# FOCUSED STUDY ACTIVITY WORK PLAN

## General Information

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| **Work Plan Unique Identifier:** | *A-MD-2-1718* | |
| **Focused Study Activity Title:** | Atmospheric Process Study – Deposition and Effects | |
| **Focused Study Category:** | Monitoring Design and Method Improvement | |
| **Geographic Location (***choose from drop-down menu. If Project Location is in more than one area choose from second drop-down***)** | Regional Municapility of Wood Buffalo | Remote Sites - Saskatchewan |
| **Monitoring Site(s) Coordinates** *(latitude and longitude)* | See table below | |

Monitoring Sites – Deposition and Effects (2016 – 2017)

| Site ID | Description | CASA Google Earth | | Converted Coordinates | | Passive | PAS-DD | Tree coring | Active | Hg | N+S |
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| *Remote Sites (Helicopter access)* | | | | | | | | | | | |
| JP210 | Baseline SE Near Corner Gordon Lake | 56.2718 | -110.4463 | 56°16'18.42"N | 110°26'46.56"W | Y | | Y | | | |
| JP101 (JPL1) | Jack Pine Low Deposition 1 | 56.5396 | -112.2755 | 56°32'22.5"N | 112°16'31.74"W | Y | | Y | | | |
| AH7 | WBEA map AH7, CASA Map AH8 | 56.8298 | -111.7678 | 56°49'47.34"N | 111°46'4.2"W | Y | | Y | | | |
| JP 309 (AH8-R) | Replacement | 57.1019 | -112.0754 | 57°6'6.78"N | 112°4'31.5"W | Y | | Y | | | |
| JPL7 | Jack Pine Low Deposition 7 | 57.8903 | -111.4352 | 57°53'24.9"N | 111°26'6.78"W | Y | | | | | |
| JPH4 | Jack Pine High Deposition 4 | 57.1198 | -111.4243 | 57°7'11.43"N | 111°25'27.59"W | Y | | | | | |
| JP 212 | New Site as of May 2007 | 57.0539 | -111.4089 | 57°3'14.16"N | 111°24'31.92"W | Y | | Y | | | |
| JPH2 | Jack Pine High Deposition 2 | 56.9096 | -111.5407 | 56°54'34.62"N | 111°32'26.58"W | Y | | | | | |
| AH3 | Aspen High Deposition 3 | 56.6964 | -111.1223 | 56°41'47.1"N | 111°7'20.22"W | Y | | Y | | | |
| JP213 | Jack Pine Meteorological Tower | 57.0473 | -109.7497 | 57°02'50.5"N | 109°44'58.9"W | Y | | Y | | | |
| JP201 | Jack Pine Meteorological Tower | 57.0321 | -113.7355 | 57°01'55.6"N | 113°44'07.9"W | Y | | | | | |
| JP308 | Jack Pine | 57.0850 | -112.8535 | 57°05'06.0"N | 112°51'12.6"W | | | Y | | | |
| JE312 | Jack Pine Edge Plots | | | | | | | Y | | | |
| JP102 | Jack Pine | 56.9096 | -111.5407 | 56°54'34.6"N | 111°32'26.6"W | | | Y | | | |
| JP311 | Jack Pine Meteorological Tower | 56.5645 | -111.9478 | 56°33'52.3"N | 111°56'52.0"W | | | Y | | | |
| JP108 | Jack Pine | 56.7052 | -109.9270 | 56°42'18.6"N | 109°55'37.2"W | | | Y | | | |
| JP316 | Jack Pine Meteorological Tower | 56.3533 | -110.1185 | 56°21'11.8"N | 110°07'06.6"W | | | Y | | | |
| JE337 | Jack Pine Edge Plots | | | | | | | Y | | | |
| JP205 | Jack Pine Meteorological Tower | 57.8378 | -110.4490 | 57°50'16.0"N | 110°26'56.4"W | | | Y | | | |
| *Continuous Sites (road access)* | | | | | | | | | | | |
| AMS1 | Fort McKay | 57.1894 | -111.6405 | 57°11'21.86"N | 111°38'25.81"W | Y | | Y | Y | | |
| AMS 4 | Buffalo Viewpoint | 56.9967 | -111.5926 | 56°59'48.12"N | 111°35'33.36"W | Y | | | Y | | |
| AMS 5 | Mannix | 56.9688 | -111.4820 | 56°58'7.68"N | 111°28'55.2"W | Y | Y | | | | |
| AMS 6 | Patricia McInnes | 56.7514 | -111.4766 | 56°45'4.99"N | 111°28'35.75"W | Y | Y | Y | | Y | |
| AMS9 | Barge Landing | 57.1982 | -111.5996 | 57°11'53.52"N | 111°35'58.56"W | Y | Y | | | | |
| AMS 11 | Lower Camp | 57.0269 | -111.5007 | 57°1'36.73"N | 111°30'2.7"W | Y | | | Y | | |
| AMS13 | Syncrude UE-1 | 57.1492 | -111.6424 | 57°8'57.12"N | 111°38'32.64"W | Y | Y | | | Y | |
| AMS 14 | Anzac | 56.4489 | -111.0381 | 56°26'56"N | 111°2'17"W | Y | Y | | | | |
| AMS 17 | Wapasu | 57.2592 | -111.0386 | 57°15'33.1"N | 111°02'18.9"W | | | | Y | | |
| AMS 18 | Conklin | 55.6323 | -111.0789 | 55°37'56.4"N | 111°04'43.9"W | | | | Y | | |
| *CAPMoN* | | | | | | | | | | | |
| PHL | Pinehouse Lake, SK | 55.5122 | -106.7245 | 55°30'43.9"N | 106°43'28.2"W | | | | | | Y |
| FLV | Flat Valley, SK | 54.2946 | -109.2092 | 55°17'40.6"N | 109°12'33.1"W | | | | | | Y |

* PACs are monitored at Passive, PAS-DD, tree coring and Active site
* Active sampling at AMS4 to begin in 2017/18 and active sampling at AMS5 to end in 2017/18.

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| **Responsible Manager(s):** | Stewart Cober<br>Jaime Dawson |
| **Organization and contact information:** | Environment and Climate Change Canada (ECCC)<br>Air Quality Processes Research Section, Air Quality Research Division (AQRD), Atmospheric Science and Technology Directorate (ASTD)<br>4905 Dufferin Street, Toronto ON M3H 5T4<br>stewart.cober@canada.ca; tel. 416-739-4618<br>jaime.dawson@canada.ca; tel. 905-336-4883 |
| **Date Study initiated:** | November 2010: passive and active measurements<br>February 2015 (Pinehouse Lake, SK), February 2016 (Flat Valley, SK): Nitrogen (N) + Sulphur (S) measurements<br>April 2015: Inferential deposition modelling |
| **Monitoring Category:**<br>*(From OSM long-term plan; choose from drop-down menu)* | Atmospheric Monitoring |
| **Strategic Objective of Focused Study:** *(From OSM long-term plan; choose from drop-down menu)* | Objective A2: Detect and report levels and trends of oil sands related chemical substances being deposited from the atmosphere |
| **Hypotheses:**<br>*(Briefly outline the specific hypotheses that your focused study is aiming to address)* | Under this work plan, several projects investigating deposition from air in the oil sands (OS) region were combined into a single integrated project. This work to be carried out under the 'Deposition and Effects' work plan will contribute to and inform the 'Integrated Deposition Monitoring Design' project (A-PD-6-1718) that will be initiated in 2017/18 and will support the 'Causes and effects of atmospheric deposition of multiple pollutants' Synthesis Report planned for 2020-21 (under the R-1-1718 'Air Evaluation, Integration, Synthesis and Reporting' work plan).<br><br>***Component 1 of 5 - Passive monitoring of PACs in air:***<br><br><u>Monitoring Design and Method Improvement</u><br>*H1) Passive air monitoring for PACs (Polycyclic Aromatic Compounds) at sites across the oil sands region combined with dispersion/inferential modeling can be used to generate maps of PAC deposition from air across the oil sands region in space and time*<br>*H2) Recently developed passive dry deposition samplers (PAS-DD) complement the data obtained from conventional PUF (polyurethane foam) disk type samplers and provide a comparable and direct measure of dry deposition that can be evaluated against model results*<br>*H3) Petcoke contributes significantly to PAC levels in air (and deposition) across the oil sands region*<br>*H4) PAC transformation products (e.g. oxy- and nitro-PAHs* |

