CENTRE OF DOCUMENTATION, RESEARCH AND EXPERIMENTATION ON ACCIDENTAL WATER POLLUTION

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• Oil spills in France

Spill of heating oil into a mountain river following a road accident (Bramont River, Nozières)

On 8th June, a tanker truck overturned on a hairpin bend on a mountain road running directly above the Bramont River near the town of Nozières (Lozère area). Part of its cargo of heating oil (14 m^3 out of 32 m^3) spilt into the river, and was then carried by the torrential flow as far as the Tarn River (2.5 km downstream).

The initial response operations consisted in stopping the leak and lifting the tanker truck, after which teams from the departmental fire brigade (SDIS) set up a series of containment booms and sorbents at several points along the river, in particular at the confluence of the Bramont and the Tarn.

The Prefecture requested Cedre's intervention on 12th June to conduct site surveys and make recommendations on the clean-up techniques to be implemented for the affected stretch of river.

From the outset, the environmental context presented certain particularities:

- the torrential flow of the river due to heavy rainfall in the days preceding the incident caused both the rapid downstream spread of the heating oil as well as its mixing in the water mass;
- the river's steep gradient, alternating between small waterfalls and pools, as well as the uneven topography of the banks and their dense vegetation made access difficult in many places, rendering these areas unsuitable for both the surveys and the deployment of oil containment/recovery operations.

On the Bramont River,[1] the mixing of the light oil resulted in some exposure of the banks and sediments to the pollution, causing the mortality of aquatic fauna (fish and various invertebrates such as crustaceans and insects), observed during surveys conducted jointly with the French Biodiversity Agency. Moreover, the substrates locally trapped some of the oil in the form of emulsified clusters in crevices and droplets infiltrated into the sediment. The oil was then remobilised as the bottom was reworked (notably release of droplets and appearance of sheen due to trampling, moving of stones, etc.) and caused a persistent odour in the days following the incident. In certain areas, the vegetation on the banks also occasionally trapped some of the oil (for example, a few litres on a stretch of bank located approximately 50 m downstream from the point of the spill). On the Tarn River, from the confluence with the Bramont, no visual or olfactory trace of oil was detected during the surveys conducted by Cedre, no doubt as a result of the strong dilution of the oil beyond this point.

The response operations therefore mainly focused on the Bramont River, and more specifically on its confluence with the Tarn River where the high flows nevertheless made it difficult to deploy effective containment systems in the first few hours following the spill. Two days after the incident, residual quantities of heating oil were recovered there via the implementation, by the SDIS, of equipment comprising successively (from upstream to downstream): (**i**) a flat construction boom lined with a sorbent boom (with sorbent pads in the collector pool (photo 1); (**ii**) a water reservoir (approximately 25 m x 10 m, dug using a power shovel), creating a lull in the river and the recoalescence of the heating oil mixed in the upstream sectors (then recovered using sorbents placed at the weir) (photo 2); and (**iii**) a floating boom lined with a sorbent boom on the Tarn River (photo 3).

Photo 1 (source: Cedre)

Photo 2 (source: Cedre)

Photo 3 (source: Cedre)

Upstream, small systems comprising booms and sorbent pads were temporarily placed at three sites presenting a suitable configuration (accessibility and relative hydrodynamic calm) for the recovery of the residual oil that was gradually remobilised.

[1] Where the water catchments are located upstream of the spills location, except for a diversion canal – protected during the emergency response operations.

Consequences of the mixing of the heating oil: traces of emulsified oil trapped on the underside of stones (**left**); release (sheen) from loose substrates (**centre**); impacted individuals of freshwater species living on stony/gravelly bottoms (white-clawed crayfish - *Austropotamobius pallipes*) (**right**) (source: Cedre)

In conclusion, the containment/recovery systems implemented on the Bramont River made it possible to recover most of the residual heating oil, a source of oil releases in fairly small quantities (mostly sheen).

The recommendations for finalising the clean-up operations included two options, depending on the feasibility of response actions:

- In a localised manner, i.e. in areas that were both accessible and more likely to have trapped residual heating oil (e.g. pools, areas of hydrodynamic calm), conducting of manual recovery operations (mowing of oiled vegetation, recovery using sorbents), and, where necessary, remobilisation using low-pressure water jets (e.g. submerged mixing of sediments, rinsing of banks), from upstream to downstream while maintaining/reinforcing the recovery system in place at the confluence with the Tarn. It should be noted that in this case, the intermediate containment systems on the Bramont River needed to be removed to promote the flow of remobilised oil.
- Recourse to natural rinsing and biodegradation processes in areas with too uneven a topography to allow access or ensure the safe deployment of responders. The effectiveness of this option was highly dependent on weather conditions (rainfall, sunshine, etc.) and implied the prior acceptance of a possible delay for the complete absorption of the residual oil. In this case, the recovery system (confluence with the Tarn River) did not need to be left in place due to the expected low quantities of released oil.

• Main oil spills worldwide

Upwellings of crude oil from an abandoned well: Lizama 158 oil field (Colombia)

On 2nd March, in the Colombian municipality of San Vicente de Chucurí (40 km from Barrancabermeja, Santander Department), the Lizama and then Sogamoso rivers (the latter a tributary of the Magdalena, the country's largest river) were polluted by a leak of crude oil from an onshore well (Lizama 158 oil field) previously operated by the state-owned company Ecopetrol and out of service since 2015.

According to Ecopetrol, the incident, which took place from 2nd to 15th March, was the result of a casing failure at an outcrop, caused by pressure variations in the ground, possibly due to (or in any case aggravated by) seismic activity.

The first measures implemented, not very detailed in our information sources, consisted primarily in containing the oil as far as possible on the Lizama River, with the installation of more than 100 booms. The oil nevertheless spread down a 25 km-stretch of the Lizama and some 20 km of the Sogamoso River, from which around 18,000 m^3 of a water/sludge/oil mixture were recovered. On the basis of this volume, it was estimated that approximately 100 m^3 of oil had been discharged into the rivers.

The incident occurred in a palm grove and, more widely, affected an entire rural region, causing repercussions for local residents in these areas: temporary rehousing, suspension of access to water resources with a resulting decrease in socio-economic activities (agriculture, fishing, etc.), as well as questions relating to the potential risks to human health.

Given these various concerns, one month after the spill the Colombian Ministry of Environment and Sustainable Development requested technical assistance from the United Nations, which dispatched a delegation of experts to the site, including an engineer from Cedre under the European Union's ERCC,[2] within a UNEP/OCHA Joint Environment Unit.[3]

As regards the environmental component of this mission, the actions to be undertaken essentially included the conducting of surveys of the oiled sites (cleaned up to various degrees at this stage), in order to provide the Colombian State with (i) an assessment of the environmental impact risks and the adequacy of the emergency response operations (recovery), as well as (ii) advice on any potential adaptation of the techniques to be implemented for finalising the clean-up operations.


*Assessment conducted following the emergency response operations: oiled vegetation (**left**); removal of bags of oiled solid waste (**right**) (source: Cedre)*

At the source of the spill, operations to permanently seal the well were initiated at the beginning of April 2018, for an anticipated duration of four weeks and with recourse to logistics and expertise also from outside the country – in this case, from the United States.

Spill of diesel due to a pipeline failure (Marathon Petroleum, US)

On 20th March, near the town of Solitude (Indiana), a breach in a pipeline operated by Marathon Petroleum caused a spill of approximately 160 m^3 of diesel fuel into Big Creek, a tributary of the Wabash River (which flows into the Ohio River). The pipeline operator rapidly deployed two booms that apparently contained the pollution in Big Creek, where the US Environmental Protection Agency (EPA) later reported having seen no visible acute impacts on either fish or birds, the latter returning for the nesting season only later in the spring.

Rainfall, rail accident, and large spill of crude oil into a river (Little Rock River, US)

On 22nd June in the state of Iowa, approximately 600 m^3 of crude oil spilt into the Little Rock River following the derailment of a rail convoy comprising 33 tank cars, an accident caused by the collapse of waterlogged soils due to the river having burst its banks.

Spill of crude oil from rail tank cars into the Little Rock River (source: www.ntsb.gov)

The response operations, not detailed in our information sources, were conducted by specialised companies commissioned by the railway network operator, under the supervision of the relevant public agencies, grouped together within a Unified Command which also included representatives of the private companies involved. The spread of the oil in the flood water led to the contamination of agricultural land, requiring the replacement of the topsoil.

