

MORRIS R. FLYNN, PH.D., P.ENG.

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Personal & Professional

- **Year of birth:** 1977
- **Citizenship:** Canada & United States
- **Professional standing:** Registered as a Professional Engineer with the Association of Professional Engineers and Geoscientists of Alberta (APEGA)
- **ORCID:** 0000-0002-7559-9463

Academic Work Experience

- **U. Alberta, Dept. of Mechanical Engineering** — Edmonton, AB
Director of First Year Engineering: 2022 - present; Associate Chair: 2017–2020. Full Professor: 2020 - present; Associate Professor: 2014–2020; Assistant Professor: 2008–2014. Adjunct Professor (Dept. of Mathematical and Statistical Sciences): 2019 - present
 - Lead a multifaceted research group that investigates a variety of environmental and industrial fluid mechanics problems.
Major external research support; triangle indicates share of funding for joint grants:
 - * New Frontiers in Research Fund - Exploration (2020-2024): Can *Ephydra thermophila* help us design better pipelines? (PI, \$ 273,175, \$ 150,000[▷])
 - * Canada's Oil Sands Innovation Alliance, COSIA (2020-2021): The role of bubble ebullition on the vertical transport of fine solids in end-pit lakes (PI, \$ 27,285)
 - * U. Alberta Inst. for Oil Sands Innovation, IOSI (2020-2021): The role of bubble ebullition on the vertical transport of fine solids in end-pit lakes (PI, \$ 27,285)
 - * NSERC Discovery (2019-2025): Localized buoyant convection in porous media: plumes and dispersion (PI, \$ 290,006)
 - * NSERC Collaborative Research and Development (2018-2023): Heat pipe design optimization through the application of surface chemical treatments and the adaptation of core annular flow theory (PI, \$ 302,793, \$ 151,397[▷])
 - * Engineered Air (2018-2023): Heat pipe design optimization through the application of surface chemical treatments and the adaptation of core annular flow theory (PI, \$ 240,000, \$ 120,000[▷])
 - * NSERC Engage (2017): Buoyancy-driven flow in porous media: validation of numerical models using novel theoretical results (PI, \$ 25,000)
 - * NSERC Collaborative Research and Development (2017-2022): Design and optimization of cooling towers (co-PI, \$ 480,000, \$ 172,800[▷])
 - * International Cooling Tower Inc. (2017-2022): Design and optimization of cooling towers (co-PI, \$ 240,000, \$ 86,400[▷])
 - * Suncor Energy Ltd. (2016): Pond dynamics simulations (PI, \$ 44,056)
 - * NSERC Engage (2016): Cooling tower plume abatement: combining turbulent plume theory and psychrometrics (PI, \$ 16,279)
 - * NSERC Collaborative Research and Development (2015-2017): Laboratory studies investigating chemical flux across tailings-cap water zones, simulating an end pit lake in the Athabasca oil sands region (co-PI, \$ 585,051, \$ 65,006[▷])

- * NSERC Discovery (2014-2019): Gravity current propagation through density stratified media with applications to transport in the built environment and pollution dispersion in nature (PI, \$ 135,000)
- * Syncrude Canada Ltd. (2014-2016): Laboratory studies investigating chemical flux across tailings-cap water zones, simulating an end pit lake in the Athabasca oil sands region (co-PI, \$ 679,833, \$ 75,537[▷])
- * NSERC Climate Change and Atmospheric Research (2013-2018): Ventilation, interactions and transports across the Labrador Sea (co-PI, \$ 5,000,000, \$ 22,000[▷])
- * NSERC Engage (2013-2014): Oilsand lump digestion in non-aqueous extraction; the design of a large-scale testing facility (PI, \$ 25,000)
- * Carbon Management Canada (2012-2015): Physical-chemical response to geomechanical processes during geologic sequestration of sc-CO₂ (co-PI, \$ 750,000, \$ 59,550[▷])
- * NSERC Strategic Network (2011-2016): Smart net-zero energy buildings research network (co-PI, \$ 7,050,000, \$ 70,000[▷])
- * NSERC Research Tools & Instruments (2011): PIV-LIF system for application in similitude environmental fluid mechanics experiments (co-PI, \$ 81,206, \$ 40,603[▷])
- * NSF (2010-2013): Collaborative research on phantom jams, continuum modeling, and connections with detonation wave theory (international collaborator, \$ 249,765 USD)
- * NSERC Discovery (2009-2014): Temperature stratification effects in low-energy ventilation and temperature control of the built environment (PI, \$ 146,850)
- * NSERC Research Tools & Instruments (2009): Thermal imaging facility (co-PI, \$ 25,967, \$ 6492[▷])

Courses taught, average evaluation score, number of students and times taught:

- * MEC E 230 – Introduction to thermo-fluid sciences [4.7/5, 150, 3]
- * MEC E 371 – Heat transfer [4.7/5, 100, 4]
- * MEC E 390 – Numerical Methods [4.7/5, 100, 9]
- * MEC E 430 – Fluid Mechanics II [4.8/5, 100, 11]
- * MEC E 630 – Graduate Fluid Mechanics [4.8/5, 30, 8]
- * MEC E 636 – Graduate Environmental Fluid Mech. (self-developed) [4.9/5, 15, 6]
- * ENGG 600 – Engineering Ethics and Professionalism [N.A., 280, 2]
- * 2010 workshop on academic integrity and research ethics (self-developed) [N.A., 35, 1]
- * 2012 PIMS Fluids Dynamics Summer School (lecturer and experimental laboratory coordinator) [N.A., 20, 1]

Awards:

- * Confederation of Alberta Faculty Associations (CAFA) Distinguished Academic Early Career Award, 2013
- * Faculty of Engineering Undergraduate Teaching Award, 2010, 2015, 2018
- * Faculty of Engineering Graduate Teaching Award, 2021

Most significant service contributions (U. Alberta):