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| | *(polycyclic aromatic hydrocarbons)) are produced in the atmosphere of the oil sands region and are more widely distributed (away from the oil sands region) compared to parent PACs*<br><br><u>Investigation of Cause or Potential Ecological Impact</u><br>*H5) PAC transformation products result in enhanced in-vitro toxicity of air samples*<br><br><u>Study to Reconstruct a Historical Environmental State</u><br>*H6) Tree cores can be used to reconstruct historical trends for PACs in air across the oil sands region, including the pre-mining period, and to delineate the spatial range of the impacted region*<br><br>***Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter (PM); PM2.5 speciation, VOCs (volatile organic compounds), polar and sulphur-containing VOCs) in air:***<br><br><u>Monitoring Design and Method Improvement</u><br>*H1) The geographical distribution and number of the active air monitoring sites for enhanced deposition can be used to collect ambient data of the targeted pollutants and generate deposition estimates*<br>*H2) Analytical methodologies will identify and detect potential chemical markers such as quinones and naphthenic acids, and can be used to derive ambient data for these new chemicals for later use in emission source attributions*<br><br><u>Study to Establish the Current Environmental State</u><br>*H3) Long term comprehensive multi-pollutant (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter; PM2.5 speciation, VOCs, polar and sulphur-containing VOC measurements will provide the data needed to fully assess the predominant primary emission sources impacting local and regional air quality including transport, transformation and deposition of target pollutants*<br>*H4) The active air monitoring data of targeted pollutants at selected sites across the oil sands combined with dispersion/inferential modeling will provide effective maps of atmospheric pollutant deposition across the region in space and time*<br>*H5) Petroleum coke dust is a source of PACs and metals in the oil sands region*<br>*H6) PACs transformation products (e.g., quinones) are produced in the atmosphere of the oil sands*<br>*H7) Naphthenic acids are present in ambient particulate matter in the oil sand region*<br><br>***Component 3 of 5 – Mercury air sampling and deposition:***<br><br><u>Investigation of Cause or Potential Ecological Impact</u><br>*H1) Atmospheric mercury levels in the oil sands region are impacted* |

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| | *by both industrial activities and natural emissions (e.g., forest fires). Differentiating the sources of mercury deposited from the atmosphere between these sources will improve understanding of overall impact of mercury deposition in the oil sands region*<br>*H2) Differences in land use affect the mercury cycle in the oil sands region*<br><br>Monitoring Design and Method Improvement<br>*H3) Atmospheric mercury monitoring and mercury in wet deposition sampling combined with improved modeling capabilities can be used to improve understanding of the mercury cycle in the oil sands region.*<br><br>***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites***<br><br>Investigation of Cause or Potential Ecological Impact<br>H1) *Industrial emissions from the oil sands region (i.e., $NO_x$ (nitrogen oxide), and $SO_2$ (sulfur dioxide)) can undergo long-range transport and transformation and impact ecosystems at significant distances downwind of emission sources*<br><br>***Component 5 of 5 - Inferential modelling of atmospheric deposition***<br>Monitoring Design and Method Improvement<br>*H1) Dispersion modeling combined with monitoring data can be used to generate gridded concentrations in air for a variety of pollutants (e.g. PACs, elements, N and S) in the oil sands region, which will then improve the accuracy of deposition maps based on inferential modeling* |
| **Deliverables:**<br><br>*What tangible goal (s) and/or product(s) will the monitoring produce and when?* | The following details deliverables are to be achieved in 2017/2018. Progress will be summarized in quarterly interim reports. Deliverables are presented looking forward to 2018/19 and 2019/20 and are based on projected activities at the present time. On an annual basis, updated deliverables and budget estimates will be provided depending on the previous years' progress and new science questions that arise.<br><br>***Component 1 of 5 - Passive monitoring of PACs in air:***<br>2017/2018:<br>D1) Improved estimates of the atmospheric deposition of PACs across the region (1 publication in 2017-18)<br>D2) Assessment of the performance of PAS-DD samplers against PUF disk samplers and evaluation of the contribution of petcoke dust to PAC levels in air (1 publication in 2017-18)<br>D3) New information on the seasonality, spatial distribution, and in-vitro toxicity of PAC transformation products and passive air samples (PUF disk versus PAS-DD sampler) (1 publication in 2017-18)<br>D4) Historical trends of PACs in air across the oil sands region based on the analysis of tree rings (1 publication in 2017-18) |

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| | D5) Continued sample collection at 18 sites in 2017-18. Samples from 5 sites will be processed while remaining 13 sites will be archived for possible future analysis<br>D6) Support ecosystem effects and biodiversity program through passive air sampling at pond study sites – link to WL-IC-11-1718, (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health)<br><br><u>2018/19 and 2019/20:</u><br>D7) Assessing metals deposition across the oil sands region using PUF disk passive air samplers deployed at ~18 sites (based on methods currently being developed within ECCC-ASTD). Linkages to other deposition studies (e.g., snow, peat) and biodiversity studies (2017 to 2020 with 1-2 papers during this period)<br>D8) Enhanced toxicity indicator mapping using passive air samplers for PACs and metals coupled with in vitro methods (based on improved assays currently being tested/developed with Health Canada under CCAP (Climate Change and Air Pollution)) (1-2 publications in 2018 to 2020)<br>D9) Support ecosystem effects and biodiversity program through passive air sampling for PACs and possibly metals (see D7) (2018 to 2020)<br>D10) Assessing PAC long term trends in air across the oil sands region from 2011 to 2018, based on passive air samples (1 publication in 2019/20)<br>D11) Tree coring survey #2 (follow-up to the 2015 survey and paper from 2017) to delineate spatial trends of PACs in air. Survey #2 will address limitations realized from Survey #1 (e.g., detection issues) (2018 to 2020)<br><br>***Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter; PM2.5 speciation, VOCs, polar and sulphur-containing VOCs) in air:***<br><u>2017/2018:</u><br>D1) Fully functional network of five enhanced deposition site (NOTE: It is recommended to keep AMS11 (Atmospheric Monitoring Site) while AMS4 is being prepared. AMS4 is now replacing AMS5. It is recommended to have overlap for AMS4 and AMS11.)<br>D2) Improved estimates of the atmospheric deposition of selected pollutants across the region (1-2 publications)<br>D3) New information on the sources and spatial distribution of metals and PACs (2 publications)<br>D4) Assessing the impact of petroleum coke dust on PACs and metals (vanadium) levels in the oil sand region (1 publication)<br>D5) New information on characterization of PACs and their transformation to the corresponding quinones (2 publications)<br>D6) New information on characterization of classical naphthenic acids in PM (1 publication) |

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| | 2018/19 and 2019/20:<br>D7) Continue monitoring of targeted multi pollutants at the five active enhanced deposition sites. Note: guidance for the number of sites required for the longer term will be provided by the PACs air synthesis report in 2017/18 under work plan R-1-1718.<br>D8) Examine long-term trends of PACs and metals from 2011 to 2018, based on active air samples (1-2 papers). Linkages to other deposition studies (e.g. snow, peat) and biodiversity studies.<br>D9) Examine long-term trends of PM2.5 and its chemical components, and VOCs based on active air samples (1-2 papers)<br>D10) Support ecosystem effects and biodiversity program through active air sampling (2018 to 2020)<br><br>***Component 3 of 5 – Mercury air sampling and deposition:***<br>2017/2018:<br>D1) QC/QA TGM (Total Gaseous Mercury) data for Fort McMurray – Patricia McInnes station (AMS 6) through 2017<br>D2) QC/QA TGM data for Fort McKay South (AMS 13) through 2017<br>D3) QC/QA Speciated Hg (Mercury) data for Fort McKay South (AMS 13) through 2017<br>D4) Install 2 mercury wet deposition collector samplers (under and outside the forest canopy) to quantify the amount of mercury deposited to the ground and collected in the forest. QC/QA (Quality Controlled/Quality Assured) Hg in wet deposition data for Fort McKay South (AMS 13) through 2017<br><br>2018/19 and 2019/20:<br>D5) QC/QA TGM data for Fort McMurray – Patricia McInnes station (AMS 6) through 2018<br>D6) QC/QA TGM data for Fort McMurray – Patricia McInnes station (AMS 6) through 2019<br>D7) QC/QA TGM data for Fort McKay South (AMS 13) through 2018<br>D8) QC/QA TGM data for Fort McKay South (AMS 13) through 2019<br>D9) QC/QA Speciated Hg and wet deposition data for Fort McKay South through 2018<br><br>***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites***<br>D1) Deliver quality controlled dataset for the 2016 measurements conducted at the Flat Valley and Pinehouse Lake sites<br>D2) Quantify the contribution of measured NO (Nitrogen Oxide), $NO_2$ (Nitrogen Dioxide), $NO_y$ (total of oxidized forms of nitrogen), and $NH_3$ (ammonia) to dry and total deposition of N; thus, providing the necessary estimation of the N deposition input at these Ecosystem and Transformation sites (Timeline: 2017/18 to 2018/19+ after the collection of 2-5 years of data)<br>D3) Quantify the contribution of long-range /transboundary transport of oil sands emissions versus other emission sectors to N and S dry and total deposition in northwestern Canada and in particular over sensitive ecosystems located at long distances from |