Leak of petrol from an ageing pipeline (Darby Creek, US)

On 19th June in Pennsylvania, a pipeline dating from 1937, running between Philadelphia and a terminal near Reading, leaked more than 120 m^3 of petrol into the Darby Creek. According to the federal agency Pipeline and Hazardous Materials Safety Administration (PHMSA), two-thirds of the spill had been contained and recovered by the end of the response operations (coordinated by local, state and federal authorities), before the leaking section was replaced and the pipeline was put back into service on 1st July.

Spill of crude oil from an oil facility into the Guarapiche River (Monagas State, Venezuela)

On 6th July, an unspecified technical failure at an oil extraction facility belonging to the Venezuelan state company Petróleos de Venezuela SA (PDVSA), near Jusepín (Monagas State), resulted in a

[2] Emergency Response Coordination Centre.

[3] Combining the environmental expertise of the United Nations Environment Programme (UNEP) with the humanitarian response network coordinated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA).

spill of some 200 tonnes of crude oil from processing storage facilities into the Guarapiche River. The activation of the operator's oil spill contingency plan included containment and recovery measures, the means employed and results of which are not detailed in our information sources beyond PDVSA's indication that the spill was "under control" three days after the incident, and that 70% of the volume spilt had been recovered. Four officials of the oil company were reportedly charged following the incident.

Spill of produced water in a sensitive and remote area (Magallanes and Chilean Antarctica Region, Chile)

On 17th October, near the Río Cullen (Magallanes and Chilean Antarctica Region), a leak of unspecified cause occurred at an oil facility owned by the Chilean national company *Empresa Nacional del Petróleo* (ENAP) and operated by the Argentine company *Yacimientos Petrolíferos Fiscales* (YPF), causing a spill of oil into the narrow Chorrillo Paraguaya River.

With a volume of approximately 720 m^3, the spill prompted the formation of a Regional Emergency Committee including representatives from local authorities and relevant government agencies alongside the response services (fire brigade, military, etc.).

Oil containment using sorbents on the Río Cullen (source: DR/Agencia UNO)

Confined to the river, the spill did not spread to the coastline, with 60% of it being recovered according to YPF.

• Main spills of other substances worldwide

Additional spill of mineral-based fluids in a wetland (Rover Pipeline site, US)

On 10th January, a spill of between 500 and 600 m^3 of bentonite drilling fluid occurred at a gas pipeline construction site, flowing into a wetland along the Tuscarawas River in Stark County (Ohio). While not involving a hazardous substance, this event followed a series of similar incidents reported between April and November 2017 in particular (see LTEI n°27).

• Past spills

Barge operator fined for repeated spills of liquid fertiliser (State of Washington, US)

In 2018, the Department of Ecology of the State of Washington released its findings from an investigation into three successive spills of liquid fertiliser from tank barges in April 2017. These separate events had resulted in a total volume of some 150 m^3 of a urea and ammonium nitrate (UAN) solution spilt into the Columbia River and its main tributary, the Snake River. Following the conclusions of the investigation, the operator (Tidewater Barge Lines, Inc.) was fined US$18,000 for identified shortcomings concerning the maintenance/servicing of these facilities, whose steel structure was found to be substantially corroded by the substance routinely transported.

The first spill occurred between 11th and 21st April 2017 during loading operations at the Tidewater terminal in Pasco. This resulted in the Snake River being polluted by more than 60 m^3 of liquid fertiliser due to corrosion of the barge's tanks. The second spill, between 20th and 24th April 2017, also occurred during transfer operations, from a different barge this time but again due to corroded tanks that leaked more than 80 m^3 of a UAN solution into the Columbia River near Vancouver.[4] A third spill was reported a few days later, from a cracked tank onboard the same barge, releasing a few cubic metres of liquid fertiliser.

Soluble and rapidly diluted in the rivers concerned (with their relatively high flow rate), these spills were sanctioned primarily because they could have been avoided through the implementation of appropriate maintenance procedures. In this regard, the company is now required to submit an annual

[4] Not to be confused with Vancouver in Canada.

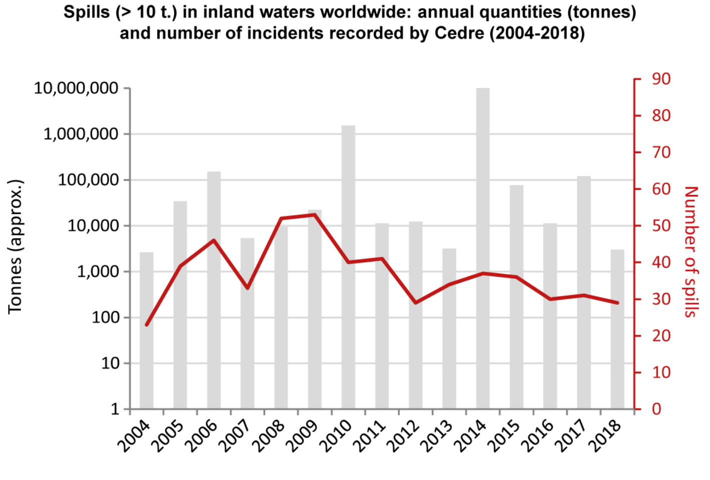
prevention and management plan to the Department of Ecology, to ensure the integrity of the steel structures and welds of its barge tanks.

• Review of significant spills having occurred worldwide in 2018

This review is based on the spills recorded by Cedre in 2018 involving volumes greater than 10 tonnes and for which sufficient information was available for statistical analysis. For a certain number of incidents, the volumes spilt are unknown or were not specified in our information sources, although the data available shows that they were clearly in excess of the 10-tonne figure. These knowledge gaps and lack of precise information undoubtedly limit the accuracy in the interpretation of the results presented below.

Spill sources

In 2018, 29 incidents followed by significant spills (≥ 10 t.) were identified in inland waters, a value below the median for entire the period 2004-2017 (37, based on similarly collected data), and below the median for each sub-period: 40 for 2004-2010, and 34 for 2011-2017. For the third consecutive year, the number of significant spills brought to our attention was somewhat lower than the overall number of incidents in the previous decade. This analysis therefore suggests a current, slightly downward trend in the number of spills over 10 m^3 reported in our information sources.



These incidents represented a total quantity of just over 3,000 tonnes of oil and other hazardous substances spilt in 2018 (Fig. 1): this is one of the lowest annual totals estimated since 2004, well below the annual median expressed for the period 2004-2017 (around 17,000 tonnes).

This was due to both the relatively low number of events recorded in 2018 and the small scale of these events, almost 75% of which involved quantities of less than 100 tonnes.

Figure 1

The data identified show that the spills in 2018 were distributed around a median value of approximately 30 tonnes. At most, only three spills involved volumes of over 500 tonnes, and none reached the 1,000-tonne mark.

In 2018, both **onshore oil facilities** and **pipelines** were the most frequent sources of significant spills in inland waters known to us, each accounting for around 21%, a third of which were related to oil storage sites for the first source (Fig. 2). The next frequent sources were **tanker trucks**, responsible for 17% of the incidents, including three in France, and then **trains**, involved in 13% of significant spills (with 10% attributable to rail tank cars; Fig. 2).

The category of **various (small and medium-sized) facilities** accounted for around 12% of the spills identified, without it being possible to distinguish the prevalent involvement, in 2018, of any specific type of structure (agricultural facilities, SMEs, supermarkets, etc.; Fig. 2).

Vessel of various types (but here most often barges) were responsible for about 10% of the significant spill events in 2018.

Of only relative accuracy due to the sometimes patchy nature of the data identified, analysis of the quantities (minimum estimates) of substances spilt by type of source suggests that **onshore oil facilities** were responsible for the highest share in the overall volume for 2018 at around 35%, with a total quantity in excess of the 1,000-tonne mark (Fig. 3). However, this was primarily due to smaller spills, with the exception of two incidents: from a secondary recovery site in Venezuela (PDVSA Jusepín production complex) in July, and from an unspecified oil facility (Yacimientos Petrolíferos Fiscales) in the Chilean Antarctic Territory in October (involving, respectively, 200 tonnes of crude oil and more than 700 tonnes of an unspecified oil).