- * Dean selection committee (Faculty of Engineering, 2023)
- * (Inaugural) Director of First Year Engineering, Faculty of Engineering (2022-present)
- * 4th Year academic advisor, Dept. of Mechanical Engineering (2021-2023)
- * Academic Planning Committee, Dept. of Mechanical Engineering (2017-2018, 2021-2023)
- * Associate Chair (Graduate), Dept. of Mechanical Engineering (2017-2020)
- * Council of the Faculty of Graduate Studies and Research (2017-2020)
- * Graduate Program Committee, Faculty of Engineering (2017-2020)
- * Chair selection committees (Dept. of Civil and Environmental Engineering, 2016-2017; Dept. of Mechanical Engineering, 2020-21)
- * 2nd Year academic advisor, Dept. of Mechanical Engineering (2015-2017)
- * Faculty Evaluation Committee, Faculty of Engineering (2014-2015)
- * Graduate Program Committee, Dept. of Mechanical Engineering (2012-2013, 2015-2020)
- * Faculty hiring committees (Dept. of Mathematical and Statistical Sciences, 2008-2010; Dept. of Civil and Environmental Engineering, 2009-2011; Dept. of Mechanical Engineering, 2011-2012; Dept. of Chemical and Materials Engineering, 2013)
- * Founder and organizer/fundraiser of the interdepartmental Theoretical and Applied Mechanics Seminar (2009-2011); chair of the Dept. of Mechanical Engineering Seminar organizing committee (2012-2014)

Most significant service contributions (industry):

- * Member of two Subject Matter Experts Groups for the Syncrude Canada Ltd. Base Mine Lake project (2014-2021)

Most significant service contributions (other):

- * Member, APS-DFD External Affairs Committee (2023-present)
- * Graduate program evaluator, Western U., Dept. of Mechanical and Materials Engineering (2021)
- * Award adjudicator for the Alberta Science and Technology Leadership (ASTech) Foundation (2017)
- * Co-organizer of the 2016 Cdn. Applied and Industrial Mathematics Society Annual Meeting (2015-2016)

Education and Training

- **Postdoctoral fellow (Applied Mathematics)** — Massachusetts Inst. of Technology
2007–2008
 - Performed a theoretical investigation of water-repellence as exploited by aquatic arthropods in underwater breathing. Conducted experiments studying the conversion of the barotropic to the baroclinic tide. Examined mathematical models of traffic flow.
- **Ph.D. Engineering Science (Mechanical Engineering)** — U. California, San Diego
2003–2006
 - *Thesis title:* Buoyancy and stratification in Boussinesq flow with applications to natural ventilation and intrusive gravity currents (Supervisors: P. F. Linden, FRS & C. P. Caulfield)

- **M.Sc. Applied Mathematics** — U. Alberta
2001–2003
 - *Thesis title*: Fluid intrusions and internal gravity wave forcing in stratified media
(Supervisor: B. R. Sutherland)
- **B.Sc. Chemical Engineering (Co-op, with Distinction)** — U. Alberta
1995–2000

Scientific Contribution

- **Refereed publications** (students' names in boldface text)
 1. Shojaee, S. A. and MRF, 2024: On the efficacy of surface-attached air bubbles as thermal insulators for pressure-driven internal flow. *J. Fluid Mech.*, accepted.
 2. **Sheikhi, S.** and MRF, 2024: Porous media gravity current flow over an interbed layer: the impact of dispersion and distributed drainage. *J. Fluid Mech.*, **984**, A33.
 3. **Kumar, V., Rahman, M. R.** and M. R. Flynn, 2024: On the hydrostatic limit for thin film flow with applications to thermosyphons. *Appl. Therm. Eng.*, **245**, 122869.
 4. **Piminchumo Sausa, A. R., Li, S., Kaye, N. B.** and MRF, 2024: The coalescence of adjacent turbulent plumes in a stratified and unstratified environment. *Env. Fluid Mech.*, accepted.
 5. **Sheikhi, S., Sahu, C. K.** and MRF, 2023: Dispersion effects in porous media gravity currents experiencing local drainage. *J. Fluid Mech.*, **975**, A18.
 6. **Bui, D., Favell, J., Kitova, E., Li, Z., McCord, K., Schmidt, E., Mozaneh, F., Elaish, M., El-Hawiet, A., St-Pierre, Y., Hobman, T., Macauley, M., Mahal, L., MRF and J. Klassen,** 2023: Absolute affinities from quantitative shotgun glycomics using concentration-independent (COIN) native mass spectrometry. *ACS Cent. Sci.*, **9**(7), 1374-1387.
 7. **Khan, M.I., Bharath, K.S.** and MRF, 2023: Effect of buoyant convection on the spreading and draining of porous media gravity currents along a permeability jump. *Transp. Porous Med.*, **146**, 721–740.
 8. **Zargar, A., Vickers, B., MRF and M. Secanell,** 2023: A hybrid cooling tower model for plume abatement and performance analysis. *Appl. Therm. Eng.*, **219**, 119593.
 9. **Zargar, A., Kodkani, A., Peris, A., Clare, E., Karupothula, P., Vickers, B., MRF and M. Secanell,** 2022: Numerical analysis of a counter-flow wet cooling tower and its plume. *Intl J. Thermofluids*, **14**, 100139.
 10. **Sutherland, B. S., Ma, Y., MRF, Frank, D., Linden, P. F., Lemasquerier, D., Le Bars, M., Pacary, C., Jamin, T., Dauxois, T. and S. Joubaud.,** 2021: Plumes in rotating fluid and their transformation into tornados. *J. Fluid Mech.*, **924**, A15.
 11. **Bharath, K. S.** and MRF, 2021: Buoyant convection in heterogeneous porous media with an inclined permeability jump: An experimental investigation of filling box-type flows. *J. Fluid Mech.*, **924**, A35.
 12. **Li, S.** and MRF, 2021: Boussinesq and non-Boussinesq turbulent plumes in a corner with applications to natural ventilation. *Phys. Rev. Fluids*, **6**, 054503.