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| | the emission areas<br>(Timeline: 2017/18 to 2018/19+ after the collection of 2-5 years of data)<br>D4) Examine trends of nitrogen and sulphur species air concentrations and deposition in light of the potential expansion of industrial activities in western Canada<br>(Timeline: 2017/18 to 2025/26; i.e., after the collection of 7-10 years of data)<br>D5) Develop and evaluate chemical transport models (GEM-MACH (Global Environmental Multi-Scale – Modelling Air quality and CHemistry)) needed to interpolate between measurement sites<br>(Timeline: Ongoing as data is made available)<br>D6) Compare against satellite (TES (Technology Experiment Satellite), OMI (Ozone Monitoring Instrument), CrIS (Cross-track Infrared Satellite), TROPOMI (TROPOspheric Monitoring Instrument), TEMPO (Tropospheric Emissions: Monitoring of Pollution)) observations of $NO_2$, $NH_3$, and $SO_2$<br>(Timeline: Ongoing as data is made available)<br><br><u>2018/19 and 2019/20:</u><br>In addition to the ongoing activities related to D2-D6<br>D7) Deliver quality controlled dataset for the 2017 measurements conducted at the Flat Valley and Pinehouse Lake sites<br>D8) Deliver quality controlled dataset for the 2018 measurements conducted at the Flat Valley and Pinehouse Lake sites<br><br>***Component 5 of 5 - Inferential modelling of atmospheric deposition***<br><u>2017/2018:</u><br>D1) Concentration maps for PACs across the region (1 publication)<br>D2) Total atmospheric deposition maps for PACs across the region (1 publication)<br>D3) Estimated atmospheric dry deposition for trace metals at the three active sampling sites (1 publication)<br><br><u>2018/19 and 2019/20:</u><br>D4) Publications of deposition estimation for other pollutants in future years<br>D5) Improved results integration and model application with other deposition measurement studies carried out under the oil sands monitoring program |

# Detailed Study Plan

(Please provide detailed information on the specifics of your focused study including – (**keywords, hypothesis and the assumptions and constraints behind your hypothesis**)

**Provide a maximum of 10 key words that describe this project. Use commas to separate them:**

Deposition, oil sands region, PACs, metals, PM, mercury, S and N, particulate matter, inferential modeling, tree cores

**Describe how you will test your hypothesis:**

***Component 1 of 5 - Passive monitoring of PACs in air:***

*H1) Passive air monitoring for PACs at sites across the oil sands region combined with dispersion/inferential modeling can be used to generate maps of PAC deposition from air across the oil sands region in space and time*

Results from passive air sampling for PACs over the period 2012-2015 at 15 to 18 monitoring sites will be analyzed and reported. These data will build on previously published results covering the period November 2010-June 2012 (Harner et al., 2013; Schuster et al., 2015) and will support an improvement to the current deposition modeling approach (Zhang et al., 2015) by combining dispersion modeling and inferential modeling to generate improved estimates of PAC deposition from air across the oil sands region (see component 5 of 5 for details on modeling). Note that starting with the 2016 samples, analysis of PACs will be reduced to the 5 monitoring sites where PAS-DD samplers are co-deployed (i.e., AMS5, AMS6, AMS9, AMS13, and AMS14). Samples will continue to be collected at all 18 sites and the samples that are not analyzed (i.e., from remaining 13 sites) will be archived for possible future analysis. **Linkages:** In 2017/18 passive air sampling will be integrated with ecosystem effects studies / biodiversity work, under WL-MD-11-1718 (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health); starting in 2017/18 measurements of PACs in air made under passive and active methods (components 1 and 2) and inferential modelling of PACs deposition (component 5) will be integrated with GEM-MACH modelling of PAHs in the oil sands region which is under A-PD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*) and the Atmospheric Pollutant Deposition Monitoring - Lakes and Snowpack study (A-LTM-S-9-1718); results from PACs synthesis report under proposal R-1-1718 (*Air evaluation, integration, synthesis and reporting*) to be completed in 2017/18 will inform future passive and active sampling including the distribution and number of sites.

(Timeframe: 2017/18 to 2021+)

Background: Since 2011, passive monitoring sites measuring PACs have ranged in number from 15 to 18. Based on recommendations stemming from a March 2016 "Deposition and Effects - Results and Planning Workshop", samples will continue to be collected at all 18 sites, since this is a minor cost which can be support as part of the existing work. However, in order to free-up resources to address other project hypotheses, samples will only be analyzed and reported from 5 sites, from 2016/17 onward. The longer term air sampling strategy for PACs will be informed by the recommendations stemming from the PACs air synthesis report to be completed in 2017/18.

*H2) Recently developed passive dry deposition samplers (PAS-DD) complement the data obtained from conventional PUF disk type samplers and provide a comparable and direct measure of dry deposition that can be evaluated against model results*

Co-deployed PUF disk and PAS-DD air samples collected over a one year period (October 2015-September 2016 at the 5 sites listed above) will be analyzed to compare the performance of the two passive sampling

methods. The results of the PAS-DD sampler will be evaluated against new deposition model results. The results of the PAS-DD sampler comparison will inform future direction and application of the PAS-DD sampler. This could result in phasing out of the PAS-DD sampler or possibly even an expanded passive deposition network based solely on the PAS-DD as part of a focused study.
(Timeframe: 2017/18 to 2018/19)

*H3) Petcoke contributes significantly to PAC levels in air (and deposition) across the oil sands region*
PUF disk and PAS-DD air samples (mentioned above) will be evaluated for the presence of petcoke dust signature. This will involve the comparison of PAC residue profiles in petcoke samples (fluid and delayed petcoke) and by inspecting individual particles trapped on passive samplers using a novel SEM/EDS (Scanning Electron Microscopy / Energy-Dispersive X-ray) technique in collaboration with the University of Alberta. Similar to work addressing H2, the outcome of this work will inform the next steps and future focused studies and applications of new analysis tools such as SEM/EDS. **Linkages:** This work is also integrated with activities in ECCC-WSTD investigating heterocyclic aromatics in petcoke, snow, sediments, and air samples.
(Timeframe: 2017-18 to 2018/19 TBC)

*H4) PAC transformation products (e.g. oxy- and nitro-PAHs) are produced in the atmosphere of the oil sands region and are more widely distributed (away from the oil sands region) compared to parent PACs*
Results of the analysis of nitro- and oxy-PACs in passive air samples from ~16 monitoring stations over the period October 2013-April 2016 will be compared to results for PAHs to delineate difference in spatial and seasonal trends. Results from PAC transformation experiments (chamber study using flow tube reactor), which are ongoing, may contribute to the identification of key transformation products in air samples. Again, due to the results-based and incremental aspect of this work, future focused study work may be required to fully address the hypothesis.
(Timeframe: 2017-18 to 2018/19)

*H5) PAC transformation products result in enhanced in-vitro toxicity of air samples*
Samples from PAC transformation experiments will be used to assess changes in in-vitro toxicity resulting from oxidation of PACs in air. The in-vitro toxicity work will build on an ECCC-led recent publication (Jariyasopit et al., 2016) and will depend on ongoing collaboration with Health Canada on testing and developing new and sensitive in-vitro screening methods to link measurements of organics in air with a range of toxicity indicator endpoints. Given the rapidly developing progress in the field of in-vitro testing, it is expected that this work will require additional time.
(Timeframe: 2017-18 to 2020)

*H6) Tree cores can be used to reconstruct historical trends for PACs in air across the oil sands region, including the pre-mining period, and to delineate the spatial range of the impacted region*
Based on a recent methodology developed and validated for measuring PACs in tree cores (Rauert and Harner, 2016) and experiments and new uptake model (Rauert et al., in prep), samples collected during July/August 2015 across 18 sites and analyzed for PACs during 2016/17 will be analyzed to delineate spatial and temporal trends of PACs across the oil sands region. We will also continue to work with Natural Resources Canada (NRCan) on the testing of isotope techniques that can be applied to PACs in tree bark and wood to differentiate sources, starting in 2017-18 and continuing in 2018-19.
(Timeframe: 2017-18 to 2018-19)

**Assumptions and Constraints behind the hypothesis and the testing method:**

- Some challenges have been experienced with the flow tube reactor study to generate transformation products of PACs. The challenges relate to the stability of the system in generating consistent results which is most likely due to sorption of more polar products to chamber surfaces. This may impact/delay work under H4A and H4B above.

