2000-2002
Graduate Teaching Fellow , <i>University of Minnesota, Minneapolis, MN</i>	2001-2002
Teaching Assistant , <i>University of Minnesota, Minneapolis, MN</i>	1997-2001
Tutor , <i>University of Minnesota, Minneapolis, MN</i>	1993-1997

HONORS/AWARDS

- Editor's Choice Award, Journal of Forensic Sciences, (2022).
- AAS Esteemed News and Views Paper Prize, (2022)
- Journal of Atmospheric and Oceanic Technology, Editor award (2020)
- National Center for Science Education, Friend of the Planet Award (2016)
- University of St. Thomas, Professor of the Year (2016)
- USA Green Deal of the Year business excellence award (2013)
- Composites Sustainability Award, American Composites Manufacturers Association Award for Composite Excellence, (2013)
- Nominated, George Mason University, Center for Climate Change Communication, Climate Change Communicator of the Year (2011)
- University of St. Thomas, John Ireland Award (2009)
- University of St. Thomas, Distinguished Educator Award (2008)
- University of St. Thomas, Engineering Professor of the Year (2005)
- Graduate Teaching Fellowship (2001/2002)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (1999/2000)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2000/2001)

- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2001/2002)
- Mechanical Engineering Teaching Assistant of the Year, Mechanical Engineering Department, University of Minnesota (1998/1999)
- Minnesota Professional Engineers Foundation Orion Buan Memorial Scholarship (1996)
- Walter and Margaret Pierce Endowment Fund Scholarship (1996)
- National Space Grant Consortium Scholarship (1996)
- Frank Louk Scholarship (1996)
- Citizens' Scholarship (1992-1995)
- Alfred O. Neir Scholarship (1994)
- Dean's List (1993-1997)

OTHER POSITIONS

Climate Blogger – Guardian Newspaper

2013-2022

PUBLICATIONS

(21 edited works, 3 books, 37 book chapters, 272 journal publications, 147 presentations, 16 granted patents, 5 patent applications, 2 granted trademarks)

TOP PUBLICATIONS BY ALTMETRIC

L. Cheng, J.P. Abraham, K.E. Trenberth, J.T. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonoc, J. Reagan, and G. Li, Another Year of Record Heat for the Oceans, *Advances in Atmospheric Sciences*, (in press). **Altmetric score = 1438, top 1% in all journals, January 2023. This altmetric score places the paper in the top 1% (top 100 out of 214000 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abraham, K.E. Trenberth, J. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, Z. Tan, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, Another Record Ocean Warming Continues Through 2021 Despite La Nina Conditions, *Advances in Atmospheric Sciences*, Vol. 39, 373-385, 2022). **Altmetric score = 4686, top 1% in all journals, January 2022. This altmetric score places the paper in the top 0.02% (top 57 out of 287000 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abraham, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit Record High in 2020, *Advances in Atmospheric Sciences*, Vol. 38, pp. 523-530, 2021. **Altmetric score = 1439, top 1% in all journals, August 2021.**

G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change*, Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 726, top 1%, July 2021.**

J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 392, top 1%, July, 2021.**

L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **This paper was in the top 100 of all published**

scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021.

L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues record global warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021.**

L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

Editing Activities (21 editorial activities)