13. Li, S. and MRF, 2021: Cooling tower plume abatement and plume modeling: a review. *Environ. Fluid Mech.*, **21**, 521–559.
14. Li, S. and MRF, 2021: Coaxial plumes: theory and experiment. *Intl. J. Heat Mass Transfer*, **174**, 121311.
15. Rahman, M. R., Waghmare, P. R. and MRF, 2021: On the deflection of the liquid-vapor interface in a wicked heat pipe. *Intl. J. Heat Mass Transfer*, **165**, 120638.
16. Rath, A. and MRF, 2020: Core annular flow theory as applied to the adiabatic section of heat pipes. *Phys. Fluids*, **32**, 083607.
17. Li, S. and MRF, 2020: Merging of long rows of plumes: Crosswinds, multiple rows, and applications to cooling towers. *Phys. Rev. Fluids*, **5**, 094502.
18. Baker, M. S., Ungarish, M. and MRF, 2020: Tailwater gravity currents and their connection to perfectly subcritical flow: laboratory experiments and shallow-water and direct numerical solutions. *Environ. Fluid Mech.*, **20**, 1141–1171.
19. Bharath, K. S., Sahu, C. K. and MRF, 2020: Isolated buoyant convection in a two-layered porous medium with an inclined permeability jump. *J. Fluid Mech.*, **902**, A22.
20. Li, S. and MRF, 2020: Merging of two plumes from area sources with applications to cooling towers. *Phys. Rev. Fluids*, **5**, 054502.
21. Kaminski, A. K. and MRF, 2020: Modal decomposition of polychromatic internal wave fields in arbitrary stratifications. *Wave Motion*, **95**, 102549.
22. Li, S. and MRF, 2020: Coaxial plumes in a windy ambient with applications to cooling towers. *J. Wind Eng. Ind. Aerod.*, **196**, 104054.
23. Ma, Y., MRF and B. R.. Sutherland, 2020: Plumes in a rotating two-layer stratified fluid. *Environ. Fluid Mech.*, **20**, 103–122.
24. Nazari-poor, H., MRF, Koch, C. R. and M. Sadrzadeh, 2018: Thermally induced interfacial instabilities and pattern formation in confined liquid nanofilms. *Phys. Rev. E*, **98**, 043106.
25. Li, S., Moradi, A., Vickers, B. and MRF, 2018: Cooling tower plume abatement using a coaxial plume structure. *Int. J. Heat Mass Transfer*, **120**, 178–193.
26. Nieuwenhuis, R., Kubota, M., MRF, Kimura, M., Hikihara, T. and V. Putkaradze, 2018: Dynamics regularization with tree-like structures. *Appl. Math. Model.*, **55**, 205–223.
27. Sahu, C. K. and MRF, 2017: The effect of sudden permeability changes in porous media filling box flows. *Transp. Porous Med.*, **119**, 95–118.
28. Paxman, D., Trottier, S., MRF, Kostiuik, L. and M. Secanell, 2017: Experimental and numerical analysis of a methane thermal decomposition reactor. *Intl. J. Hydrogen Energy*, **42**, 25166–25184.
29. Ma, Y., MRF and B. R. Sutherland, 2017: Convection from a line-source into a two layer stratified ambient fluid. *J. Fluid Mech.*, **818**, 46–67.

30. Moradi, A. and MRF, 2017: Emptying filling boxes – free turbulent versus laminar porous media plumes. *J. Fluid Mech.*, **817**, 490–513.
31. Sahu, C. K. and MRF, 2016: Filling box flows in an axisymmetric porous medium. *Transp. Porous Med.*, **112**, 619–635.
32. Nicholson, M. and MRF, 2015: Gravity current flow over sinusoidal topography in a two-layer ambient. *Phys. Fluids*, **27**, 096603.
33. Polet, D. T., MRF and F. A. H. Sperling, 2015: A mathematical model to capture complex microstructure orientation on insect wings. *PLoS One*, **10**(10): e0138282.
34. Sahu, C. K. and MRF, 2015: Filling box flows in porous media. *J. Fluid Mech.*, **782**, 455–478.
35. Nabi, S. and MRF, 2015: Buoyancy-driven exchange flow between two adjacent building zones connected with top and bottom vents. *Building and Environment*, **92**, 278–291.
36. Marleau, L. J., MRF and B. R. Sutherland, 2015: Gravity currents propagating up a slope in a two-layer fluid. *Phys. Fluids*, **27**, 036601.
37. Sahuri, R. M., Kaminski, A. K., MRF and M. Ungarish, 2015: Axisymmetric gravity currents in two-layer density-stratified media. *Environ. Fluid Mech.*, **15**, 1035–1051.
38. Roes, M. A., Bolster, D. and MRF, 2014: Buoyant convection from a discrete source in a leaky porous medium. *J. Fluid Mech.*, **755**, 204–229.
39. Marleau, L. J., MRF and B. R. Sutherland, 2014: Gravity currents propagating up a slope. *Phys. Fluids*, **26**, 046605.
40. Nabi, S. and MRF, 2014: Influence of geometric parameters on the eventual buoyancy stratification that develops due to architectural exchange flow. *Building and Environment*, **71**, 33–46.
41. Seibold, B., MRF, Kasimov, A. R. and R. R. Rosales, 2013: Constructing set-valued fundamental diagrams from jamiton solutions in second order traffic models. *Networks and Heterogeneous Media*, **8**(3), 745–772.
42. Bhattacharya, S., Craster, R. V. and MRF, 2013: Buckling of a thin, viscous film in an axisymmetric geometry. *Phys. Fluids*, **25**, 043102.
43. Bellino, P. W., Rangwalla, A. S. and MRF, 2013: A study of *in situ* burning of crude oil in an ice channel. *Proc. Comb. Inst.*, **34**, 2539–2546.
44. Nabi, S. and MRF, 2013: The hydraulics of exchange flow between adjacent building zones. *Building and Environment*, **59**, 76–90.
45. Bellino, P. W., MRF and A. S. Rangwalla, 2013: A study of spreading of crude oil in an ice channel. *J. Loss Prevention in the Process Industries*, **26**(3), 558–561.
46. MRF, Ungarish, M. and A. W. Tan, 2012: Gravity currents in a two-layer stratified ambient: the theory for the steady-state (front condition) and lock-released flows, and experimental confirmations. *Phys. Fluids*, **24**, 026601.