- Characterization of petcoke is based on petcoke samples (fluid and delayed) provided by University of Alberta (Zhang et al., 2016). We assume that these samples are representative of petcoke across the oil sands region.
- Analysis of tree coring results to produce historical trends of PACs will be constrained by the current uncertainties in how gas- and particle-phase PACs deposit onto and accumulate in tree wood.

***Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse and fine particulate matter (PM), PM2.5 speciation, VOCs, polar and sulphur-containing VOCs) in air:***

*<u>H1) The geographical distribution and number of the active air monitoring sites for enhanced deposition can be used to collect ambient data of the targeted pollutants and generate deposition estimates</u>*

The previous project initiated under OSM included three pilot sites, AMS5, AMS11 and AMS13 (terminated in 2015), to measure PACs and PM2.5 metals. Additional multi-pollutant measurements (coarse and fine PM, PM metals, speciated PM2.5, and VOCs) were implemented at two additional enhanced deposition sites (AMS1, AMS18; started in 15-16) designated as "supersites". Under this new design for fiscal year 17-18, the third "supersite" (Buffalo Viewpoint, AMS4), planned to be in operation mid-year during fiscal year 16-17 (delays due to May 2016 Fort McMurray wildfires), will be operational at the beginning of fiscal year 17-18. At the same time, the pilot site (Mannix, AMS5) will be phased out in 17-18. This will complete the enhanced deposition network comprised of five integrated monitoring sites (AMS1, AMS4, AMS11, AMS17, and AMS18).

**Linkages:** Under WL-IC -11-1718 (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health); starting in 2017/18 measurements of PACs in air made under passive and active methods (components 1 and 2) and inferential modelling of PACs deposition (component 5) will be integrated with GEM-MACH modelling of PAHs in the oil sands region which is under A-PD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate* ); results from PACs synthesis report under proposal R-1-1718 (*Air Evaluation, Integration, Synthesis and Reporting* ) to be completed in 2017/18 will inform future and active and passive sampling including the distribution and number of sites; results from PM2.5 speciated measurements will be integrated with Component 4 and Component 5.

(Timeframe: 2017-18)

*<u>H2) Analytical methodologies will identify and detect potential chemical markers such as quinones and naphthenic acids, and can be used to derive ambient data for these new chemicals for later use in emission source attributions</u>*

Novel analytical methodologies developed in fiscal 16-17 to identify quinones and naphthenic acids in samples collected in oil sand region will be finalized and published in fiscal year 17-18.

(Timeframe: 2017-18)

<u>*H3) Long term comprehensive multi-pollutant (PACs, metals, coarse (PM10-2.5) and fine PM2.5; PM2.5 speciation, VOCs, polar and sulphur-containing VOCs)* measurements will provide the data needed to fully assess the predominant primary emission sources impacting local and regional air quality including transport, transformation and deposition of target pollutants</u>

- Continuation of present atmospheric monitoring of multi-target pollutants at enhanced deposition sites: AMS1, AMS5 (to be replaced by AMS4), AMS11, AMS17, AMS18.
- The long term sampling strategy (e.g., number and distribution of sites) will also depend on the outcomes of the PACs air synthesis report expected in late 2017/18.
- Commence measurements at the third "supersite" (AMS4) and stop measurements at the AMS5 site
- Data from active air sampling for metals and PACs over the period 2010-2014 at 3 pilot sites will be analyzed and results reported (3 publications).
- Initiate analysis of results for other target pollutants collected at AMS17 and the two enhanced deposition "supersites" AMS1 and AMS18.

(Timeframe: 2017-18)

*H4) The active air monitoring data of targeted pollutants at selected sites across the oil sands combined with dispersion/inferential modeling will provide effective maps of atmospheric pollutant deposition across the region in space and time.*
These data will support an improvement to the current deposition modeling approach by combining dispersion modelling and inferential modeling to generate improved estimates of PACs and metals deposition from air across the oil sands region (1-2 papers). **Linkages:** This work is also integrated with activities under A-PD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*).
(Timeframe: 2017-18 to 2018/19+)

*H5) Petroleum coke dust is a source of PACs and metals in the oil sands region*
The 4-year datasets for PACs and metals in samples collected at three sites (AMS05, AMS11 and AMS13) will be used to: (1) characterize air pollutant levels with emphasis on benzo[a]pyrene (BaP) and vanadium; (2) assess to what degree the dust from petcoke is detectable in ambient air; and (3) provide informed evidence to support future AOSR (Alberta Oil Sands Region) management strategies
**Linkages:** Starting in 2017-18, this work will integrate with passive PACs evaluation for the presence of petcoke dust (Component 1) (1 publication).
(Timeframe: 2017-18)

*H6) PACs transformation products (e.g. quinones) are produced in the atmosphere of the oil sands*
Results of the analysis of gas-phase (GP) and particle-phase (PM) ambient air aerosol samples collected separately in 2013 summer intensive field campaign will be reported (2 publications). So far, data indicated that PAHs oxidizes faster in GP, and the level of transformation products (quinones) increases in the PM phase with time. Also, the temporal changes in the monitored concentrations suggest that a difference in the positional isomer or alkylation influences the generation and stability of quinones arising from the same parent PAH.
(Timeframe: 2017-18)

*H7) Naphthenic acids (NAs) are present in particulate matter (PM) in the oil sand region.*
The results from the analysis of atmospheric PM samples by the developed method (H2) will be reported (1 publication). This preliminary study presents, to our knowledge, the first direct identification of classical NAs in atmospheric particulate matter.
(Timeframe: 2017-18)

**Assumptions and Constraints behind the hypothesis and the testing method:**
Sample analysis, data interpretation and reporting might be delayed due to the implementation of the new national ECCC laboratory information management system (NLIMS), and in conjunction with laboratory renovations.

***Component 3 of 5 – Mercury air sampling and deposition:***
*H1) Atmospheric mercury in the oil sands region is driven by background levels and wildfire events*
Results from ongoing total gaseous mercury (TGM) monitoring and ongoing speciated atmospheric mercury (gaseous elemental mercury (GEM) + gaseous oxidized mercury (GOM) + particulate bound mercury (PBM)) monitoring in the oil sands region since 2014 will be analyzed and reported. These data will build on previously published results (Parsons et al., 2013) covering October 2010 through May 2013, with the addition of speciated Hg data that were not available at the time of the previous publication. (Timeframe: 2017-18). TGM is being measured at 2 sites in the area (AMS6 and AMS13) for comparative purposes. AMS6 is considered an upwind site (not impacted by industrial activities, yet still within the region) and AMS13 is considered a downwind site (atmospheric mercury reaching this site has been impacted by the emissions to the atmosphere through industrial/mining activities). Once the processes studies (H2 and H3) have been

completed, a location further removed from the oil sands primary industries to replace AMS6 would be warranted to represent a larger regional atmospheric mercury signature. At this time, the cost to continue measuring mercury at AMS6 is minimal (4K) and the value of this comparative data is well worth the cost.

*H2) Differences in land use affect the mercury cycle in the oil sands region*

Mercury has been shown to deposit from the atmosphere close to oil sands facilities (Kirk et al., 2014). Subtle differences in total gaseous monitoring (TGM) data collected at Fort McMurray – Patricia McInnes (AMS 6 station) compared to TGM data collected at Fort McKay South (adjacent to AMS 13 station) suggest that local land use may play a minor role influencing TGM concentrations observations (Parsons et al., 2016). Upcoming co-located sampling of mercury in wet deposition (open air + through fall sampling) will complement the ongoing atmospheric mercury measurements in the oil sands region. Speciated mercury sampling will continue at AMS 13 as required, to supplement wet deposition sampling data. The number of atmospheric speciation sampler systems will be reduced to one. An ECCC study showed that the majority of mercury on particles in the OS area fall under a 2.5μm sized particle. (Timeframe: 2017-2019)

*H3) Atmospheric mercury monitoring and mercury in wet deposition sampling can be used to improve understanding of the mercury cycle in the oil sands region through improved modelling capabilities.*

Mercury can be transformed in the atmosphere from a stable chemical to one that easily deposits to the ground (eventually making its way to the ecosystem). Chemicals released to the atmosphere from industrial activities can enable this transformation of mercury and subsequent deposition. Measurements of mercury in the snow around industrial activities show strong evidence of atmospheric mercury deposition but current ground measurements of mercury in the air (away from the activities) do not reflect this transformation and deposition. It is hypothesized that the transformation of mercury occurs higher in the atmosphere closer to industrial activities and above the forest canopy. It is also thought that measurements at the current location reflect that the deposition of mercury is being taken up by the overlying forest.