1. Editor, Special edition in Numerical Heat Transfer B – AI methods in heat transfer (2023)
2. Editor, *Advances in Heat Transfer*, Vol. 56, (forthcoming, 2023).
3. Editor, *Advances in Heat Transfer*, Vol. 55, (forthcoming, 2023).
4. Editor in Chief, Numerical Heat Transfer A/B
5. Editor, *Advances in Atmospheric Sciences (AAS)*, 2022.
6. Editor, *Advances in Heat Transfer*, Vol. 54, Elsevier, 2022.
7. Editor, *Advances in Heat Transfer*, Vol. 53, Elsevier, 2021.
8. Editor, *Advances in Heat Transfer*, Vol. 52, Elsevier, 2020.
9. Editor, *Advances in Heat Transfer*, Vol. 51, Elsevier, 2019.
10. Editor, *Advances in Heat Transfer*, Vol. 50, Elsevier, 2018.
11. Editor, *Advances in Heat Transfer*, Vol. 49, Elsevier, 2017.
12. Editor, *Advances in Heat Transfer*, Vol. 48, Elsevier, 2016.
13. Editor, *Advances in Heat Transfer*, Vol. 47, Elsevier, 2015.
14. Editor, *Advances in Heat Transfer*, Vol. 46, Elsevier, 2014.
15. Editor, *Advances in Numerical Heat Transfer Vol. 5: Numerical Models of Heat Exchangers*, Taylor and Francis, New York, 2017.
16. Editor, *Small-Scale Wind Power – Design, Analysis, and Economic Impacts*, Momentum Press, 2014.
17. Editor, *Advances in Heat Transfer*, Vol. 45, Elsevier, 2013.
18. Editor, *Advances in Heat Transfer*, Vol. 44, Elsevier, 2012.
19. Editor, *Advances in Numerical Heat Transfer Vol. 4: Nanoscale Heat Transfer and Fluid Flow*, Taylor and Francis, New York, 2012.
20. Guest Editor, *Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Biological Models and Equations*, Taylor and Francis, New York, 2009.
21. Guest Editor, Special Edition of the *International Journal of Heat and Mass Transfer: Bioheat and Biofluid Flow*, Elsevier, Vol. 51, 23-24, November, 2008.
22. Assistant Editor, *Handbook of Numerical Heat Transfer*, 2nd Ed. Editors: Sparrow, Minkowycz, and Murthy, John-Wiley & Sons, Inc., New York, 2006.

Editorial Board Member

1. Water Eng. & sciences.2023-present
2. *Advances in Atmospheric Sciences*, 2022-present
3. *International Journal of Forensic Sciences*, 2023-present
4. *International Society of Cardiovascular Translational Research*, 2020-present
5. *Energies, Thermal Management*, 2019-present

6. Cardiovascular Revascularization Medicine, 2018-present
7. Stem Cell Biology and Transplantation, 2015-present
8. Associate Editor, National Center for Science Education, Climate Science, 2012-present
9. International Journal of Mechanics and Energy, 2012-present
10. Open Mechanical Engineering Journal, 2007-present
11. Open Mechanical Engineering Reviews, 2007-present
12. Open Mechanical Engineering Letters, 2007-present
13. Open Medical Devices Journal, 2008-present
14. Creative Engineering Journal, 2009-present
15. ISRN Applied Mathematics, 2011-present
16. International Journal of Sustainable Energy, 2012 - present
17. International Journal of Materials, Methods, and Technologies, 2012- present

Books

1. J.P. Abraham and B.D. Plourde, Small-Scale Wind Power – Design, Analysis, and Environmental Impacts, *Momentum Press*, 2014.
2. J.P. Abraham, P.S. Ellis, M.C. MacCracken, and G.M. Woodwell, Climate controversy 2013. New York, NY: *AuthorHouse*, 2013.
3. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R.Ramazani-Rend, and J.C.K. Tong, All Fluid-Flow-Regimes Simulation Model for Internal Flows, *Nova Science Publishers, Inc.*, Hauppauge, NY, 2011.

Book Chapters (author of 37 book chapters)

1. D.K. Vashwakarma, S. Bhattacharyya, M.L. Soni, and J.P. Abraham, Effect of Inlet Flat Obstruction on Thermohydraulic Characteristics in a Smooth Circular Tube in the Transitional Flow Regime, in Bhattacharyya, Verma, Harikrishnan (eds), *Fluid Mechanics and Fluid Power, Vol. 3, Lecture Notes in Mechanical Engineering*, Springer, doi: 10.1007/978-981-19-6270-7_76.
2. F. Salamsi and J.P. Abraham, On the Finite Differences Method Using MS Excel, *Research Highlights in Mathematics and Computer Science* Vol. 6, pp 140-186, 2023.
3. F. Salamsi and J.P. Abraham, Boundary of Transition Flow Regime on Stepped Spillways by Physical Modeling, *Current Overview on Science and Technology Research*, (in press).
4. F. Salamsi and J.P. Abraham, Determination of Stilling Basin Invert Elevation and its Effect on Controlling Hydraulic Jumps, Chapter 5, *Techniques and Innovation in Engineering Research*, Vol. 2, 2022.
5. F. Salamsi and J.P. Abraham. Energy Loss at the Base of a Free Straight Drop Spillway, *Current Overview on Science and Technology Research*, Vol. 6, 2, 2022.
6. F. Salamsi and J.P. Abraham, Computation of Optimal Cross Section of Gravity Dams Using Genetic Algorithms, *Current Overview on Science and Technology Research*, Vol. 6, Chapter 1, 2022.
7. F. Salamsi and J.P. Abraham, Flow Characteristics of Skimming Regime Flow Over Stepped Spillways with Attention to Optimum Step Size, *Current Overview on Science and Technology Research*, Vol. 6, Chapter 3, 2022.