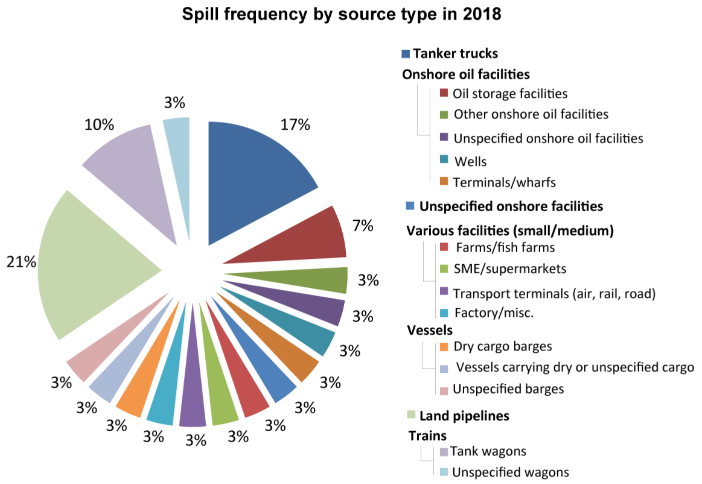


Figure 2

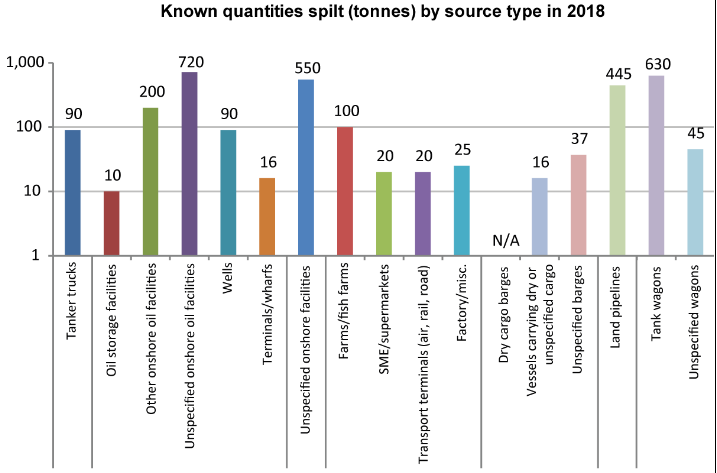


Figure 3

The next largest contribution came from **trains**, accounting for some 22% of the 2018 total and comprising small-scale incidents (median of around 30 tonnes), with the exception of one spill of approximately 600 tonnes of crude oil following the derailment of a rail tank car convoy in the state of Iowa, US, in June.

Unspecified onshore facilities contributed about 18% of the total quantity spilt (Fig. 3), related to a single large spill (around 550 m^3) of bentonite drilling fluid from a pipeline construction/laying site near the Tuscarawas River in Ohio, US, in January.

The cumulative volume spilt from **pipelines** represented approximately 15% of the total quantity spilt in 2018 (Fig. 3), a moderate share due to medium-sized spills (distributed around a median of about 100 tonnes).

Finally, despite their involvement in 17% of the cases identified, the share in the total volume attributable to **tanker trucks** was barely 3% (Fig. 3), due to the generally small quantities (median of 15 m^3) of the associated spills. Similarly, as a result of generally small spills (of around 20 tonnes, with the exception of a single event involving some 100 tonnes according to our information sources), **various (small and medium-sized) facilities** accounted for only a small proportion (around 5%; Fig. 3) of the 2018 total.

Types of substances spilt

The largest share of the 2018 total would appear, as usual, to be **oil**, accounting for at least 3,000 tonnes of oil products spilt, i.e. a total share (again underestimated) of around 76% of the annual total (Fig. 4).

Among these oil products we can distinguish:

- **Crude oil**, of which the known quantities spilt totalled about 950 tonnes, i.e. a little over 30% of the total quantity spilt. On the basis of the data brought to our attention, this share was due to half a dozen spills of more than 10 m^3, of which only two exceeded 100 m^3 (one from an oil facility in Venezuela in July, and the other from the derailment of a rail tank car convoy in the United States in June).
- In second position, **unspecified oils** (27% of the total quantity spilt), due to two spills, one of around 700 tonnes from an onshore oil facility (*Yacimientos Petrolíferos Fiscales*) in the Chilean Antarctic Territory in October, and the other of around 100 tonnes of produced water from a pipeline operated by Cor4 Oil Corp in the Canadian province of Alberta in July.
- Refined oil products, in particular **light refined products** (such as diesel, petrol, kerosene and heating oil), responsible for around 14% of the total quantity spilt. This share was linked to no less than 11 events of moderate scale (median of around 20 m^3), with the exception of two spills of more than 100 m^3: one of 160 m^3 of diesel fuel following a breach in a pipeline in the United States (Big Creek, Indiana, in March), the other of more than 120 m^3 of petrol, also from a pipeline, affecting the Darby Creek (Pennsylvania, in June).
- We can note the presence of the categories of **biofuels** and **coal derivatives** (in this case, coal), albeit in a minor way (< 2%), in the 2018 total (Fig. 4).

The identified share of effluents comprising **mineral substances** in the total quantity spilt represented around 18%, due to a spill of some 550 tonnes of bentonite drilling fluid from a pipeline under construction in the United States (Fig. 4).

Spills of **organic matter** contributed a little less than 5%, in connection with three incidents, one of which involved a spill of some 100 m^3 of slurry from a pit on a pig farm near Elliant (Finistère department, France) in April.

The share of **chemicals** was negligible in the annual total of significant spills identified in inland waters.

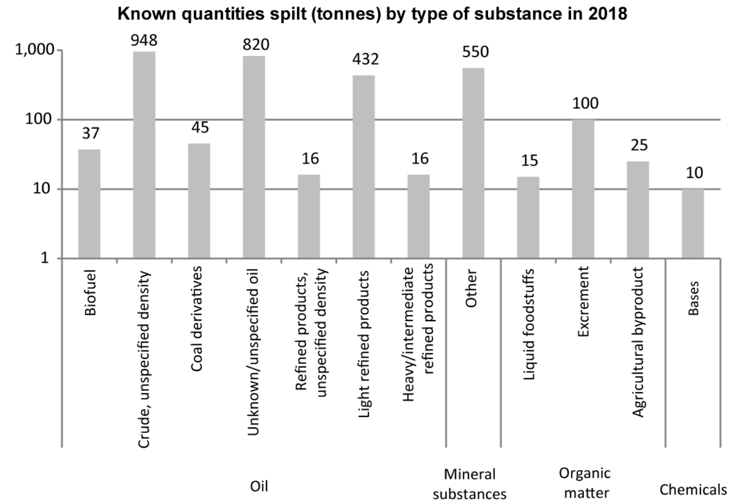


Figure 4

In this category, we are aware of only one spill of around 10 tonnes of sodium chlorite, which occurred in the Bélonce, a tributary of the Gave d'Aspe, following the overturning of a tanker truck in the town of Etsaut (Pyrénées-Atlantiques department, France) in August.

Events

The most frequently reported incidents in 2018 were **holes, breaches or ruptures** in various structures (approximately 73% of the total; Fig. 5):

- **Overturning incidents (capsizing/derailment)** represented the majority of events in this category, mostly involving land transport (tanker trucks or rail tank cars). In terms of quantities, these incidents formed the largest share of the overall total spilt in 2018, representing around 750 tonnes, primarily related to a large spill (some 600 tonnes) following the derailment of a tank car convoy in the United States in June[5] (Fig. 6).
- Some 21% of incidents in this category were due to a **loss of integrity** in various structures (notably pipelines for half of the cases in 2018; Fig. 5) and represented the second largest share in terms of quantities (almost 500 tonnes) in the overall total (Fig. 6). Distributed around a median value of 100 tonnes, the largest such spill was over 150 tonnes, resulting from a breach on a pipeline in Indiana (US) in March and the subsequent pollution of Big Creek.

The frequencies of the other types of events that led to the occurrence of **holes, breaches or ruptures** represented less than 10% of all cases (Fig. 5); their shares in the 2018 total were relatively low (between 30 and 90 tonnes; Fig. 6).