47. McHale, G., MRF, and M. I. Newton, 2011: Plastron induced drag reduction and increased slip on a superhydrophobic sphere. *Soft Matter*, **7**, 10100–10107.
48. **Tan, A. W.**, Nobes, D. S., Fleck, B. A. and MRF, 2011: Gravity currents in two-layer stratified media. *Environ. Fluid Mech.*, **11**(2), 203–224. (See also erratum published in *Environ. Fluid Mech.*, **11**(2), 225–231.)
49. Bosak, T., Bush, J. W. M., MRF, **Liang, B.**, **Ono, S.**, **Petroff, A. P.** and M. S. Sim, 2010: Formation and stability of oxygen-rich bubbles that shape photosynthetic mats. *Geobiology*, **8**, 45–55.
50. Kaye, N. B., MRF, Cook, M. J. and Y. Ji, 2010: The role of diffusion on the interface thickness in a ventilated filling box. *J. Fluid Mech.*, **652**, 195–205.
51. **Echeverri, P.**, MRF, Peacock, T. and K. B. Winters, 2009: Low-mode internal tide generation by topography: an experimental and numerical investigation. *J. Fluid Mech.*, **636**, 91–108.
52. MRF, Kasimov, A. R., Nave, J.-C., Rosales, R. R. and B. Seibold, 2009: Self-sustained nonlinear waves in traffic flow. *Phys. Rev. E*, **79**, 056113.
[Research featured in *Wired*, *The Financial Times*, *The National Post* and selected by *Discover magazine* as one of the top 100 science news stories of 2009]
53. MRF and C. P. Caulfield, 2009: Effect of volumetric heat sources on hysteresis phenomena in natural and mixed-mode ventilation. *Building and Environment*, **44**, 216–226.
54. MRF, **Boubarne, T.** and P. F. Linden, 2008: The dynamics of steady, partial-depth intrusive gravity currents. *Atmosphere-Ocean*, **46**, 421–432.
55. MRF and J. W. M. Bush, 2008: Underwater breathing: the mechanics of plastron respiration. *J. Fluid Mech.*, **608**, 275–296.
[Research featured in *The New York Times*, *The Boston Globe*, *The Globe and Mail*, *CBC Radio*, *news.nationalgeographic.com* and the popular science book *Nasty, Brutish and Short: The Quirks & Quarks Guide to Animal Sex and Other Weird Behaviour*]
56. MRF and P. F. Linden, 2006: Intrusive gravity currents. *J. Fluid Mech.*, **568**, 193–202.
57. MRF and C. P. Caulfield, 2006: Natural ventilation in interconnected chambers. *J. Fluid Mech.*, **564**, 139–158.
58. Sutherland, B. R., MRF and K. Dohan, 2004: Internal wave excitation from a collapsing mixed region. *Deep-Sea Res. II*, **51**, 2889–2904.
59. MRF and B. R. Sutherland, 2004: Intrusive gravity currents and internal gravity wave generation in stratified fluid. *J. Fluid Mech.*, **514**, 355–383.
60. Sutherland, B. R., Kyba, P. J. and MRF, 2004: Intrusive gravity currents in two-layer fluids. *J. Fluid Mech.*, **514**, 327–353.
61. MRF, Onu, K. and B. R. Sutherland, 2003: Internal wave excitation by a vertically oscillating sphere. *J. Fluid Mech.*, **494**, 65–93.
62. Onu, K., MRF and B. R. Sutherland, 2003: Schlieren measurement of axisymmetric internal wave amplitudes. *Experiments in Fluids*, **35**, 24–31.

63. Sutherland, B. R., MRF and K. Onu, 2002: Schlieren visualisation and measurement of axisymmetric disturbances. *Nonlin. Proc. Geophys.*, **10**, 303–309.
 64. MRF, Bara, B., Czarnecki, J. and J. Masliyah, 2001: An investigation of the effect of air addition during oilsand conditioning. *Can. J. Chem. Eng.*, **79**, 468–470.
- **Conference proceedings** (students' names in boldface text)
 1. **Baker, M. S.**, MRF and M. Ungarish, 2019: Perfectly subcritical gravity currents: laboratory and numerical experiments and two-layer shallow water solutions. *Proceedings of the Joint Canadian Society for Mechanical Engineering and CFD Society of Canada International Congress 2019 (CSME-CFDSC Congress 2019)*, London, ON, June 2–5, 2019 (peer-reviewed).
 2. **Clare, E.**, MRF, Secanell, M. and B. Vickers, 2019: An experimental cooling tower model for performance evaluation and 3D airflow measurement. *Proceedings of the Joint Canadian Society for Mechanical Engineering and CFD Society of Canada International Congress 2019 (CSME-CFDSC Congress 2019)*, London, ON, June 2–5, 2019 (peer-reviewed).
 3. **Wynnychuk, D.**, **Moradi, A.** and MRF, 2018: Porous media filling boxes: the influence of control volume geometry. *Proceedings of the 8th Intl. Symposium on Environmental Hydraulics*, Notre Dame, IN, June 4–7, 2018.
 4. **Li, S.**, **Moradi, A.** and MRF, 2018: Coaxial plume dynamics with applications to visible plume abatement. *Proceedings of the 8th Intl. Symposium on Environmental Hydraulics*, Notre Dame, IN, June 4–7, 2018.
 5. **Wang, Z.**, MRF and C. R. Koch, 2017: Model order reduction and boundary control of incompressible Boussinesq flow. *Proceedings of the 25th Annual Computational Fluid Dynamics Society of Canada (CFDSC) Conference*, Windsor, ON, June 18–20, 2017 (peer-reviewed).
 6. MRF, **Roes, M. A.**, **Sahu C. K.** and D. Bolster, 2016: Buoyant convection from a discrete source in closed and leaky porous media. *Proceedings of the 8th International Symposium on Stratified Flows*, San Diego, CA, Aug. 29–Sept. 1, 2016. Intl. Association for Hydro-Environment Engineering and Research.
 7. **Moradi, A.** and MRF, 2016: Porous media plumes: transient filling box solutions. *Proceedings of the 8th International Symposium on Stratified Flows*, San Diego, CA, Aug. 29–Sept. 1, 2016. Intl. Association for Hydro-Environment Engineering and Research.
 8. **Sahu, C. K.** and MRF, 2015: Buoyancy-driven flows in a confined porous medium. *Proceedings of the 25th Canadian Congress of Applied Mechanics*, London, ON, May 31–June 4, 2015 (peer-reviewed).
 9. **Kubota, M.**, MRF, Hikihara, T. and V. Putkaradze, 2014: Tree-like resonators assembly for broadband energy harvesting. *Proceedings of the ASME 2014 Intl. Conf. on Multibody Systems, Nonlinear Dynamics, and Control (MSNDC)*, Buffalo, NY, Aug. 17–20, 2014 (peer-reviewed).