8. F. Salamsi and J.P. Abraham, Determination of Stilling Basin Invert Elevation and its Effect on Controlling Hydraulic Jumps, *Technological Innovation In Engineering Research*, (in press).
9. R. Daneshfaraz, E. Aminvash, and J.P. Abraham, Hydraulic Characteristics of Fish-Passes on Inclined Drops, *Research Developments in Science and Technology*, Vol. 4, pp. 108-123, 2022.
10. F. Salamsi, J.P. Abraham, and A. Salamsi, Design Considerations for Pumping Stations Using Variable Speed Pumps, *Novel Perspectives of Engineering Research*, Vol. 10, pp. 98-118, 2022.
11. F. Salamsi, J.P. Abraham, Drainage Gallery in Concrete Gravity Dams and its Effect on Reduction of Uplift Forces, *Novel Perspectives of Engineering Research*, Vol. 10 pp. 43-62, 2022.
12. F. Salamsi, and J.P. Abraham, Numerical Simulation Using the Finite Element Method to Investigate the Effect of Horizontal Drains and Cutoff Walls on Seepage and Uplift Pressure in Heterogeneous Earth Dams, *Novel Perspectives of Engineering Research*, Vol. 9, pp. 58-85, 2022.
13. F. Salamsi, J.P. Abraham, B. Nourani, Determining the Analysis of the Stability of Embankments Against Sliding and Prediction of Sliding and Critical Factor of Safety, *Novel Perspectives of Engineering Research*, pp. 98-125, 2022.
14. F. Salamsi and J.P. Abraham, Effect of Horizontal Drain Length and Cutoff Wall on Seepage and Uplift Pressure in Heterogeneous Earth Dam with Numerical Simulation, *Novel Perspectives of Engineering Research*, Vol. 9, pp. 58-85, 2022.
15. F. Salamsi and J.P. Abraham, Numerical Investigation of Reduction of Uplift Forces by Drain Pipes Under the Bed of a Canal, *Novel Perspectives in Engineering Research*, Vol. 7, pp. 117-139, 2022.
16. F. Salamsi and J.P. Abraham, A Case Study on the Weep Hole and Cutoff Wall Effect for Decreasing Uplift Pressure on Hydraulic Structures, *Innovations in Science and Technology*, Vol. 6, pp. 12-38, 2022.
17. F. Salamsi and J.P. Abraham, Comparison of Uplift Pressure and Hydraulic Gradient in Three Types of Dams: Concrete Gravity dams, Homogeneous, and Heterogeneous Earth-Filled Dams, *Innovations in Science and Technology*, Vol. 3, pp. 71-86, 2022.
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2. L. Cheng, and J.P. Abraham, Perspectives on Ocean sand Their Role in the Global Energy Budget and Water Cycle, *American Meteorological Society 102nd Annual Meeting, Houston, Kevin Trenberth Symposium*, January 23-27, 2022 (invited).

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18. J.P. Abraham, Climate Change, the Evidence is in the Oceans, *Presented at the National Laboratory for Marine Science and Technology*, Qingdao, China, October 25, 2018.
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Granted Trademarks

1. US Trademark Registration Number 5656322, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.
2. US Trademark Registration Number 5656323, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

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GRANTS (funding \$24.02 million)

<i>Varian Medical Systems</i>	2023-present
<i>Flotherm</i>	2021-present
<i>LEMA, LLC, MN</i>	2016-present
<i>HRST, Inc., MN</i>	2021
<i>Biotronik</i>	2021