Wet deposition measurements will be collected both under and outside the forest canopy to assess part of the role that the forest around the OS area impacts the input and uptake of atmospheric mercury.

Overall, a primary goal of the mercury monitoring program is to better understand the mercury cycle within the oil sands region, including transport and deposition of atmospheric mercury, and subsequent transformation to methylmercury in terrestrial, aquatic, and biotic systems. Data from the atmospheric mercury monitoring program, including wet deposition sampling, will be used in conjunction with the other mercury programs (water and wildlife, e.g. Linkage with snow deposition study) to further develop overall mercury modelling currently being developed by ECCC staff scientists. The atmospheric component of the mercury cycle is necessary to understand/predict mercury deposition trends/forecasts. (Timeframe: 2017-2020)

**Linkages:** GEM-MACH Hg modelling under A-PD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*; Hg deposition in snow under A-LTM-S-9-1718 Atmospheric Pollutant Deposition Monitoring - Lakes and Snowpack.

**Assumptions and Constraints behind the hypothesis and sampling of mercury in the air:**

- Atmospheric speciated mercury measurements with 2 parallel instruments have proven to be a challenge for remote measurements. The data collected will be fully reviewed and assessed for completeness for the sampling period.
- Currently, speciated mercury (GOM and particle bound mercury) are operationally defined terms and thus we assume that the sum of GEM and GOM reflect total gaseous mercury (TGM).
- During the Fort McMurray wildfires the pumps on the instruments stopped running. Should there be additional wildfires in the near vicinity, we will likely face the same sample collection challenges.

***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:***

*H1) Industrial emissions from the oil sands region (i.e., $NO_x$, and $SO_2$) can undergo long-range transport and transformation and impact ecosystems at significant distances downwind of emission sources*

– Real time measurements of gaseous nitrogen and sulphur species (NO, $NO_2$, $NO_y$, $NH_3$ and $SO_2$) will continue to be monitored as an enhancement to routine Canadian Air and Precipitation Monitoring Network (CAPMoN) measurements at two Ecosystem/Transformation sites: Pinehouse Lake (SK) and Flat Valley (SK). The additional gas phase measurements are needed to estimate dry deposition of the most important nitrogen and sulphur species. Measurements began at Pinehouse Lake (PHL), SK in February 2015 and at Flat Valley (FLV), SK in February 2016 and both of these sites are part of CAPMoN. It is recommended that the measurements continue for 5 years (period of time subject to review) in order to provide the required data to answer the science based questions related to long range transport, transformation, and deposition of oil sands emission sources.

– Data collected at these sites will undergo routine quality assurance/quality control and standard CAPMoN data management practices. For data collected each year, final review will begin at the end of the calendar year with data being made available via the Government of Canada data portal in the second quarter of the following fiscal year.

– Regionally-representative continuous gaseous NO, $NO_2$, $NO_y$, $NH_3$ and $SO_2$ data from this activity will be used to quantify air concentrations and dry deposition at sites downwind from the oil sands.

**Linkages:** The data collected as part of this project, combined with the existing nitrogen and sulphur species components of the air and precipitation measurements of CAPMoN, will enable the quantification of total nitrogen deposition at these sites (component 5 of A-MD-2-1718), which can be used to establish critical load maps (Trent University). The data will be used to estimate the influence of long-range/transboundary transport and transformation of emissions from the oil sands (A-PD-4-1718 ) relative to other western Canadian sources, examine trends in nitrogen and sulphur species, aid in the development and evaluation of chemical transport models (A-PD-4-1718), and assist in the validation of satellite measurements of $NO_2$ , $NH_3$, and $SO_2$ (A-PD-4-1718 ). Air concentration data will also be available for assessing the state of air quality in the region.
(Timeframe: 2017-18 to ~2022)

<u>Background:</u> The costs of daily operation of the PHL and FLV sites are covered under CAPMoN. The current work plan supports the enhanced N and S measurements (NO, $NO_2$, $NO_y$, $NH_3$, $SO_2$) needed to understand deposition of oil sands-related compounds in areas downwind of the industrial activities. These measurements are not part of the standard CAPMoN suite and complement the typical CAPMoN air tower (p-$NO_3^-$ (particulate nitrate), p-$NH_4^+$ (particulate ammonium), $HNO_3$ (nitric acid), $SO_2$, and p-$SO_4^{2-}$ (particulate sulfate)), and precipitation ($NO_3^-$ (nitrate ion), $NH_4^+$ (ammonium ion), and $SO_4^{2-}$ (sulfate ion)). With these enhanced measurements a more complete calculation of the total dry deposition of N and S species can be made and with the CAPMoN wet deposition total deposition and dry/wet comparisons can be accomplished. The data can also be used for the purpose of satellite and model validation.

**Assumptions and Constraints behind the hypothesis and the testing method:**

- It is assumed that detectable ambient air concentrations of gaseous N and S pollutants will be observed at ecosystem sites and that the measured levels will be significant enough for evaluating chemical transport models and validating satellite observations.
- It is assumed that pollutants emitted in oil sands region may be transported long distances to sensitive ecosystems downwind.
- Some challenges to date that we have experienced have been due to forest fires. Measurements at both sites have been impacted by forest fires either upwind or locally and these may pose additional

uncertainties in the deposition estimates.

***Component 5 of 5 - Inferential modelling of atmospheric deposition***

*H1) Dispersion modeling combined with monitoring data can be used to generate gridded concentrations in air for a variety of pollutants (e.g. PACs, elements, N and S) in the oil sands region, which will then improve the accuracy of deposition maps based on inferential modeling*

– An air dispersion model has been modified and run for the year 2011. The simulated concentrations have been compared with monitored air concentrations of PACs at the 17 passive sampling sites. Gridded concentrations, once evaluated and adjusted based on available measurements, will be used to produce dry and total deposition estimates.

– Work will also be started to estimate dry deposition of 40+ trace elementals at the three monitoring sites. A literature survey of particle size distribution of trace elementals will first be conducted. A particle dry deposition model, forecasted meteorology, particle size distribution, and monitored air concentration will then be coupled together to obtain dry deposition estimation of all trace elements at locations they are monitored.

– The above planned work is likely to be finished by the end of fiscal year 17/18. Estimation of dry deposition of other pollutants can be done in a similar approach in future years (as documented in other project components, e.g., CAPMoN monitoring of nitrogen species). As evidence supporting the proposed approach, the mercury dry deposition framework developed by Zhang et al. has been adopted in the U.S. National Atmospheric Deposition Program - the Atmospheric Mercury Network (NADP/AMNet) since 2009. The first six-year mercury dry deposition results have now been published (Zhang et al., 2016) and data produced from this project will also soon be online on the NADP website. (Timeframe: 2017-18)

**Linkages:** The inferential dry deposition framework developed in this component applies to various pollutants and makes use of the air concentration data monitored in the other four components of this project. Deposition results from this project component will be compared with deposition estimates stemming from aircraft campaign under A-PD-4-1718 (*OS air pollution emissions, transformation and fate*). Deposition estimates from this project will also be integrated with ecosystem effects studies / biodiversity work (multiple projects under water and biodiversity components), and will be used for the synthesis report “Causes and effects of atmospheric deposition of multiple pollutants” under R-1-1718 and inform the work plan A-PD-6-1718 Integrated Deposition Monitoring Design.
(Timeframe: 2017/18 to 2021+)

**Assumptions and Constraints behind the hypothesis and the testing method:**
Uncertainties in dry deposition estimation are typically on the order of a factor of 2.0 for seasonal or annual averages of the highly-studied pollutants, such as inorganic sulphur and nitrogen species. Uncertainties for other pollutants such as PACs, trace elements and heavy metals are expected to be larger than those of sulfur and nitrogen species due to the greater challenges in measuring and modeling dry deposition of these pollutants.