10. Nabi, S. and MRF, 2013: Architectural exchange flows and their influence on interior temperature stratification and building ventilation. *Proceedings of CLIMA 2013*, Prague, Czech Republic, June 16–19, 2013 (peer-reviewed).
 11. Bhattacharya, S., MRF and R. V. Craster, 2013: On the Stokes-Rayleigh analogy and the buckling of a thin, viscous film in an annular geometry. *Proceedings of the 24th Canadian Congress of Applied Mechanics*, Saskatoon, SK, June 2–6, 2013 (peer-reviewed).
 12. Tan, A. W., Nobes, D. S., Fleck, B. A. and MRF, 2010: Partial depth gravity currents in two-layer stratified media. Part 1: A study of the wave amplitude. *Intl. Conference on Environmental Science and Engineering (ICESE 2010)*, Singapore, Aug. 25–27, 2010.
 13. Kaye, N. B., MRF, Cook, M. and Y. Ji, 2010: The role of turbulent diffusion on thermal comfort in naturally ventilated buildings. *5th Intl. Symposium on Computational Wind Engineering (CWE2010)*, Chapel Hill, NC, May 23–27, 2010. Intl. Assoc. for Wind Engineering.
 14. MRF, Vander Lind, D., Peacock, T. and N. J. Balmforth, 2007: On the low mode structure of internal tides. *5th Intl. Symposium on Engineering Hydraulics*, Tempe, AZ, Dec. 4–7, 2007. Intl. Assoc. of Hydraulic Engineering and Research (peer-reviewed).
 15. MRF and C. P. Caulfield, 2006: Transient blocking in multi-chamber natural ventilation. *6th Intl. Symposium on Stratified Flows*, Perth, Australia, Dec. 10–14, 2006. Intl. Assoc. of Hydraulic Engineering and Research.
 16. MRF and B. R. Sutherland, 2003: Internal wave excitation by gravity currents. *14th Conference on Atmospheric and Oceanic Fluid Dynamics*, San Antonio, TX, June 9–13, 2003. American Meteorological Society.
- **Standalone arXiv.org manuscripts** (student's name in boldface text)
 1. Mayoraz, V. and MRF, 2018: Natural vs. blocked ventilation in naturally ventilated buildings – the effect of finite and decoupled sources. arXiv:1809.05963, Sept. 16, 2018 (58 pages).
 2. MRF, Kasimov, A. R., Nave, J.-C., Rosales, R. R. and B. Seibold, 2008: On “jamitons,” self-sustained nonlinear traffic waves. arXiv:0809.2828, Sept. 17, 2008 (6 pages).
 - **Textbook**
 1. Mmbaga, J. P., Nandakumar, K., Hayes, R. E. and MRF, 2015: *Computational Methods for Engineers – Modeling, Algorithms and Analysis*. Alpha Education Press, 310 pages.
 - **Book chapter**
 1. Kaye, N. B. and MRF, 2012: Flow through buildings. In *Handbook of Environmental Fluid Dynamics, Volume 2: Systems, Pollution, Modeling and Measurements* (editor H. J. S. Fernando). CRC Press, pp. 97–109.
 - **Book review**
 1. MRF, 2010: Review of *An Introduction to Gravity Currents and Intrusions* by M. Ungarish. *J. Fluid Mech.*, **649**, 537–539.

- **Selected technical reports** (students' names in boldface text)
 1. Rahman, M. S. and MRF, 2021. The role of bubble ebullition on the vertical transport of fine solids in end-pit lakes. IOSI project final technical report (31 pages).
 2. Sahu, C. K. and MRF, 2017. Buoyancy-driven flow in porous media: validation of numerical models using novel theoretical results. Prepared for SoilVision Systems Ltd. (17 pages).
 3. MRF, **Balakrishna, S., Mohammed, O., Naikyar, E. and C. Surma**, 2017. A laboratory experimental study of mixing in the vicinity of the Base Mine Lake mudline: implications for cap water turbidity. Prepared for Syncrude Canada Ltd. (24 pages).
 4. MRF and **O. Mohammed**, 2016. Pond dynamics simulations: similitude laboratory experiments of PASS Lake mudline stability. Prepared for Suncor Energy (9 pages).
 5. **Moradi, A.** and MRF, 2016. Plume rise model from multiple cooling towers. Prepared for International Cooling Tower Inc. (31 pages).
 6. MRF and **C. Surma**, 2015. The dynamic viscosity and yield stress of OSPW-diluted FFT collected from Base Mine Lake. Prepared for Syncrude Canada Ltd. (9 pages).
 7. **Bhattacharya, S., Rashid, M. A., MRF and B. A. Fleck**, 2014. Oilsands lump digestion in non-aqueous extraction; bench-top experiments examining solvent transport through compacted oilsands. Prepared for Imperial Oil Ltd. (16 pages).
 8. **Sen, D., MRF and B. A. Fleck**, 2014. Oilsands lump digestion in non-aqueous extraction; design of a large-scale testing facility. Prepared for Imperial Oil Ltd. (20 pages).
 9. MRF, 2011: [TITLE WITHHELD]. Prepared for Syncrude Canada Ltd. (8 pages).
- **Patent and disclosure** (student's name in boldface text)
 1. **Hikihara, T., Kimura, M., Nieuwenhuis, R., MRF and V. Putkaradze**, 2015: Energy harvesting from random forces using tree-like structures. Japanese patent number 2015-212524.A.
 2. **Putkaradze, V., Nieuwenhuis, R., MRF, Kimura, M. and T. Hikihara**, 2013: Energy harvesting with branching structures. Report of invention submitted to TEC Edmonton on 2013/08/01.
- **Software** (student's name in boldface text)
 1. **PlumeAbate** (for International Cooling Tower Inc.) – Matlab[®]-based algorithm that predicts the atmospheric dispersion of the visible/invisible plumes produced by adjacent cooling towers (with **A. Moradi**, 2016).