<i>Starky</i>	2020
<i>Marvin Windows</i>	2020-2022
<i>Cardiovascular Systems, Inc.</i>	2019-2021
<i>ALS Consulting</i>	2019
<i>Medivator, MN</i>	2018-2019
<i>Medivators, MN</i>	2014-2015
<i>EKOS, MN</i>	2018
<i>Marcor</i>	2018
<i>Marvin Windows</i>	2018
<i>Medtronic, Fridley, MN</i>	2017-2020
<i>Orbital ATK</i>	2017-2018
<i>Pride Engineering, MN</i>	2017-2018
<i>Cargill, MN</i>	2016-2017
<i>EKOS, MN</i>	2016-2017
<i>Precision Air, MN</i>	2016
<i>3M, MN</i>	2015-2017
<i>Flourescence, Inc., MN</i>	2015
<i>Smiths Medical, MN</i>	2014-2015
<i>WTS LLC, MN</i>	2014-2022
<i>Somnetics, MN</i>	2014
<i>Lake Region Medical, MN</i>	2013-2014
<i>Amphora Medical, MN</i>	2013-2014
<i>ALS Consulting, MN</i>	2013-2016
<i>Medtronic, Fridley, MN</i>	2013-2016
<i>Devicix, MN</i>	2012-2013
<i>CriticCare, MN</i>	2012
<i>HRST, Inc., MN</i>	2012-2015
<i>QIG Group, OH</i>	2011-2013
<i>Phraxis, MN</i>	2011-2012
<i>Cardiovascular Systems, Inc., Roseville, MN</i>	2007-2015
<i>Translational Biologic Infusion, AZ</i>	2011-2013
<i>Galil Medical, Roseville, MN</i>	2011
<i>Imation, Oakdale, MN</i>	2010
<i>Medtronic, Fridley, MN</i>	2008-2011
<i>R4 Engineering, India</i>	2008-2009
<i>Horizontal Winds,</i>	2008-2
<i>Lockheed Martin, Eagan, MN</i>	2007-2009
<i>St. Jude Medical, Minnetonka, MN</i>	2007-2009
<i>Arizant Medical, Eden Prairie, MN</i>	2006
<i>Johnson and Johnson, Newark, NJ</i>	2004-2005
<i>Cortron/XeteX, Fridley, MN</i>	2005
<i>MicroControl Company, MN</i>	circa 2001
<i>Donaldson Co., Bloomington, MN</i>	1999-2003
<i>Augustine Medical, Eden Prairie, MN</i>	2000-2003
<i>Midmac Systems Inc., St Paul, MN</i>	2002
<i>Remmele Engineering Inc., St Paul, MN</i>	2002-2005
<i>Urologix, Minneapolis, MN</i>	circa 2004
<i>Restore Medical, Minneapolis, MN</i>	circa 2002
<i>Jennio, Minnesota</i>	circa 2001
<i>Caterpillar, Minneapolis, MN</i>	circa 2000
<i>ADC telecom, Minneapolis, MN</i>	circa 2000

<i>Entropy Solutions</i>	circa 2000
<i>XeteX, Inc., Minneapolis, MN</i>	1996-2000
<i>Pneuseal, St. Paul, MN</i> 1996-1998	
<i>Los Alamos National Laboratory, Los Alamos, NM</i>	1994

GRANTS (funding \$24.02 million)

Varian Medical Systems, Inc. Brain thermal transport, oncology applications	2023
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LEMA, LLC \$20m for development and deployment of solar-power off grid systems. Part of Consolidated Appropriations Act, 2023	2016-2022
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HRST, Inc. \$34,000 for analysis of flow patterns in power plants	2021
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Biotronik \$44k for simulation of heating caused by implanted medical devices	2021
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Flotherm (SBIR award FAIN 2034065) \$20k for simulation of body-heating devices \$48k for simulation of body-heating devices SBIR funding, NSF Small Business Innovative Research project	2020-2023
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Starky \$6k for thermal modeling of hearing aid batteries	2019-2020
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National Science Foundation (Co-PI, FAIN = 2018403) \$424k for engineering PIV instrumentation	2020-2021
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Intertek \$13k for study of tissue surrogates for biological heating	2019-2020
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Cardiovascular Systems, Inc. \$13k for thermal model of blower impellor for a dialysis pump \$9k for thermal model of blower impellor for a dialysis pump \$4k for thermal model of blower impellor for a dialysis pump \$20k for flow model of blower impellor for a dialysis pump \$5k for flow model of blower impellor for a dialysis pump	2019-2021
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ALS Consulting \$15k for thermal model of power plant	2019
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Medivators	2019
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\$12k for thermal model of thermal sterilization	
Marvin Windows	2019-2022
\$4k for thermal analysis of a tiny home	
\$5k for thermal model of manufacturing line	
\$4k for thermal model of manufacturing line	
Medtronic	2019
\$22k for simulation of tissue temperatures during transcutaneous recharge	
\$25.5k for simulation of tissue temperatures during transcutaneous recharge	
Medivators	2018
\$18k to research airflow in medical sterilization equipment.	
Marvin Windows	2018-2020
\$6k to research thermal processes during window ventilation	
\$4k to research thermal processes of natural lighting	
\$4k to research thermal processes of natural lighting	
Medtronic	2018
\$3k to research battery heating rates	
\$8k to research thermal tolerance of brain tissue	
EKOS	2018
\$14k for analysis of flow distribution within stents	
Marcor	2018
\$10k for fluid and heat transfer analysis	
Pride Engineering	2017
\$3k to calculate a metal stamping machine process	
Orbital ATK	2017-2018
\$30k to simulate fluid flow	
\$12k to simulate fluid flow	
Medtronic	2017
\$5k to research thermal tolerance of brain tissue	
\$14k to calculate cranial temperature increases during transcranial recharge	
3M	2017
\$14k to simulate airflow in ultra-clean operating rooms.	
Zoll Engineering	2017
\$5.5k for design of flow through a ventilation medical device	