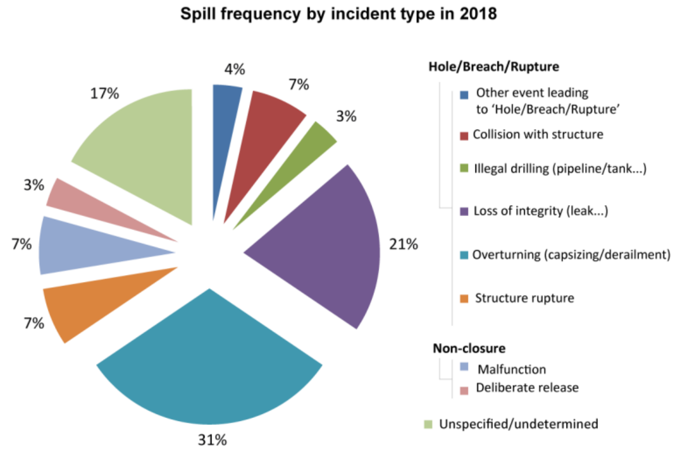


Figure 5

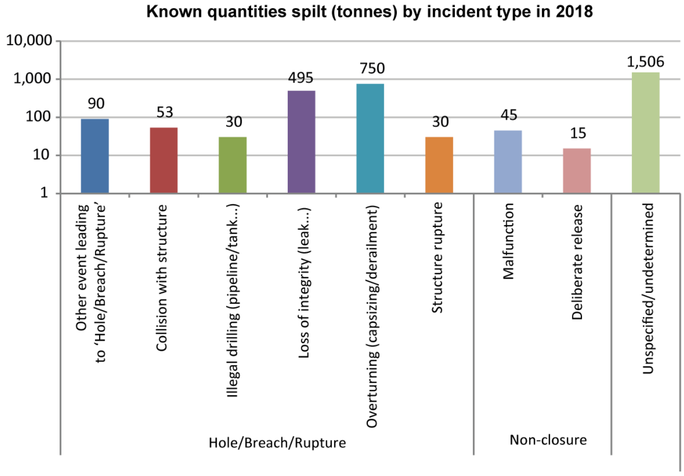


Figure 6

The year 2018 saw a fairly high frequency (around 17%; Fig. 5) of **unspecified** events in our information sources; a category that also made the largest contribution to the year's total quantity (Fig. 6), due to large spills (median volume of 200 tonnes).

Causes

Firstly, analysis of the frequencies of each cause shows that these were **unknown or unspecified** in our information sources for nearly half (48%) of the cases listed in 2018 (Fig. 7). Among the most significant cases in this category, we can mention the spill of between 500 and 600 tonnes of bentonite drilling fluid into a wetland near the Tuscarawas River (Stark County, Ohio, US) in January, and the spill of more than 700 tonnes of unspecified oil from an oil facility into a river of the Chilean Antarctic Territory in October. In addition, all the spills of unspecified causes represented, cumulatively, the largest share (56%) of the estimated total quantity spilt (Fig. 8). Clearly, these information gaps make it difficult to identify the main causes of the spills recorded over the period under review.

Among the causes identified, **technical failures of facilities** were nevertheless largely prevalent (at the origin of 31% of cases; Fig. 7). Often **unspecified** (17% of cases), they were quite frequently (10%) due to the **defectiveness/dilapidation** of various structures (notably pipelines in two-thirds of cases in 2018). Overall, the quantities spilt that can be attributed to **technical failures of facilities** accounted for around 20% of the total estimated volume for the year, i.e. approximately 600 tonnes – more than half of which were caused by the **defectiveness/dilapidation** of various structures (the origin of spills with a median volume of 100 tonnes) (Fig. 8).

[5] For the rest of the events of this type, the quantities spilt were moderate (median of around 20 tonnes).

The causes grouped under the **external interference** category were identified in 10% of the events, and proved to be a minor contributor to the overall spill total in 2018 as they involved small spills (typically of around 30 tonnes) according to our information sources.

Finally, and although less represented (7%), **natural causes**, and more specifically **atmospheric conditions**, feature among the causes identified as contributing most to the spill total. These were notably linked to the derailment of a rail tanker convoy in the United States in June and the spill of several hundred tonnes of crude oil into a river, caused by soil destabilisation in an area flooded by the river after heavy rainfall.

Human error was reported in only about 4% of the events recorded here (Fig. 7), a cause that, in theory, was not a major contributor to the estimated volume spilt in 2018 (Fig. 8).

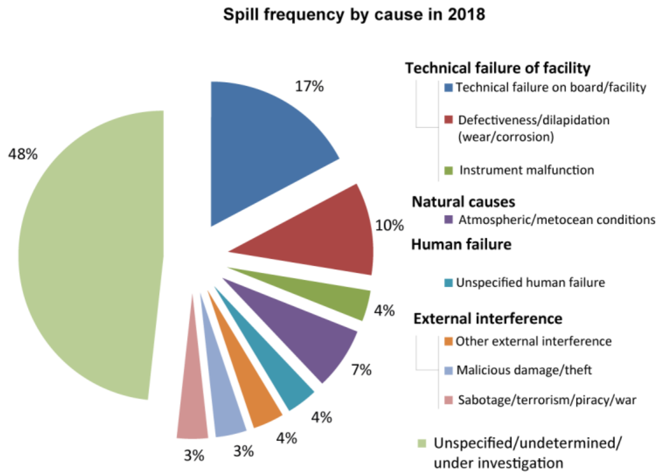


Figure 7

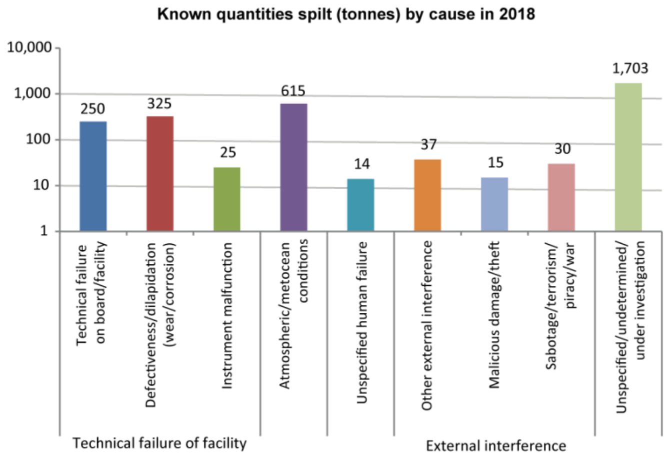


Figure 8

- ## Containment

Shallow waters and strong currents: the BoomVane 0.3 shallow draft paravane

At the end of 2018, the range of paravanes marketed by North American firm Elastec saw the addition of the BoomVane 0.3.

As its name suggests, the draught of this model is 30 cm, intended to facilitate its use in rivers and/or waterways with strong currents, and thus the deployment of containment booms in both dynamic and static mode. Its design is otherwise similar to the rest of the BoomVane range.

BoomVane 0.3 (source: Elastec)

For further information:
https://www.elastec.com/products/floating-boom-barriers/accessories/boomvane/0-3m-boomvane/?utm_medium=email&utm_source=MyNewsletterBuilder&utm_content=1125332027&utm_campaign=Elastec+Looks+Back+at+2018+1413763670&utm_term=Learn+More+About+03m+BoomVane

Site protection: the Digue Bag anti-flooding device

Since 2018, the company Seawall (based in Saint-Quentin, France) has been marketing a modular system called Digue Bag, originally designed for building anti-submergence or anti-flood cofferdams.

The Digue Bag can also have an application in a spill response context (emergency boom laying in protection mode). This temporary sea wall system is based on the assembly, using integrated straps and ratchets, of several unit modules (DB-011) of the bigbag type – in this case flexible polypropylene bags (200 g/m^2) which, when filled with either aggregates (sand, gravel, etc.) or water depending on the models, take on a parallelepiped shape measuring 90 x 90 x 110 cm (W/L/H), for a maximum individual weight of 1.5 tonnes.

Cofferdam consisting of Seawall DB-011 modules (source: Seawall)

• Recovery

Pumping: testing at Cedre of the WindTrans Zelda II HVLS pump

Canadian company WindTrans Systems is marketing a new model of positive displacement pump, the Zelda II HVLS (High Volume Low Speed). This pump is intended to facilitate the transfer of large volumes of fluids at low rotational speed, a characteristic that makes it potentially useful for the transfer of oils, notably by reducing the phenomena of cavitation and emulsification of the pumped substances.

The Zelda II HVLS is self-priming and designed to be operated manually (with a hand crank) or driven by a motor. This light aluminium pump can be transported to sites that cannot be readily accessed by vehicles, such as riverbanks, marsh edges, etc.

Given these features, Cedre decided to conduct tests, at the end of 2018, to assess the performance and potential of this equipment for deployment in difficult access sites, for the benefit and with the support of its partners (Total and the French Ministry of Ecological and Social Transition).

Twenty-two pumping trials were conducted using fluids of increasing viscosity: water, medium viscous oil (class II; 1,500 cSt), and heavy fuel oil (class III; 12,200 cSt).