- **Invited and departmental presentations (since 2010):**

1. Sept. 27, 2017 IUTAM/AMERIMECH Symposium: Dynamics of Gravity Currents (Santa Barbara, CA)
2. May 30, 2017 Dept. of Mech. Eng., U. British Columbia (Vancouver, BC)
3. Dec. 8, 2016 Suncor Energy PASS Technology Development Wkshp. (Calgary, AB)
4. May 3, 2016 Dept. of Applied Mathematics, U. Waterloo (Waterloo, ON)
5. Apr. 22, 2016 Dept. of Mech. Eng., U. Manitoba (Winnipeg, MB)
6. Feb. 18, 2016 Dept. of Mech. and Indus. Eng., Northeastern U. (Boston, MA)
7. Apr. 22, 2015 Schlumberger DBR Technology Center (Edmonton, AB)
8. Jan. 26, 2015 Dept. of Math. & Stat. Sci., U. Alberta (Edmonton, AB)
9. May 22, 2013 Dept. of Mech. and Indus. Eng., U. Toronto (Toronto, ON)
10. Apr. 22, 2013 Dept. of Mech. and Mfg. Eng., U. Calgary (Calgary, AB)
11. Nov. 14, 2012 Dept. of Mathematics, Massachusetts Inst. of Tech. (Cambridge, MA)
12. Nov. 9, 2012 Syncrude Research & Development (Edmonton, AB)
13. May 3, 2012 Dept. of Oceanography, Dalhousie U. (Halifax, NS)
14. Feb. 21, 2012 Dept. of Mech. & Nuclear Eng., Penn State U. (State College, PA)
15. Apr. 28, 2011 B. P. Institute, U. Cambridge (Cambridge, UK)
16. Dec. 17, 2010 Dept. of Mathematics, McGill (Montreal, PQ)
17. Oct. 18, 2010 Inst. of Applied Mathematics, U. British Columbia (Vancouver, BC)

- **Selected contributed presentations (since 2010, triangle indicates online presentation):**

1. Apr. 23, 2023 Canadian Hydrogen Convention (Edmonton, AB) *poster*
2. Sept. 1, 2022 9th Intl. Symposium on Stratified Flows (Cambridge, UK)
3. June 16, 2022[▷] Cdn. Applied & Industrial Maths. Soc., 2022 Annual Meeting (Kelowna, BC)
4. Jan. 11, 2022[▷] Syncrude Base Mine Lake Technical Advisory Panel Workshop (online)
5. Nov. 30, 2021[▷] COSIA/IOSI Knowledge Dissemination Workshop (online)
6. Aug. 31, 2020[▷] InterPore2020 (online)
7. Aug. 13, 2020[▷] Syncrude Base Mine Lake Technical Advisory Panel Workshop (online)
8. Nov. 24, 2019 72nd Meeting of the APS Division of Fluid Dynamics (Seattle, WA)
9. Jan. 22, 2019 Environmental Fluid Dynamics: Confronting Grand Challenges (Les Houches, France) *poster*
10. June 5, 2018 8th Intl. Symposium on Environmental Hydraulics (Notre Dame, IN)
11. Nov. 20, 2017 70th Meeting of the APS Division of Fluid Dynamics (Denver, CO)
12. July 18, 2017 Cdn. Applied & Industrial Maths. Soc., 2017 Annual Meeting (Halifax, NS)
13. May 29, 2017 Cdn. Geophysical Union Annual Mtg. (Vancouver, BC)
14. Jan. 26, 2017 Syncrude Base Mine Lake Technical Advisory Panel Workshop (Edmonton, AB)
15. Aug. 29, 2016 8th Intl. Symposium on Stratified Flows (San Diego, CA)

16. June 27, 2016 Cdn. Applied & Industrial Maths. Soc., 2016 Annual Meeting (Edmonton, AB)
17. Jan. 26, 2016 Syncrude Base Mine Lake Technical Advisory Panel Workshop (Edmonton, AB)
18. Oct. 19, 2015 3rd Annual VITALS Science Meeting (Halifax, NS)
19. May 21, 2015 4th Meeting of the Smart Net-zero Energy Building Research Network (Saskatoon, SK)
20. Nov. 23, 2014 67th Meeting of the APS Division of Fluid Dynamics (San Fran., CA)
21. Oct. 2, 2014 Subsurface Carbon Storage Symposium (Calgary, AB) *poster*
22. June 23, 2014 Cdn. Applied & Industrial Maths. Soc., 2014 Annual Meeting (Saskatoon, SK)
23. Nov. 25, 2013 66th Meeting of the APS Division of Fluid Dynamics (Pittsburgh, PA)
24. July 25, 2013 Complex Fluids & Flows in Industry & Nature II (Vancouver, BC)
25. June 3, 2012[▷] PDE and Modelling of Traffic Workshop (King Abdullah U. of Science and Technology, Saudi Arabia)
26. Apr. 30, 2012 1st Meeting of the Smart Net-zero Energy Building Research Network (Halifax, NS)
27. July 14, 2011 Complex Fluids & Flows in Industry & Nature I (Vancouver, BC)
28. Nov. 23, 2010 63rd Meeting of the APS Division of Fluid Dynamics (Long Beach, CA)
29. June 14, 2010 Wave Phenomena IV (Edmonton, AB)
30. Apr. 6, 2010 Applied Mathematics Inst., U. Alberta (Edmonton, AB)

- **Invited public talk:**

1. Sept. 24, 2015 Get Science R!ght – Town Hall Meeting and Panel Discussion (Edmonton, AB)

- **Journal/conference review** — *ASME J. Fluids Eng.* (1), *Appl. Math. Model*(1), *Appl. Therm. Eng.* (1), *Building and Environment* (3), *Can. J. Civil Eng.* (1), *CSME 2012 Congress* (1), *CSME 2016 Congress* (1), *Chem. Eng. Sci.* (1), *Coast. Eng. J.* (1), *Communications in Nonlinear Science and Numerical Simulation* (1), *Computers and Fluids* (1), *Environ. Fluid Mech.* (12), *European J. Mech. - B/Fluids* (3), *Experiments in Fluids* (1), *Fire Safety J.* (1), *Heat Transfer* (1), *Indoor and Built Environ.* (1), *Int. J. Heat and Mass Transfer* (2), *Int. J. Thermal Sci.* (1), *J. Eng. Mathematics* (1), *J. Fluid Mech.* (44), *J. Fluid Mech. Rapids* (9), *J. Geophys. Res. – Oceans* (2), *J. Hydraul. Eng.* (1), *J. Hydraul. Res.* (1), *J. Insect Physiology* (1), *J. Building Performance Simulation* (1), *J. Roy. Soc. Interface* (3), *Physica-A* (1), *Phys. Rev. Lett.* (1), *Phys. Rev. Fluids* (11), *Phys. Fluids* (7), *Proc. Roy. Soc. A* (1), *Publications of the Astronomical Society of Australia* (1), *Q. J. Roy. Meteorol. Soc.* (1), *Science of the Total Environment* (1), *Transp. Porous Med.* (1), *5th Intl. Symposium on Environmental Hydraulics* (1), *24th Canadian Congress of Applied Mechanics* (2)