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Passive sampling for PACs:

Harner, T., Su, K, Genualdi, S., Karpowicz, J., Ahrens, L., Mihele, C., Schuster, J., Charland, J-P., Naraya, J. Calibration and application of PUF disk passive air samplers for tracking polycyclic aromatic compounds (PACs). *Atmos. Environ.* 2013, 123-128.

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Zhang, L., Cheng, I., Wu, Z., Harner, T., Schuster, J., Charland, J-P., Muir, D., Parnis, M.J. Dry deposition of polycyclic aromatic compounds in the Athabasca oil sands region. J. Adv. Mod. Earth Sys. 07, doi:10.1002/2015MS000473

Zhang, Y., Shotyk, W., Zaccone, C., Noernberg, T., Pelletier, R., Bicalho, B., Froese, D.G., Davies, L., Martin, J.W. *Environ. Sci. Technol.* 2016, 50, 1711-1720.

<u>Mercury :</u>

Kirk, J. L.; Muir, D. C.; Gleason, A.; Wang, X.; Lawson, G.; Frank, R. A.; Lehnherr, I.; Wrona, F., Atmospheric deposition of mercury and methylmercury to landscapes and waterbodies of the Athabasca oil sands region. *Environmental science & technology* 2014, *48* (13), 7374-83.

Parsons, M.; McLennan, D.; Lapalme, M.; Mooney, C.; Watt, C.; Mintz, R., Total Gaseous Mercury Concentration Measurements at Fort McMurray, Alberta, Canada. *Atmosphere* 2013, *4* (4), 472-493.

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<u>N and S Measurements :</u>

Bash, J.O., J. T. Walker, M. W. Shephard, K. Cady-Pereira, D. K. Henze, D. B. Schwede, L Zhu, and E.J. Cooter, Modelling reactive nitrogen in North America: Recent developments, observational needs, and future directions, EM Magazine, September (2015).

Cole, A. S., A. Robichaud, M. D. Moran, P. Makar, A. Lupu, M. Shaw, V. Fortin, and R. Vet, ADAGIO (Atmospheric Deposition Analysis Generated by optimal Interpolation from Observationns) : Project plans and status, ACID RAIN 2015, October 19-23, 2015, Rochester, N.Y.

Mclinden, C., V. E. Fioletov, M. W. Shephard, N. Krotkov, C. Li, R. Martin, M. D. Moran, and J. Joanna, Space-based detection of missing sulfur dioxide sources of global air pollution, Nature Geoscience, 9 (7), 2724-, 2016.

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Shephard, M.W., C. Mclinden, K.Cady-Pereira, M. Luo, S. G. Moussa, A. Leithead, J. Liggio, R. M. Staebler, A Akingunola, P. Makar, P. Lehr, J. Zhang, D. K. Henze, D. B. Millet, J. O. Bash, L. Zhu, K. C. Wells, S. Caps, S. Chaliyakunnel, M. Gordon, K. Hayden, J. R. Brook, M. Wolde, and S.-M. Li, Tropospheric Emission Spectrometer (TES) satellite observations of ammonia, methanol, formic acid, and carbon monoxide over the Canadian oil sands; validation and model evaluation, Atmos. Meas. Tech., 8, 5189-5211, 2015.

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Inferential deposition modeling:

Zhang L., Cheng I., Muir D., and Charland J.-P., 2015. Scavenging ratios of polycyclic aromatic compounds in rain and snow at the Athabasca oil sands region. Atmospheric Chemistry Physics, 15, 1421–1434.

Zhang L., Cheng I., Wu Z., Harner T., Schuster J., Charland J.-P., Muir D., and Parnis J.M., 2015. Dry deposition of polycyclic aromatic compounds to various land covers in the Athabasca oil sands region. Journal of Advances in Modeling Earth Systems, 7, 1339-1350.

Zhang L., Wu Z., Cheng I., Wright L.P, Olson M.L., Gay D.A, Risch M.R., Brooks S., Castro M.S., Conley G.D., Edgerton E.S., Holsen T.M., Luke W., Tordon R., and Weiss-Penzias P., 2016. The estimated six-year mercury dry deposition across North America. Environmental Science and Technology, in press, doi:10.1021/acs.est.6b04276.

# Data Management

*If this work generates data please summarize your project-level data management plan.*

| Deliverables | Timeframe | |
|---|---|---|
| Data Collection Period: | | |
| ***PAC passives:*** | | |
| *- Collection of passive air samples at 18 sites – ongoing* | Start : 2010-11-01 | End: 2021-03-31 |
| *- Toxicity testing of alkylated-PAC transformation product samples (from chamber study experiments)* | Start : 2017-04-01 | End: 2017-09-30 |
| ***PACs, metals and other target pollutants:*** | | |
| *- On-going collection of active air samples at 5 sites using the NAPS (National Air Pollution Surveillance) program one-day-in-six schedule (all samplers, all sites) and one-day-in-three schedule (for PM2.5 speciation and dichotomous samplers at the three supersites, AMS1, AMS4 and AMS18* | Start : 2017-04-01 | End: 2018-03-31 |
| ***Atmospheric Mercury:*** | | |
| *- Collection of continuous TGM data at 2 sites – ongoing* | Start : 2017-04-01 | End: 2018-03-31 |
| *- Collection of semi-continuous Speciated Hg at 1 site – ongoing* | Start : 2017-04-01 | End: 2018-03-31 |
| *-Collection of weekly wet deposition samples at 1 site – new* | Start : 2017-06-01 | End: 2018-03-31 |
| ***Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** | | |
| *Collection of continuous NO, $NO_2$, $NO_y$, $NH_3$, and $SO_2$ data from two sites (Pinehouse Lake and Flat Valley, SK)* | Start : 2017-04-01 | End: 2018-03-31 |
| Data Analysis Period: | | |
| *<u>Laboratory analysis and QA/QC of data:</u>* | | |
| ***PAC passives:*** | | |
| *PAC passives data (2011 to 2015)* | Start : 2017-02-01 | End: 2017-09-14 |
| *Tree core data* | Start : 2016-04-01 | End: 2017-04-30 |
| *Alkylated-PAC degradation study and in-vitro toxicity* | Start : 2016-04-01 | End: 2017-04-30 |
| ***PACs, metals and other target pollutants:*** | | |
| *PM2.5 metals (up to mid of 2016)* | Start : 2016-04-01 | End: 2017-05-31 |
| *Active (high volume) PACs (up to end of 2015)* | Start : 2016-04-01 | End: 2017-06-30 |
| *PM Speciation (2015-16)* | Start : 2016-04-01 | End: 2017-12-30 |
| *VOC (2015-16)* | Start : 2016-04-01 | End: 2017-12-30 |
| ***Atmospheric Mercury:*** | | |
| *-TGM data at 2 sites (2017)* | Start : 2018-01-01 | End: 2018-03-31 |
| *-Speciated Hg data at 1 site (2017)* | Start : 2018-01-01 | End: 2018-03-31 |
| *-Wet Deposition Hg data at 1 site (2017)* | Start : 2017-04-01 | End: 2018-03-31 |

| | | |
|---|---|---|
| | ***Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** *NO, $NO_2$, $NO_y$, $NH_3$, and $SO_2$ data for both the Pinehouse Lake and Flat Valley sites collected during the 2016 calendar year.* | Start : 2017-01-01 End: 2017-06-30 |
| | Data Release Date: *Metadata and data consistent, complete and meet basic standard format for publication in Open Data; on or linked to JOSM portal*<br><br>***PAC passives:***<br>*Tree core data*<br>*Alkylated-PAC degradation study*<br><br>***PACs, metals and other target pollutants:***<br>*Active PACs, metals (up to end-of-2014)*<br>*Other target pollutants:*<br><br>***Atmospheric Mercury:***<br>*TGM data at 2 sites (2017)*<br>*Speciated Hg data at 1 site (2017)*<br>*Wet Deposition Hg data at 1 site (2017)*<br><br>***Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:***<br>*NO, $NO_2$, $NO_y$, $NH_3$, and $SO_2$ data for both the Pinehouse Lake and Flat Valley sites collected during the 2016 calendar year.* | <br><br><br><br>2017-06-30<br>2017-06-30<br><br><br>2017-06-30<br>2018-03-31<br><br><br><br>2018-03-31<br>2018-03-31<br>2018-03-31<br><br><br>2017-09-30 |