View of the Zelda II HVLS equipped with hand cranks (source: Cedre)

Trials using a hand crank and two operators; Pumping well for assessments at variable suction heights (source: Cedre)

To estimate the potential for implementation without mechanical means, the trials were performed[6] using hand cranks, operated by two operators – whose appreciation of the level of difficulty was also noted. Some prospective trials were conducted using a hand-held power tool (mixer).

The maximum flow rates measured in manual operation were the following: 19.4 m^3/h for water,[7] 18 m^3/h for class II oils, and 2.1 m^3/h for class III oils. For the latter two types of oil, however, the physical effort involved in the trials was considered difficult to very difficult, suggesting a limited possibility of sustained operations in manual mode with only two operators from moderate viscosities onwards.

For all of the trials and substances, the pump proved to have good self-priming capabilities, as well as a good suction capacity over a significant height (up to 8 m on medium viscous oils).

For information purposes, the few measurements performed in mechanical operating mode using the hand-held power tool demonstrated:

- the potential gain in terms of flow rate, increased by a factor of 2 to 3;
- the need for more powerful drive equipment than the one used here (e.g. tractor, internal combustion engine, etc.) for the transfer of medium to highly viscous fluids, due to a high resistive torque but also and especially when the discharge pressure increases.

[6] In accordance with AFNOR standard NF T71-401.
[7] Compared with 55.6 m^3/h in mechanical operation using the hand-held power tool.

Despite the limitations identified for pumping oil in manual mode, the trials demonstrated certain advantages (lightness, self-priming capability, suction height) and a potential for improving performance by means of a mechanical drive using equipment adapted to the context of the planned use (power, size, etc.).

Sites with strong currents: new version of the Vikoma Fasflo skimmer

Late 2018, British manufacturer Vikoma announced the release of a revised version of its Fasflo skimmer, designed for the recovery of floating oil in relatively confined and fast-flowing waters (rivers, estuaries, etc.).

The Fasflo 25 and Fasflo 75 are thus replaced by the Mini and Maxi Fasflo skimmers, with flow rates of 25 and 75 m^3/hour, respectively. The general design remains largely unchanged. It has a skimming head with a floating weir comprising two aluminium or fibreglass floats on either side, and fitted with connections allowing two deflector/funnel booms to be attached for deployment in dynamic mode (alongside a vessel) or in static mode (a boom moored on a bank, quay, pontoon, etc.). According to the manufacturer, the model can operate at incoming current speeds of up to 4 knots.

Maxi Fasflo deployed in dynamic mode (source: Vikoma)

For the Maxi version, the oil recovered in the weir is discharged to a storage tank (on shore or on board a vessel) via an integrated positive displacement pump (powered by the GP70 diesel/hydraulic power unit). For the Mini version, the oil is transferred via a small associated pump (diesel-powered V190D lobe pump).

It would appear that the modifications made to the original model essentially concern a reconfiguration of the skimmer opening, particularly with a reinforced bow section and strengthened boom bridle, providing extra stability to the deflector booms. The deflector booms now appear to be connected by cross bridles, and have been fitted with a connection linking their inflation valves.

For further information:
https://www.vikoma.com/Oil_Spill_Solutions/Skimmers/Fasflo.html

Dynamic recovery in semi-sheltered waters: the Koseq Compact small sweeping arms

For several years now, Dutch firm Koseq has been offering a compact, containerised version of its sweeping arms: Koseq Compact 502 (see LTML n°41).

Since 2018, Koseq has been marketing the Compact 5 and Compact 8 models (measuring 5.3 and 8.2 m in length, respectively), thus extending its range of sweeping arms designed to equip small vessels of opportunity (note that the Compact 5 is nothing other than a non-containerised version of the 502). Designed for use in harbours, inland and semi-sheltered near-shore waters, these models are equipped with a weir skimmer at the base of each sweeping arm that can accommodate an oleophilic brush, disc or drum skimmer, coupled, when specifically requested by the client, with a submersible centrifugal pump comprising a worm screw driven by a hydraulic motor, with a rated capacity of 150 m^3/hour (Marflex MSP 100).

View of the Koseq Compact 2.5 sweeping arm (source: Koseq)

In the autumn of 2018, Koseq also announced an even smaller model, the Compact 2.5 measuring 2.5 m in length and weighing 200 kg, which is more specifically geared towards responding to small-scale spills – in port areas or in confined spaces (water bodies, rivers, etc.), for example.

According to various press releases[8] issued by the manufacturer, this model also has a pumping capacity of 150 m^3/hour, and is equipped with a modular skimming system (brush, disc or drum).

For further information:
https://koseq.com/models/compact-5/
https://www.linkedin.com/pulse/koseq-compact-25-new-sweeping-arm-model-annette-bosch?trk=related_artice_KOSEQ%20-%20COMPACT%202.5%20-%20A%20NEW%20SWEEPING%20ARM%20MODEL_article-card_title

[8] To the best of our knowledge and at the time of writing, the Compact 2.5 model is not featured on the company's website.

Fast-flowing rivers and estuaries: testing of the Rapid River Response System (Elastec) and OilTrawl NO-T-600 (NorLense)

At the request of two of its public partners (Maritime Affairs Directorate/MTES and Cerema[9]) and an industrial partner (Total), Cedre conducted an assessment in 2018 in the Loire estuary of the *in-situ* performance of containment and recovery systems designed for areas with strong currents. These assessments benefited from the logistical support of the Port of Nantes Saint-Nazaire, the “Phares et Balises” (lighthouses and beacons) subdivision (SPB) of Saint-Nazaire, Total’s FOST,[10] as well as the provision of equipment and experts by the companies Elastec and NorLense.

The performance in terms of concentration/recovery of floating oil and the deployment methods (manoeuvrability, nautical means required, etc.) of the R3S or Rapid River Response System (Elastec) and OilTrawl NO-T-600 (NorLense) were assessed *in situ* in 2018. These trials followed on from the NOFI system trials in 2013 and 2015 (Current Buster® 4 and Current Buster® 2, respectively), and then the trials in 2017 on the DESMI Speed Sweep and the Sweep Skimmer MOS 15 from Lamor/Egersund Group. Performed using a simulated pollutant (popcorn), the latest trials concerned the implementation potential of the systems in both dynamic mode (trawling) and static mode (from the dock).

The R3S, designed for the dynamic recovery of oil slicks in shallow waters with strong currents, combines a small recovery barge[11] and – on its bow – a MARCO Portable Filterbelt Skimmer,[12] located at the apex of a V-shaped collector pool, itself formed by two sections of permanent light booms (Optimax), separated by two deflectors (Boomvane) towed by a service vessel (here the SPB’s *Bonne Anse* buoy tender) operating at low speed.

R3S system: FOST-1 *in support/recovery, towed by the* Bonne Anse *(source: Cedre/Altiview)*

Under the conditions of the assessment in dynamic mode (wind under 5 knots, no waves), and once the correct configuration of the booms was obtained (“V” shape), the system proved to be correctly manoeuvrable. The progressive increase in trawling speed made it possible to visually assess (by the appearance of vortexes along the deflection arms) the limit of effectiveness of the system at 2.1 knots (relative speed at the system’s inlet).

With regard to the mobilisation of a low-draught vessel of opportunity at the apex of the system (landing craft, barge, oyster punt, etc.), certain important points were noted.

These included: (i) the ability, during transits, to raise the skimmer (particularly in the absence of a derrick/load arm), and (ii) the oiltight seal between the end/base of the booms and the boat (or skimmer).[13]

Trials of the R3S in static mode made it possible to estimate at 0.9 knots the minimum current speed necessary for the deployment by the Boomvane used of an 80-metre section of deflector boom (corresponding to a recovery width of 30 metres).

The OilTrawl NO-T-600 is a system comprising three parts, namely two deflector booms, a concentrator-oil/water separator, and a floating flexible tank connected to the rear of the system for storing the recovered oil (here with a capacity of 10 m^3 [14]). According to the manufacturer, it is operable for a range of currents entering the system of between 1 and 4 knots, trawled (i) with a single vessel using the manufacturer’s Trawldoor paravane or (ii) by a pair of vessels (see also LTML n°40).

Assessments in “pair trawling” mode were conducted using the *FOST-1* and *Bonne Anse* vessels, confirming the difficulties in deploying this type of system using vessels that are dissimilar in terms of size, power and manoeuvrability (windage, hull, etc.).