- **Grant review** — American Chemical Society Petroleum Research Fund (1), Fonds de recherche du Québec – Nature et technologies (1), King Abdulaziz City for Science and Technology (KACST) Basic/Applied Research Grant Program [administered by the American Association for the Advancement of Science Research Competitiveness Program] (7), Mitacs Elevate (1), NSF CAREER [Integrative Organismal Systems] (1), NSERC Discovery (7), NSERC i2i (1)

- **Tenure/promotion review** — 3 (Canada, Israel, Lebanon)

Other Academic and Industrial Work Experience

- **U. Alberta, Dept. of Mathematical & Statistical Sciences** — Edmonton, AB
Research Assistant: 2001
- **U. Alberta, Dept. of Chemical & Materials Engineering (Syncrude Research Center)** —
Edmonton, AB
Research Assistant: 1998–2000
- **Petro-Canada** — Calgary, AB
Reservoir & Production Engineering Student: 1998
- **Imperial Oil (Esso)** — Judy Creek, AB
Gas Plant Operator: 1997
- **Edmonton Telephones (now Telus)** — Edmonton, AB
Utility Worker: 1995, 1996

Appendix A – Trainee supervision

- **Trainee supervision** — A summary of my supervisory record is given in tables 1, 2 and 3.

Table 1: Graduate student supervision (arranged chronologically by date of admission).

Name	Years	Degree	% Supervision	Present/next position	Research area
Alan Tan	2009-2010	M.Sc.	66% (B.A. Fleck)	Ph.D. student, Nanyang Tech. U.	Rectilinear gravity currents in two-layer stratified media
Saleh Nabi [Sadler scholarship, R.R. Gilpin scholarship]	2009-2014	Ph.D.	100%	Research scientist, Mitsubishi Electronic Research Laboratory (USA)	Buoyancy-driven exchange flow with applications to architectural fluid mechanics
Sanjay Bhattacharya	2010-2012	M.Sc.	100%	Consulting engineer, TEC Edmonton	Buckling of a thin viscous film
Mark Roes	2010-2014	M.Sc.	100%	Technical designer, Bioware	Steady buoyant convection in a ventilated porous medium
Alexis Kaminski [NSERC CGS, QEII scholarship, Walter H. Johns fellowship, CFUW Margaret Brine fellowship]	2010-2012	M.Sc.	100%	Assistant professor, U. California, Berkeley	Modal decomposition of tidal conversion flow
Hiram Villalobos	2012-2012	M.Sc.	100%	Master's student, U. Texas, El Paso	[None selected]
Larissa Marleau	2012-2014	M.Sc.	50% (B.R. Sutherland)	Direct entry officer – pilot, Canadian Forces	Gravity currents on slopes
Chunendra Sahu	2012-2016	Ph.D.	100%	Assistant professor, IIT Kanpur	Buoyant convection in a closed porous medium
Micah Yusuf	2013-2014	M.Eng.	100%	Project engineer, Propak Systems Ltd.	Modeling transport processes related to the non-aqueous extraction of bitumen from oilsand
Zichuan Wang	2013-2016	M.Sc.	50% (C.R. Koch)	Manufacturing engineer, Linamar Corp.	Boundary-actuated control of a heated cavity

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Table 1 – continued from previous page

Name	Years	Degree	% Supervision	Present/next position	Research area
Mitch Nicholson	2013-2015	M.Sc.	100%	Project engineer, International Cooling Tower Inc.	Stratified-ambient gravity current flow over topography
Ali Moradi	2014-2016	M.Sc.	100%	Project engineer, International Cooling Tower Inc.	Transient buoyant convection in a ventilated porous medium
Yongxing Ma	2014-2018	Ph.D.	50% (B.R. Sutherland)	Post-doctoral fellow, Bedford Inst. of Oceanography	Mixing and stratification due to combined horizontal and vertical convection
Shuo Li [CSC scholarship, Doctoral recruitment scholarship]	2016-2020	Ph.D.	100%	Research engineer, Shift Energy Inc.	Novel strategies for cooling tower plume abatement
Lisa Clare	2016-2019	M.Sc.	50% (M. Secanell)	Project engineer, International Cooling Tower Inc.	Design and validation of a model-scale wet/dry cooling tower
Bharath Kattamal.	2017-2021	Ph.D.	100%	Senior CFD analyst, ENA2 Innovative Consulting Inc.	Buoyant convection in porous media: permeability jumps and sloping interfaces
Mitch Baker [QEII scholarship]	2017-2019	M.Sc.	100%	Research engineer, U. Alberta	Perfectly subcritical gravity currents
Aishwarya Rath	2018-2020	M.Sc.	100%	Ph.D. student, Johns Hopkins U.	Using core annular flow theory to model the liquid/vapor flows inside a heat pipe
Aditya Kodkani	2018-2021	M.Sc.	100%	Simulation engineer, Stellantis	1D modeling and optimization of a cooling tower
Vincent Mayoraz (visiting student, EPFL)	2018-2018	M.Sc.	100%	Engineer EPF, Holinger AG	Numerical simulations of naturally-ventilated buildings forced by wind and internal buoyancy
Md. Rishad Rahman [Doctoral recruitment scholarship]	2018-2020	Ph.D.	66% (P. Waghmare)	Ph.D. student, Imperial College London	Optimizing the thermal performance of heat pipes containing a heterogenous wick

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Table 1 – continued from previous page

Name	Years	Degree	% Supervision	Present/next position	Research area
Md. Imran Khan	2018-2022	M.Sc.	100%	Engineer, Acuren Group Inc.	Buoyant convection in porous media: drainage, advection and dissolution
Antonio Peris (visiting student, Universitat Politecnica de Catalunya)	2019-2019	M.Sc.	50% (M. Secanell)	[Unknown]	The impact of environmental and operating parameters on plume abatement
Amgad Bahanan [House of Invention International Scholarship]	2020-2022	M.Sc.	50%	[Unknown]	Hybrid cooling tower optimization
Saeed Sheikhi [Doctoral recruitment scholarship]	2020-present	Ph.D.	100%	-	Numerical simulations of discrete-source buoyant convection in porous media
Vivek Kumar	2021-2023	M.Sc.	50% (P. R. Waghmare)	Ph.D. student, Georgia Tech.	Effect of fill fraction on heat pipe performance
Raihanual Kabir	2021-present	M.Sc.	50% (P. R. Waghmare)	-	Optimizing the thermal performance of heat pipes containing a heterogeneous wick
Govind Kumar	2021	M.Eng.	100%	[Unknown]	Redesigned queen bee shipping box
Dino Niemarlija	2021	M.Eng.	100%	Applications consultant, Ontracks	Examining hydrogen storage solutions in Alberta
Sabyasachi Paul	2023-2024	M.Eng.	100%	[Unknown]	Examining hydrogen storage solutions in Alberta
Omid Jadidi	2024	M.Sc.	100%	-	[Not yet selected]

Table 2: Undergraduate student supervision (arranged chronologically by date of research engagement).