# Reporting and Publications

*Provide information on the anticipated reports / publications. (Insert additional rows if needed)*

| Expected Subject/Titles of Publications or Reports | Short Description of Publication or Report | Expected Year of Publication |
|---|---|---|
| ***Component 1 of 5 - Passive monitoring of PACs in air:*** | | |
| Factors influencing the concentrations of PACs in air across the Athabasca oil sands region | As per the expected subject/title | 2017/18 |
| Comparing PUF disk and PAS-DD samplers for measuring PACs and petcoke dust contributions in air samples across the oil sands region | As per the expected subject/title | 2017 |
| Oxy- and nitro-PACs in air across the oil sands region: seasonal trends, spatial distribution, and in-vitro toxicity | As per the expected subject/title | 2017/18 |

| | | |
|---|---|---|
| Historical trends of PACs in air across the oil sands regions derived from tree-ring cores | As per the expected subject/title | 2017/2018 |
| ***Component 2 of 5 - Active monitoring of targeted multi-pollutants*** | | |
| Sources of Particulate Matter in the Athabasca Oil Sands Region: Investigation through a Comparison of Trace Element Measurement Methodologies | As per the expected subject/title | 2017/18 |
| Application of ultrahigh-performance liquid chromatography–quadrupole time-of-flight mass spectrometry (UPLC/QTOF-MS) for the characterization of organic aerosol: searching for naphthenic acids | As per the expected subject/title | 2017/18 |
| Contribution of Petroleum Coke to Benzo[a]pyrene and Vanadium Levels in Atmospheric Aerosols in the Athabasca Oil Sands Region | As per the expected subject/title | 2017/18 |
| Characterization of 19 non-derivatized quinones in ambient air: Gas-particle phase partition, distributions and daytime-nighttime variability | As per the expected subject/title | 2017/18 |
| Characterization of the ambient air content of parent polycyclic aromatic hydrocarbons and their transformation into the corresponding quinones | As per the expected subject/title | 2017/18 |
| Polycyclic Aromatic Compounds in the Lower Athabasca Region of Oil Sands in Albert – 2010-2014 Characterization and Trends | As per the expected subject/title | 2017/18 |
| ***Component 3 of 5 – Mercury air sampling and deposition:*** | | |
| Atmospheric mercury monitoring in the oil sands region | As per the expected subject/title | 2018 |
| ***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** | | |

| | | |
|---|---|---|
| Estimation of the impact of oil sands emissions on the total deposition of N and S species observed at downwind ecosystems. | This paper will attempt to estimate the fraction of N and S deposition that can be attributed to oil sands emission in relation to other sources. Estimation will be based on calculated deposition at each site and employ back trajectories to determine origin of air mass. | 2019/2020 |
| ***Component 5 of 5 - Inferential modelling of atmospheric deposition*** | | |
| Model simulations of PACs air concentrations with existing and revised emission inventory and comparison with measurements | The purpose of this paper is to improve the PACs emission inventory to produce air concentration maps for subsequent dry deposition estimation | 2017 |
| Mapping atmospheric deposition of PACs | As per the expected subject/title | 2017 |
| Estimates of dry deposition of trace elements | As per the expected subject/title<br><br>Potential publications on other pollutants in future years if monitored air concentration data are available | 2017<br><br>2018 and later years |

# Technical / Professional Roles and Responsibilities

*Identify members of the monitoring team/organization, their roles and responsibilities. Identify monitoring organization leads if different from overall monitoring activity lead. (Insert additional rows if needed)*

| Role | Responsibilities | Resource Name/Organization |
|---|---|---|
| Project Lead / Principal Investigator | Project coordination and principal investigator (passives) | ECCC |
| Project Co-lead | Project coordination | ECCC |
| Project Co-Lead / Principal Investigator | Project Co-lead and principal investigator (deposition modelling) | ECCC |
| Principal Investigator | Principal Investigator (Enhanced deposition) | ECCC |
| Principal Investigator | Principal Investigator (Mercury air sampling and deposition) | ECCC |
| Principal Investigator | Principal Investigator (N and S deposition | ECCC |
| Oil Sands Senior Support (air monitoring component) | Provide coordination and liaison within ASTD, and with the Oil Sands Secretariat and OSM partners | ECCC |
| Section Manager / Air Component Lead | Air program OS overall management lead | ECCC |
| ***Component 1 of 5 - Passive monitoring of PACs in air:*** | | |
| Science / Technical Support | Logistics, shipping and sample/instrumental analysis for PAC passive samples | ECCC |

| | | |
|---|---|---|
| Science / Data Support | Process studies on PACs and data analysis including QA/QC for passive sampling for PACs | ECCC |
| Science Specialist | Process studies on PAC uptake by trees and data analysis for tree core studies | ECCC |
| Science Specialist | Data analysis, QA/QC and reporting for passive air monitoring results for PACs | ECCC |
| Science / Technical Support | WBEA contact and support for passive sampling for PACs at WBEA sites | AEP / WBEA |
| ***Component 2 of 5 - Active monitoring of targeted multi-pollutants*** | | |
| Principal Investigator | Overseeing integrated sampling network, data analysis and reporting, and coordination with other projects / components. | ECCC |
| Science Specialist | QA/QC - field operations | ECCC |
| Science Specialist | Media/field sample handling and reporting | ECCC |
| Science Specialist | PM metals and PM speciation analysis, and reporting | ECCC |
| Science Specialist | Analysis of VOCs, polar and sulphur VOCs and reporting | ECCC |
| Science Specialist | Sample preparation and analysis of PACs, and reporting | ECCC |
| Data Specialist | Data validation and reporting | ECCC |
| Science / Technical Support | Management of Ambient Air Technical Program and Terrestrial Environmental Effects Monitoring Program | AEP / WBEA |
| Technical Support | Field Technical Support | AEP / WBEA |
| Project coordination | Overall project logistics, O&M, capital and field operations; liaisons with OS industry and local communities | AEP / WBEA |
| ***Component 3 of 5 – Mercury air sampling and deposition*** | | |
| Technical Support | Field Technical Support | ECCC |
| Technical Support | Field Technical Support | ECCC |
| Technical Support | Data analysis support | ECCC |
| Technical Support | Field Technical Support | ECCC |
| ***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** | | |
| Science / Data Specialist | Oversee field operations; QA/QC of data | ECCC |
| Field Technician | Perform maintenance, repairs, and conduct quarterly audits on measurement instrumentation; Daily review of incoming data to ensure instrumentation and data acquisition is functioning properly; Provide training and support | ECCC |

| | | |
|---|---|---|
| | for site operators. | |
| ***Component 5 of 5 - Inferential modelling of atmospheric deposition*** | | |
| Project Co-Lead / Project Investigator | Project coordination and principal investigator (Inferential modeling of atmospheric deposition) | ECCC |
| Data Support | Coding and data processing | ECCC |

# Deliverables **(Year 1)** If your Focus Study is longer than 1 year then complete **Appendix 3** for multi-year deliverables breakdown

Provide a summary of tangible quarterly deliverables. Identify major project areas (deliverables) and results that can be identified as a tangible goal. This could include: field work, lab work/ analysis, evaluation, data, reports, publications, SOPs etc. Do not define process as your Deliverable e.g. 'fly to Ft. McMurray to conduct fieldwork' or 'seek Director approval for report'.

| |
|---|
| **Deliverable(s)** (please provide enough information to support status reporting) |
| **Q1 – April to June** |
| An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal. |
| **Q2 – July to September** |
| An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal. |
| **Q3 – October to December** |
| An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal. |
| **Q4 – January to March** |
| An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal. |
| |