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[9] Centre for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning.
[10] Fast Oil Spill Team.
[11] For these trials, the FOST’s landing craft *FOST-1* (Lamor 7500 OS) was used.
[12] It should be noted that for a real oil spill, and due to the generally small size of the barge used at the apex of the collector pool, it would be necessary to implement additional means for (i) pumping/transferring and (ii) storing the recovered oils (in this respect, the company offers a floating flexible tank of a capacity of around 4 m^3, a configuration not tested here).
[13] In its complete (“turnkey”) form, the R3S enables the coupling of the MARCO belt to a Kvichak barge, the connection system of which appears to satisfy this need for an oiltight seal.
[14] Also available with a capacity of 20 or 30 m^3, an optional pump can be fitted to continuously discharge the oil to the support vessel’s storage tanks.

The deployment of the OilTrawl by the *Bonne Anse* alone (19 m; 2x175 hp) using the Trawldoor paravane made it possible to avoid the coordination and communication issues encountered when towing with two vessels. In this configuration, the sea state capability of the system proved to be very satisfactory, both in a straight line and in any sharp turns. A loss of the simulated pollutant started to appear at around 3.5 knots of relative current measured at the system's inlet. It should be noted that the internal inflatable spiral reinforcement system appears to help the deflector arms adapt well to the deformations of the water surface (troughs of about 50 cm during the trials).

View of the NO-T-600 OilTrawl being towed by the Bonne Anse *(out of shot) using the Trawldoor paravane (foreground) (source: Cedre)*

The robustly designed and relatively easy to install Trawldoor paravane proved to be sufficiently heavy to require lifting equipment for launching (here, the *Bonne Anse*'s deck crane). Finally, the trials in static mode confirmed the possibility of installing the OilTrawl alongside a dock using a paravane to keep the arms open to the current, and to perform the slackwater turning manoeuvre previously performed on other equipment tested on the site.

In conclusion, these recovery systems do indeed push the envelope where the effectiveness of traditional booms is concerned, from around 0.7 knots in frontal current (frequent in estuaries). However, for optimal implementation, they require the use of appropriate nautical means and a certain level of technical skill, highlighting the importance of regular training and exercises for the operators/companies using these systems.

Mini-skimmers: Vikomop band skimmer, Hermit drum skimmer, and Picofly mechanical weir skimmer

- **Oleophilic band skimmer: the Vikomop from Vikoma**

Vikoma has developed a new version of the oleophilic band skimmer concept manufactured for a long time by OPEC Ltd. The result of a partnership between the two British companies, this is a small skimmer model called Vikomop, with a low flow rate (12 m^3/hour according to the manufacturer).

While it is essentially designed for an industrial market (treatment of polluted water), the reduced size of this model, its stainless steel construction, and its availability in thermal (diesel) or hydraulic versions contribute to making it a potentially interesting mobile system (in terms of transportation and deployment, for example) for certain emergency situations: in front of docks, in the event of the impossibility of launching large skimming heads, etc. The manufacturer indicates the availability of bands in lengths of between 3 and 120 m, and in two types depending on the oil to be recovered (light or heavy/viscous). The relatively simple design of the device apparently also enables easy installation, operation and maintenance.

While little used and not widely available in oil spill response equipment stockpiles in France, it should be noted that this type of oleophilic band skimmer has been marketed by OPEC in the United Kingdom since the 1970s for both industrial applications and oil spill response operations, as well as by manufacturers in Finland (Lamor), Norway (Henriksen), and Denmark (DESMI), to name but a few.

The Vikomop oleophilic band skimmer (source: Vikoma)

For further information: https://www.vikoma.com/res/Vikomop

- **Oleophilic drum skimmer: the Hermit from Elastec**

Elastec launched its Hermit Skimmer at the end of 2018. Again with a very low flow rate (between 2 and 3 m^3/hour according to the manufacturer), but with the potential advantage of being very compact (68 x 46 x 13 cm), this skimmer is composed of an oleophilic drum (HDPE) mounted on an aluminium frame comprising (in addition to a small weir) two mini arms fitted with floats intended to concentrate/guide the surface layer of water towards the drum. The system is operated by an explosion-proof air motor (ATEX certified in Zone 1 and Zone 2 environments).

Hermit Skimmer (source: Elastec)

For further information:
https://www.elastec.com/products/oil-spill-skimmers/drum-oil-skimmers/tank-oil-skimmer/

Picofly mini skimmer (source: Vikoma)

- **Mechanical weir skimmer: the Picofly from Vikoma**

Although primarily designed for industrial applications (wells, manholes, drains, etc.), it is worth noting the addition of the Picofly to Vikoma's range of small portable skimmers. This is a mini-weir skimmer equipped with four floats, with a (very) small flow rate (4 m^3/hour), but the reduced size and light weight of which can prove useful in small-scale spills to collect floating oil that may be trapped in very tight areas.

For further information: https://www.vikoma.com/Portable_Skimmers.html

- ## Sorbents

Performance assessments of reusable sorbents

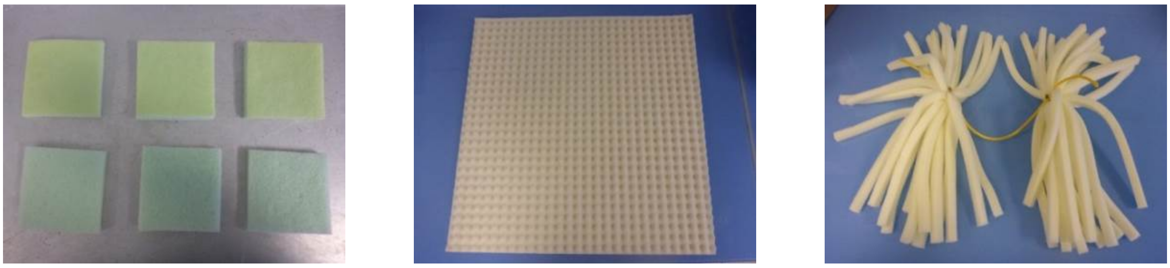
At the request of two of its public partners (Maritime Affairs Directorate/MTES and Cerema) and an industrial partner (Total), Cedre's laboratory conducted assessments in 2018 of innovative sorbent products launched on the market in recent years and presented by their manufacturers as offering good performance in terms of effectiveness and high reuse potential. The aim of these tests was to better assess their possible operational and economic benefits in the event of real oil pollution (limiting of the volumes of sorbents consumed, quantities of oiled waste to be treated, etc.).

The sorbents concerned and currently marketed are supplied in various forms (pads, rolls, belts, mats, etc.), consisting of low density polyethylene (LDPE) foams to which various copolymers have been added, an apolar and therefore oleophilic and hydrophobic material. Moreover, their open cell structure (comparable to that of a sponge) is supposed to both optimise the sorption potential (by increasing the contact surface between the product and the oil to be recovered), and enable reuse (up to several times) after extraction of the oil, generally by squeezing/wringing.

The products manufactured by the companies Palziv and Aquaflex were assessed.

Samples of the AquaPal sorbent, available in pads/rolls of LPDE and ethylene vinyl acetate (EVA; Open Cell Rolls Blue), or LPDE and ethylene methyl acrylate (EMA; Open Cell Rolls Green), recently launched by Israeli company *Palziv*, a specialist in the manufacture of polyethylene foams, were subjected to standardised testing (as per AFNOR standard NF T90-360). This was complemented by prospective, small-scale testing to characterise the retention properties of the materials after initial use and mechanical wringing of the samples (in this case, by squeezing).

Following these standardised tests, comparative measurements of retention values were performed on various samples of the Aquaflex sorbent (from American company AquaFlex Holdings LLC) at fixed values of the initial mass of oil to mass of sorbent ratio. It should be noted that Aquaflex is the new name of the company previously known as OPFLEX Environmental Technologies, which for several years had been marketing a product of the same name (OPFLEX; see LTEI n°22), a foam derived from an EMA copolymer, available in various shapes and sizes: pads, belts, eelgrass, etc.



Various forms of reusable sorbents (LDPE foam + different copolymers). From left to right: pads, honeycombed mat, mops (source: Cedre)

In summary, the results obtained confirmed the hydrophobicity of the different products assessed and their high sorption capacity, variable depending on the form – pad, mop, etc. – but consistently greater than 10, i.e. more than double the threshold value[15] set by the NF T90-360 standard for acceptance in the list of substances validated by Cedre.