Name	Year(s)	Univ.	% Supervision	Present/next position	Research area
Russell Yurko	2009	Alberta	50% (A. Amirfazli)	[Unknown]	Thin film flow around a sharp corner
Rishad Javadli	2009	Alberta	100%	[Unknown]	Mixing by gravity currents in batch delivery pipeline systems
Mitch Nicholson	2011-2012	Alberta	33% (J. Leonard, S. Yu)	Project engineer, International Cooling Tower Inc.	Permeability and porosity measurements of compost material
Ryan Sahuri [NSERC USRA]	2012	Alberta	100%	Applications and controls engineer, Spartech Manufacturing	Axisymmetric gravity currents in two-layer stratified media
Delyle Polet [NSERC USRA]	2012-2013	Alberta	50% (F. Sperling)	Ph.D. student, U. Calgary	Hydrophobic and aerodynamic influence of hairs on insect wings
Rochelle Nieuwenhuis [NSERC USRA]	2013	Alberta	50% (V. Putkaradze)	Front line supervisor, the Mustard Seed	Energy harvesting by the deflection of leaves due to wind
Lukas Rossato	2013	UFRGS (Brazil)	50% (C.R. Koch)	[Unknown]	Buoyant convection with time-variable forcing along the boundary
Esmatullah Naikyar	2014	Alberta	100%	Founder and CEO, Naik AR Corp.	Laboratory modeling of stratified mixing in an end-pit lake
Christopher Surma	2015	Alberta	100%	M.Sc. student, U. Alberta	Laboratory modeling of stratified mixing in an end-pit lake
Subramaniam Balakrishna [Mitacs Globalink]	2015	NIT Tiruchirappalli (India)	100%	Ph.D. student, U. Michigan	Laboratory modeling of stratified mixing in an end-pit lake
Omar Mohammed	2015-2016	M.Sc.	100%	Associate, Price-Waterhouse-Coopers	Laboratory modeling of stratified mixing in an end-pit lake
Johny Jose [Mitacs Globalink]	2016	IIT Kharagpur (India)	100%	Research engineer, Mercedes-Benz India	Buoyant convection in a nonuniform porous medium
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Table 2 – continued from previous page

Name	Year(s)	Univ.	% Supervision	Present/next position	Research area
Dallyn Wynnychuk	2016-2017	Alberta	100%	M.A.Sc. student, U. Waterloo	Transient buoyant convection in a porous medium of arbitrary dimension
Finn Griggs	2017	Alberta	100%	Pilot-in-training, Canadian Forces	Perfectly subcritical gravity currents
Utkarsh Raj [Mitacs Globalink]	2017	IIT Kharagpur (India)	100%	[Unknown]	Buckling of a non-Newtonian thin viscous film
Harshil Pisavadia	2018	Alberta	100%	M.Sc. student, U. Alberta	Conceptual design of a “convertible” wet-dry cooling tower
Zavier Berti [NSERC USRA]	2021	Alberta	100%	Master’s student, LEGI France	Heat transfer through surface-attached bubbles
Toan Nguyen	2021	Alberta	100%	B.Sc. student, U. Alberta	Online course content (MEC E 371)
Mansimran Singh [NSERC USRA]	2022-2023	Alberta	100%	B.Sc. student, U. Alberta	Dispersion in porous media buoyancy-driven flow
Adolfo Piminchumo [Emerging Leaders in the Americas Program]	2022	Universidad de Ingeniería y Tecnología (Peru)	100%	B.Sc. student, Universidad de Ingeniería y Tecnología, Peru	Merging turbulent plumes
Riley Meister	2023	Alberta	100%	B.Sc. student, U. Alberta	Heat transfer through surface-attached bubbles
Cristian Palacios [Emerging Leaders in the Americas Program]	2023	Universidad de Ingeniería y Tecnología (Peru)	100%	B.Sc. student, Universidad de Ingeniería y Tecnología, Peru	Turbulent plume entrainment

Table 3: Post-doctoral/researcher supervision (arranged chronologically by date of research engagement).

Name	Year(s)	Status	% Supervision	Present/next position	Research area
Deb jyoti Sen	2013-2014	Research engineer	100%	Consulting engineer, TEC Edmonton	Oilsand lump digestion in non-aqueous extraction processes; the design of large-scale laboratory experiments
Chunendra Sahu	2017	Post-doctoral fellow	100%	Assistant professor, IIT Kanpur	Buoyancy-driven flow in porous media: validation of numerical models using novel theoretical results
Lisa Clare	2020	Research engineer	50% (M. Secanell)	Project engineer, International Cooling Tower Inc.	Design and validation of a model-scale wet/dry cooling tower
Aishwarya Rath	2020	Research engineer	50% (P. R. Waghmare)	Ph.D. student, Johns Hopkins U.	Optimizing the thermal performance of heat pipes containing a heterogeneous wick
Md. Shajid Rahman	2020	Post-doctoral fellow	100%	Lecturer, Northeastern Univ. (Vancouver campus)	The role of bubble ebullition on the vertical transport of fine solids in end-pit lakes
Arash Zargar	2021-2022	Research engineer	50% (M. Secanell)	Ph.D. student, U. Toronto	1D modeling and optimization of a cooling tower
Firoozeh Yeganehdoust	2021-2022	Post-doctoral fellow	100%	Post-doctoral fellow, Concordia U., Montréal	Heat transfer through surface-attached bubbles
Amir Shojaee	2023-present	Research engineer	100%	-	Heat transfer through surface-attached bubbles