Cargill	2016-2017
\$14k for analysis of food frier	
\$15k for analysis of a food processing device	
EKOS	2017
\$14k for analysis of flow distribution within stents	
\$14k for analysis of flow distribution within stents	
\$12k for analysis of flow distribution within stents	
ALS Consulting	2016
\$15k for analysis of fluid flow in power plants	
Precision Air	2016
\$1600 for simulation of airflow in operating rooms	
Medtronic	2016
\$12k for simulation of tissue temperatures during transcutaneous recharge	
3M	2015
\$12k to simulate airflow in ultra-clean operating rooms.	
Cardiovascular Systems, Inc.	2015-2016
\$8,000 for the study of deformable arteries	
\$6,000 for biological flows and impellor design	
AF Energy	2015
\$3000 wind turbine calculations	
Intellectual Ventures Laboratory	2015
\$2000 wall condensation calculations	
Medivators	2015
\$4000 for flow and pressure calculations medical chamber.	
Floursecence, Inc.	2015
\$2,000 designing biological heater for cell environments	
Mador Technologies	2015
\$20,000 analyzing a liquid nitrogen water condensation device	
Koronis Biomedical Technologies	2015
\$5,000 simulation of fluid flow	
Mador Technologies	2014-2015
\$8,000 analyzing a liquid nitrogen water condensation device	
National Resources Defense Council	2015

\$10k for climate education work	
Medtronic	2014
\$12k for simulation of tissue temperatures during transcutaneous recharge	
Smiths Medical	2014
\$9.5k for design and optimization of medical warming blankets	
\$10k for the design and improvement of medical fans	
\$12k for the design and analysis of human thermal analogs	
WTS LLC	2014-present
\$1.5m for the design of solar pasteurization systems	
Medivators	2014
\$4000 for flow and pressure calculations medical chamber.	
\$3000 for flow and pressure calculations medical chamber.	
Somnetics	2014
\$6000 for flow and pressure calculations in CPAP devices.	
Lake Region Medical	2013-2014
\$4500 for simulations of a guidewire manufacturing oven	
Amphora Medical	2013-2014
\$55.5k for design of RF probes for ablation of bladder tissue	
ALS Consulting	2013-2014
\$17.5k for analysis of fluid flow in power plants	
Medtronic, Inc.	2012-2013
\$13k for analysis of subdermal heating associated with recharge of neuromodulation systems.	
Phraxis	2013
\$2,250 for the analysis of blood flow through an AV shunt	
Translational Biologic Infusion Catheter	2011-2013
\$21.5k for the study of flow and pressure drop in a stem-cell delivery catheter	
Advanced Circulatory Systems, Inc.	2013
\$4200 for fluid flow modeling of medical-device blowers	
HRST, Inc.	2012-2015
\$11,250 for analysis of flow patterns in manifolds	
Devicix	2012
\$2000 for the analysis of medical-fluid injection devices	
Helical	2012-2013
\$18,200 for the design and analysis of rooftop wind turbines	