Prospective assessments of reuse after wringing (by compression), performed at a laboratory scale on one of the products (Open Cell Rolls, Blue), suggest that this type of material does indeed conserve its retention properties, at least for the six successive sequences applied. Nevertheless, and with a view to clarifying this aspect, the residual oil content noted during these assessments highlights the need to conduct pilot-scale testing (e.g. standard size sorbent pads, more effective compression devices (notably rollers), etc.), which could also enable further assessment of their mechanical resistance (possible occurrence of tearing, disintegration, etc.) under conditions close to field use.

Reusable sorbents (cont.): FoamFlex200 polyurethane foam from Test1

Italian company Test1 recently developed and marketed the FoamFlex200, a sorbent with oleophilic and hydrophobic properties in the form of a flexible open-cell polyurethane foam, apparently combined with various compounds that improve oil affinity (e.g. graphene or nano-fillers, according to the manufacturer).

Test1 also announced a hydrophobic effect of this foam greater than 95%, as well as a very high sorption capacity (up to around 30 times its weight, increasing with the viscosity of the oil).

In addition to these capabilities, the company claims that the product can be reused up to 200 times thanks to a mechanical wringing process using specific roller devices. These are also available from the company under the name FF-Wring in different sizes, from a motorised version weighing 68 kg to a small manually operated unit weighing 25 kg. The high number of reuses is apparently due to the high tensile strength of the material.

Test1 markets its FoamFlex200 in the form of booms, mats and pads. This development was backed by the UK Oil & Gas Technology Centre as part of a programme[16] to support (through development, marketing, etc.) companies offering innovative technologies that address the concerns of the UK energy sector (notably in the North Sea).

For further information:
https://www.test1solutions.com/; https://www.test1solutions.com/doc/BR2.pdf

Various models of the FF-Wring (source: Test1)

Cedre: validation of hydrophobic floating sorbents

At the request of Brazilian company Biosolvit Ltda, the bulk hydrophobic floating sorbent Bioblue Natural Absorber (in the form of bio-polymer flakes) was tested by Cedre's laboratory in accordance with AFNOR standard NF T90-360. In view of its performance, it was added to the list of bulk hydrophobic floating sorbents for use on oils published by Cedre and available on its website (www.cedre.fr).

It should also be noted that, following a similar request and the conducting of tests according to *ad hoc* standardised procedures, the list of packaged hydrophobic floating sorbents (pads, rolls, mats, etc.) now includes the products AquaPal Blue and AquaPal Green manufactured by Israeli company Palziv. These products take the form of foam pads (i.e. with an open-cell type structure; see above) in low density polyethylene (LDPE) with the addition of various copolymers.

For further information:
http://www.biosolvit.com/en
https://www.palziv.com/

- **Oil detection**

[15] Five times the weight of sorbent for sorbent pads, mats, belts, etc.
[16] The TechX Pioneer technology accelerator programme, in partnership with Equinor, BP and KPMG.

Aerostat 3: small tethered balloon for monitoring polluted surfaces

Since 2018, American company Elastec has been marketing the Aerostat 3, a small-volume (3 m^3) tethered balloon advertised as a compact and relatively inexpensive version of an aerial surveillance system that is also simpler to operate than a drone, for example, and requires less expertise.

Inflated with helium, the aerostat can remain in a stationary position for extended durations to enable real-time monitoring of floating pollution or even to check the effectiveness of response systems (containment or recovery, for example) using an on-board camera equipped with a wireless communication system.

From a visual perspective, the model is strongly reminiscent of the Hawk Owl developed by British company Owls Surveillance Ltd, but with a smaller volume (15 m^3 for the Hawk Owl).

Aerostat 3 (source: Elastec)

Equipped with a signalling system (radar deflector and LED lighting), the Aerostat 3 is designed to be able to attain altitudes of up to 200 m, secured to an anchoring system by means of a rope made of UHMWPE[17] fibre (Dyneema, from Dutch company DSM) chosen for its resistance (torsion, abrasion, etc.), its light weight, and its low elongation/deformation properties. It is also worth noting that the small on-board digital camera (action camera) is mounted on a gimbal stabiliser with three motorised axes, controlled remotely via software and a joystick.

For further information:
https://www.elastec.com/products/aerial-surveillance/#photos; https://www.owls-surveillance.com/

CLAM: field kit for the sampling and extraction of chemical contaminants in the marine environment

North-American company Aqualytical has developed a small-scale device called CLAM (Continuous Low-Level Aquatic Monitoring) for the *in-situ* sampling of organic contaminants in the marine environment.

Weighing less than 900 grammes, this system has a rounded polycarbonate shell (about 15 cm in diameter). It is powered by an autonomous battery, and houses a small submersible pump that creates a flow of water (of a volume that can be measured using a flow meter) passing through a solid phase extraction cartridge (SPE discs).[18] The target compounds are dissolved organic semi-volatile compounds, notably phthalates, organochlorine or organophosphorus pesticides, PCBs, etc.

This system has been tested by various US government agencies (and notably by NOAA in 2018). One of its advantages is its autonomy of 48 hours. This enables the analysis of large volumes of water and thus, as required, (i) the integration of conditions over a relatively long period of time, as well as (ii) the ability to detect very low concentrations (below detection limits in one-litre samples of water, according to the comparative assessments conducted by NOAA). In addition, cartridge extraction enables storage for several weeks prior to laboratory processing, a major advantage over more usual spot water sample analyses that require shorter deadlines.

For further information: https://aqualytical.com/water-monitoring-extraction-kits/

Detailed view of the CLAM system and the complete field kit (CLAM 5000) (source: aqualytical.com)

- ## Floating litter/debris

[17] Ultra-high molecular weight polyethylene.
[18] Compliant with US EPA Method 3535A (SW-846): Solid-Phase Extraction (SPE).

The Brute Bin Trash Collector from Elastec

American company Elastec has been supplying containment systems for floating litter for several years now, in particular its Brute Boom and Net Boom, a range that now includes a collection system marketed under the name Brute Bin since 2018.

This is a floating pontoon made of an aluminium alloy. Its structure comprises two lateral floats on either side of a recovery basket, the opening of which, positioned facing the current, is equipped with shackles for installing on each side a deflector/funnel section of the Brute Boom (permanent floating boom with cylindrical sections made of HDPE, the longitudinal axis of which comprises a steel chain to reinforce the system).

Brute Bin floating litter recovery pontoon with Brute Boom deflector booms (source: Elastec)

The upstream ends of the boom sections are moored to the banks or any other *ad hoc* structure (pontoon, dock, etc.) depending on the specific constraints of the site where the system is installed. The basket has integrated lifting eyes so that it can be lifted and emptied by crane when necessary.

Intended to be positioned in areas of inflow or convergence/accumulation of floating litter (river confluences, stormwater outfalls, etc.), the Brute Bin is available in two versions/capacities of approximately 9.5 m^3 (L x W x H = 3.7 x 2.5 x 1 m) and 14.5 m^3 (4.9 x 2.5 x 1.2 m), respectively.

For further information:
https://www.elastec.com/products/floating-boom-barriers/trash-debris-boom/

• Response preparedness

Pollution caused by sinking heavy oil: assessments of underwater barrier prototypes by the USCG Research and Development Center (US)

Teams from the US Coast Guard Research and Development Center (RDC) specialised in oil spill response operations reported that in 2018 they assessed the potential contribution of underwater barrier prototypes in responding to spills of oils that tend to sink in inland waters and drift close to the bottom, depending on the intensity of the local hydrodynamics. This initiative aimed to find solutions to the perceived need to improve the capacity of response operations to spills involving unconventional oils (notably diluted bitumen or dilbit generated by the use of oil sands).

Initial assessments were conducted on the Kalamazoo River (Morrow Lake area, Michigan), a site chosen to evaluate the performance and limitations of a system designed to deflect oil drifting close to or on the bottom towards recovery areas under strong current conditions. These trials focused on the maintaining of the system (configuration, position, motion, sag, scour, tension, etc.) over periods of up to 24 hours and using various mooring methods depending on the type of substrate of the river bottom.

***Left**: view of a section (7.6 m x 90 cm) of the underwater deflection barrier prototype for rivers with strong currents; **Right**: lifting the deflection barrier using a winch. Note the use of plastic construction barriers filled with sand as underwater anchoring points (source: USCG Research and Development Center)*

As this is a prototype developed by the RDC, the precise characteristics are not detailed at this stage. However, the design of the submerged system is similar to a silt curtain of PVC construction, with the upper edge consisting of a permanent flotation element to hold a skirt made of X-Tex filter fabric (from Ultratech International) in a vertical position.[19] The lower edge comprises a PVC sheath accommodating the components ensuring ballast, tensioning, and mooring on the bottom (chains, slings, etc.). Its dimensions are relatively imposing (sections of 7.6 m in length and 90 cm in height).