# Detailed Financial Breakdown – Year 1 of 3 (2017-2018)

Also complete **Appendix B** for the multi-year financial breakdown

| **Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED)** | **OS Funding** | **External Funding (*outside JOSM*)** |
|---|---|---|
| **O&M - Operations and Maintenance:** | | |
| Helicopter Costs | $ | $ |
| Field Costs | $ | $ |
| Internal Lab Analysis (PDF and coop students) (passives) | $85 000 | $ |
| Consumable Materials & Supplies (passive) | $60 000 | $ |
| Instrument / capital costs (GC/MS/MS; ASEs; reactions chamber; passive samplers) (passive) | | $ 55 000 |
| Operations cost for enhanced deposition sites (n=4, Stony Mountain, Buffalo Viewpoint, Fort McKay and Wapasu enhanced deposition sites. Note: does not include AMS11.) (AEP-WBEA) (active) | $187 800 | $ |
| Consumable Materials & Supplies (active) | $195 000 | $ |
| Instrument / capital costs (Lab equipment: ICs, XRF, ICP-MS, OC/EC, GC-MS's, HPLC, LC-MS/MS, etc.) (active) | | $ 125 000 |
| Field Costs (mercury) | $3 100 | $ |
| Consumable Materials & Supplies (mercury) | $20 600 | $ |
| Instrument Costs (wet deposition samplers) (mercury) | $20 000 | $43 500 |
| Data management (N+S) | $12 100 | $ |
| Consumable Materials & Supplies (N+S) | $25 000 | $ |
| Instrument / capital costs (N+S) | | $ 34,800 |
| Deposition Modeling (PDF, modelling) | $50 000 | $ |
| **Sub-Total** | **$658 600** | **$258 300** |
| **O&M - Travel** | | |
| Conferences (Dioxin 2017, Vancouver) (passive) | $2000 | $2000 |
| Field Work (QA/QC) (active) | $7000 | $ |
| Field Work (mercury) | $17 000 | $ |
| Conferences (NADP 2017 Fall Meeting, San Diego) (mercury) | $2 000 | $ |
| Field Work (QA/QC) (N+S) | $18 000 | $ |
| **Sub-Total** | **$46 000 (Total)** | **$2000** |
| **O&M - External Contracts :** | | |
| Goods and Services Contract (analytical instrument) (active) | $45 000 | $75 000 |
| Goods and Services Contracts (WBEA field support, Data QA/QC) (mercury) | $18 000 | $ |

| Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED) | OS Funding | External Funding (*outside JOSM*) |
|---|---|---|
| Goods and Services Contract (Wet deposition Hg lab analyses) (mercury) | $35 000 | $ |
| Goods and Services Contract (estimated site operations) (N+S) | $ | $50 000 |
| Goods and Services Contract (dispersion/inferential modeling) | $25 000 | $ |
| **Sub-Total** | **$123 000** | **$125 000** |
| | | |
| **Salaries:** | | |
| Principal Investigator (passives) | $ | $50 000 |
| Technical / Professional Assistants (passives) | $ | $65 000 |
| Data Management (passive) | $50 000 | $ |
| Principal Investigators (active) | $ | $37 000 |
| Technical / Professional Assistants (active) | | $284 843 |
| Technical / Professional Assistants (active) | $210 116 | $ |
| Principal Investigator (mercury) | $ | $85 000 |
| Technical / Professional Assistants (mercury) | $122 600 | $105 100 |
| Principal Investigator (N+S) | $ | $48 000 |
| Technical / Professional Assistants (N+S) | $62 000 | $ |
| Principal Investigator (modeling) | $ | $50 000 |
| Oil Sands Project Coordination | $35 000 | |
| **Sub-Total** | **$479 716** | **$724 943** |
| | | |
| **Total Salaries** | **$479 716** | **$724 943** |
| **Total O&M** | **$827 600** | **$385 300** |
| **2017-2018 GRAND TOTAL* (BEFORE OTHER RELATED COSTS)** | **$1 307 316** | **$1 110 243** |

* Total salary costs for ECCC ($479,716) in 2017-18 with other related costs are $659,705. Total O&M costs for ECCC ($639,800) in 2017-18 with other related costs are $728,395. Total O&M costs for AEP in 2017-18 are $187,800. **The Grand Total for ECCC and AEP in 2017-18 is $1,575,900.**

# Appendix 1 - Approvals

## Project Submitted by:

| | | |
|---|---|---|
| Name: Stewart Cober | | |
| Organization:<br>ECCC | Signature: | Date: |

## Project Approved by:

| | |
|---|---|
| **Dr. Monique Dubé (AEP)** | **Dr. Kevin Cash (ECCC)** |
| Signature<br> | Signature<br> |
| Date | Date |

**APPENDIX 2 – Detailed Multi-year Financial Breakdown** (Complete the following detailed financial breakdown; add or delete categories as required)

| Budget requirements | Year 1 (2017- 2018) APPROVED | | Year 2 (2018- 2019) ESTIMATE, PENDING APPROVAL | | Year 3 (2019- 2020) ESTIMATE, PENDING APPROVAL | |
|---|---|---|---|---|---|---|
| | Cash ($) | In-kind ($) | Cash | In-kind | Cash | In-kind |
| 1) Salaries and benefits | 474 716 | 724 943 | 474 600 | 724 943 | 474 600 | 724 943 |
| a) Investigators | | 270 000 | | 270 000 | | 270 000 |
| b) Technical/professional assistants | 479 716 | 454 943 | 474 600 | 454 943 | 474 600 | 454 943 |
| c) Field Staff | | | | | | |
| 2) Operations and maintenance (O&M) | 358 000 | 258 300 | 358 000 | 258 300 | 338 000 | 258 300 |
| a) Facilities (operation of 4 enhanced deposition sites) (AEP-WBEA) | 187 800 | | 187 800 | | 187 800 | |
| b) Equipment (Hg wet dep.) | 20 000 | | 20 000 | | | |
| c) Lab analysis (PDF and coop students) (passives) | 85 000 | | 85 000 | | 85 000 | |
| d) Data management | 12 100 | | 12 100 | | 12 100 | |
| e) Field work | 3 100 | | 3 100 | | 3 100 | |
| f) Modeling (PDF) | 50 000 | | 50 000 | | 50 000 | |
| g) Instrument capital costs (55K (passive); 125K (active); 43.5K (Hg); 34.8K (N+S)) | | 258 300 | | 258 300 | | 258 300 |
| 3) Consumable Materials and supplies | 300 600 | | 300 600 | | 300 600 | |
| a) Passive sampling and analysis | 60 000 | | 60 000 | | 60 000 | |
| b) Air sampling and analysis consumables (active) | 195 000 | | 195 000 | | 195 000 | |
| c) Mercury consumables | 20 600 | | 20 600 | | 20 600 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| d) N+S consumables | 25 000 | | 25 000 | | 25 000 | |
| 4) Travel | 46 000 | 2000 | 46 000 | 2000 | 46 000 | 2000 |
| a) Conferences and meetings | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| b) Field work | 44 000 | | 44 000 | 44 000 | 44 000 | |
| c) Project-related travel | | | | | | |
| 5) Dissemination & Engagement | 0 | 0 | 0 | 0 | 0 | 0 |
| a) Publications/Reports | | | | | | |
| b) Translation (if required) | | | | | | |
| c) Communications | | | | | | |
| d) Stakeholder Engagement | | | | | | |
| e) Indigenous Peoples Engagement | | | | | | |
| 6) External Contracts | 123 000 | 125 000 | 123 000 | 125 000 | 123 000 | 125 000 |
| a) Goods and services (instrument; Active) | 45 000 | 75 000 | 45 000 | 75 000 | 45 000 | 75 000 |
| b) WBEA field support and data QA/QC (Hg) | 18 000 | | 18 000 | | 18 000 | |
| c) Lab analysis (Hg, wet dep.) | 35 000 | | 35 000 | | 35 000 | |
| d) Site operations (CAPMoN) | | 50 000 | | 50 000 | | 50 000 |
| e) Dispersion modelling | 25 000 | | 25 000 | | 25 000 | |
| **Grand Total (*before other related costs)** | 1 307 316 | 1 110 243 | 1 302 200 | 1 110 243 | 1282 200 | 1 110 243 |

* Total salary costs for ECCC ($479,716) in 2017-18 with other related costs are $659,705. Total O&M costs for ECCC ($639,800) in 2017-18 with other related costs are $728,395. Total O&M costs for AEP in 2017-18 are $187,800. **The Grand Total for ECCC and AEP in 2017-18 is $1,575,900.**

**APPENDIX 3 –Years 2 and 3 Deliverables** (Complete the following detailed breakdown. Provide a summary of tangible quarterly deliverables. Identify major project areas (deliverables) and results that can be identified as a tangible goal.)

| **Year 2 (2018- 2019)** |
|---|
| **Deliverable(s)** (please provide enough information to support status reporting)<br><br>The following deliverables are based on projected activities at the present time. On an annual basis, updated deliverables and budget estimates will be provided depending on the previous years' progress and new science questions that arise. |
| **Q1 – April to June** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q2 – July to September** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q3 – October to December** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q4 – January to March** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |

| **Year 3 (2019- 2020)** |
|---|
| **Deliverable(s)** (please provide enough information to support status reporting)<br><br>The following deliverables are based on projected activities at the present time. On an annual basis, updated deliverables and budget estimates will be provided depending on the previous years' progress and new science questions that arise. |
| **Q1 – April to June** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q2 – July to September** |

| |
|---|
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q3 – October to December** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |
| **Q4 – January to March** |
| A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal. |