QiG Group		2012
	\$7000 for study of thermoelectric technologies to power implants	
HRST, Inc.		2012
	\$4300 for analysis of perforated plates for flow uniformity	
Energy Foundation		2012-2013
	\$30k developing climate-science communication strategies	
CriticCare		2012
	\$4,275 for numerical modeling of accelerated aging of medical devices.	
HRST, Inc.		2012
	\$5,540 for research study on mixing efficiency in heat recovery plants.	
Windstrip, LLC		2009-2013
	\$1m for development of vertical axis wind turbines to power cellular communication equipment.	
QiG Group		2011-2012
	\$20k for study of implant heating of biological tissue	
Phraxis		2011-2012
	\$8,000 for the analysis of blood flow through an AV shunt	
Energy Foundation		2011-2012
	\$71k developing climate-science communication strategies	
Cardiovascular Systems, Inc.		2011
	\$23k for the study of paclitaxel distribution techniques.	
Cardiovascular Systems, Inc.		2011
	\$5,000 for the study of temperature management in palletted products	
Galil Medical		2011
	\$9,000 for the kidney tumor cryosurgical devices.	
Multiple groups		2010
	\$13,000 for installation of solar panels in Uganda	
Imation		2010
	\$10k for the design of a polymeric extrusion die	
Cypress Wind		2010
	\$30.6k for the development of a vertical axis, small-footprint wind turbine.	
Cypress Wind		2009
	\$27k for the development of a vertical axis, small-foorprint wind turbine.	
Cardiovascular Systems, Inc.		2009
	\$80k for the study of cavitation and bolus formation during orbital atherectomy procedures.	

Medtronic, Inc.	
\$65k for analysis of subdermal heating associated with recharge of neuromodulation systems.	2008-2011
University of St. Thomas Faculty Development Grant	2009
\$4,200 for the purchase of a high-performance computer for numerical simulations.	
CSUMS: A computational Training and Interdisciplinary Research Program for Undergraduates in the Mathematical Sciences at the University of St. Thomas	2008-2013
Served as Senior Personnel on a \$716,836 NSF award for the development of applied research projects for undergraduates in mathematics.	
Lockheed Martin Innovative Program - Advanced Cooling Technology grant	2009
\$19.5k for the improvements to avionics heat pipe applications.	
Horizontal Winds	2008-2009
\$11k for research on vertical-axis wind turbines	
R4 Engineering	2008-2009
\$10k for analysis of building-support insulation systems	
Lockheed Martin Innovative Program - Advanced Cooling Technology grant	2007
\$53k for the development of advanced electronic-cooling methodologies.	
Arizant Medical	2006
Characterization of a forced-air patient warming device	
Johnson and Johnson, Newark, NJ	2004-2005
Analysis of a uterine fibroid embolization device	
Urologix	circa 2004
Design of thermoelectric device for heating/cooling of urological catheter fluids	
Donaldson Co.	1999-2003
Analysis and characterization of a filter-manufacturing device	
Augustine Medical	2000-2003
Characterization of a forced-air patient warming device	
Midmac Systems Inc.	2002
Thermal analysis of a polymeric sealing machine	
Restore Medical	circa 2002
Characterization of sleep apnea treatment	
Remmele Engineering Inc.	2002-2005
Thermal analysis of a polymeric sealing machine for insulin packaging	
Thermal analysis of liquid-based cold plates for cooling naval radar	
MicroControl Company	Circa 2001

Analysis of burn-in board devices	
Jennio	circa 2001
Analyzed devices that handle, transport, and cool turkey carcasses during processing.	
Caterpillar	circa 2000
Analysis of a screed heating machine	
ADC Telecom	circa 2000
Optimization of an AC/DC power converter	
Entropy Solutions	circa 2000
Design and Analysis of insulation and phase change thermal management for shipping containers	
XeteX, Inc	1996-2000
Design of an air-to-air heat exchanger	
Creation of a film processing machine for coating heat exchangers	
Construction and operation of a full-sized HVAC test facility	
Pneuseal	1996-1998
Operation and optimization of a polymeric sealing device for medical packaging	
Principal Investigator – Supercomputing Institute	2002-2012
Served as PI for multi-year project dedicated to performing computational fluid dynamic studies. This grant awarded computing resources at the Supercomputing Institute for Digital Simulation and Advanced Computing.	
Principal Investigator – ASHRAE Project Grant Program	2003
Awarded a \$5,000 grant funded by ASHRAE to investigate the efficacy of rotating-wheel heat and moisture exchangers.	
Faculty Advisor – Bush Grant, Young Scholars Program	2002
Faculty advisor for a \$3,000 grant for undergraduate research of air-jet heat transfer for surgical applications.	
Faculty Advisor – Bush Grant, Young Scholars Program	2002
Faculty advisor for a \$3,000 grant for undergraduate research to encourage American Indian students to pursue careers in science and technology.	
A Multi-Function Heat Exchanger for Control of Temperature, Moisture, and Air Quality	1997-2000
Project Engineer for \$475K SBIR grants awarded by NSF, grant nos. 9660900 and 9801062	