The RDC completed these trials in the spring of 2018, again in Michigan (Lake Huron) and assessing

[19] For information, this material is used for floating silt booms, notably the MarkMaster V from American company Parker Systems, Inc. (PSI) (see LTEI n°27).

the implementation of a second underwater barrier concept, anchored to the bottom from a USCG vessel with the help of divers, this time with the aim of preventing the spread/migration of locally sunken oil in areas of relative hydrodynamic calm (river meanders, lakes, possibly seabeds/coastal bottoms, etc.). During these trials, the prototype's installation/removal procedures and its *in-situ* performance (sea state capability/configuration) were assessed using a video camera mounted on an ROV.

Views of the underwater barrier prototype developed by the USCG RDC for deployment in areas of relative hydrodynamic calm (source: USCG Research and Development Center)

Assessments of a third prototype (again on the Kalamazoo River) have been announced for spring 2019 (the details of which are not known to us), after which all the results and lessons learned from the three trials will be compiled in a report to be made public, according to the RDC. To be continued...

This programme has also received interest and financial support from the US Environmental Protection Agency (EPA) as part of the Great Lakes Restoration Initiative, motivated by the increased transporting of oil sands and dilbit in the Great Lakes region.

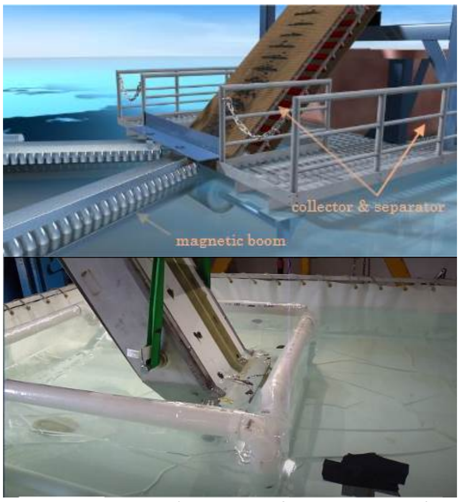
• Research

Electromagnetism for oil spill containment and recovery

In 2018, as a result of a project initiated several years ago, American company Natural Science LLC and the Fermi National Accelerator Laboratory (Fermilab)[20] announced the signing of a license agreement granting the former the rights to use an Electromagnetic Oil Spill Remediation Technology, dubbed E-MOP, designed for oil containment and recovery via a patented electromagnetic boom system, implemented in conjunction with a process involving the prior magnetisation of the oil concerned. The principle is based on the phenomenon of preferential incorporation of particles of microscopic magnetite (Fe_3O_4) into the oil: the oil-water mixture (i.e. an oil spill in an aquatic environment) is first seeded with the magnetite particles.

This phenomenon reportedly results in a magnetic colloidal suspension that can be moved using a magnet, in this case an electromagnetic boom, possibly supplemented by a belt skimmer (also electromagnetic). Natural Science LLC, which has developed prototypes of these systems, believes that they could advantageously replace conventional booms and skimmers. The company also proposes a magnetic oil/magnetite separation process.

One of the arguments put forward by the developers in favour of this method is that magnetite is not only a naturally occurring substance, it is also widely available worldwide. This would therefore reduce international shipping costs and procedures as well as procurement costs compared to other response products such as sorbents or chemical dispersants. Furthermore, according to Natural Science LLC, the optimal magnetite-to-oil ratio[21] is sufficiently low to consider the necessary quantities of magnetite to be minimal by



***Top**: modelling of the E-MOP assembly (i.e.*

[20] Managed by Fermi Research Alliance LLC (a partnership between the University of Chicago and the Universities Research Association - URA) on behalf of the U.S. Department of Energy's Office of Science.
[21] Of which we have no knowledge.

comparison with sorbents.

electromagnetic boom, collector and separator) mounted on a recovery barge; ***Bottom****: electromagnetic belt (e-ramp) prototype in action (source: Natural Science LLC)*

This proposal is reminiscent of previous Greek and Brazilian attempts in this field (development of methods for recovering slicks after the spreading of magnetic particles), which to the best of our knowledge have never been developed beyond the laboratory due notably to prohibitive application quantities. This problem is not new and has previously been encountered in the application of products designed to "trap" free oils in the aquatic environment (e.g. gelling agents).

For further information:
https://partnerships.fnal.gov/technologies/emop/
https://emop.fnal.gov/docs/docs.shtml
https://www.naturalscienceusa.com/
https://news.fnal.gov/2019/11/fermilab-oil-spill-cleanup-technology-among-finalists-for-rd-100-award/

Experimental spills of diluted bitumen in *in-situ* mesocosms: the BOREAL project (Canada)

The latest (42nd) edition of the AMOP Technical Seminar,[22] the international forum dedicated to pollution prevention, damage assessment, and clean-up of hazardous material spills in all types of environments, held in Halifax, Canada, in June 2019, included a specific session dedicated to spills in inland waters, entirely devoted to presentations related to the BOREAL project (Boreal lake Oil Release Experiment by Additions to Limnocorrals). The latter, initiated in 2017, notably brings together the Universities of Manitoba and Ottawa, Environment Canada (EC), and the International Institute for Sustainable Development (IISD). By means of experimental studies, this programme aims to better understand the potential consequences of a spill of dilbit in inland waters (e.g. fate and impacts), within the framework of the ongoing discussions in Canada concerning the regulations governing the transporting of unconventional petroleum deposits, notably by pipelines and rail convoys.

After a preliminary development and testing phase, the first *in-situ* experiments took place from June 2018 over a period of 80 days in a dedicated site within the Experimental Lakes Area (ELA),[23] located on the border of the Provinces of Ontario and Manitoba.

The experiment took place in Rawson Lake (or Lake 239), one of 58 lakes in the province of Ontario (150 km north of Manitoba).

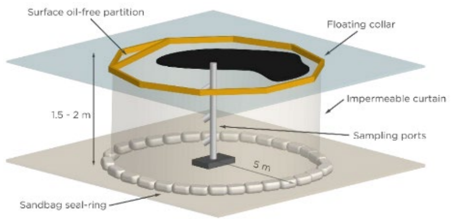


Diagram of a limnocorral (source: Stoyanovich et al., 2019)

Depending on the treatment, it consisted in spilling between 1.5 and 180 litres of a dilbit (specifically Cold Lake Winter Blend, the most commonly transported by pipeline from Alberta's oil sands) into seven of the nine mesocosms (called limnocorrals).

Aerial view of the mesocosms (with indication of the volumes of dilbit spilt) (source: Shah et al., 2019)

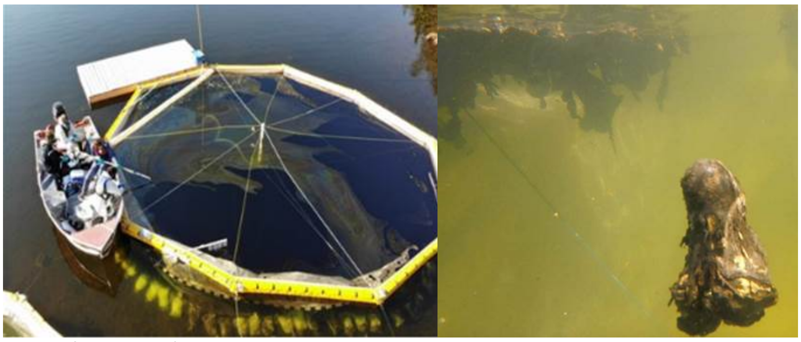
Each mesocosm measured 5 m in diameter and between 1.5 and 2 m in depth. Their surface was delimited by oil booms and the water column was isolated using a polyethylene film. Each mesocosm was equipped with a rod device enabling samples of the water column to be taken at different depths.

The preliminary results of the study into the behaviour of the dilbit were published at AMOP. First of all, at the time of the spill, the low viscosity of the dilbit caused the substance to spread widely and thus quickly cover the entire surface of the mesocosms. Subsequently, the influence of the wind and current caused the dilbit to mass on part of the surface of the mesocosms in the form of a thick accumulation.

[22] Arctic and Marine Oilspill Program.

[23] Site dedicated to environmental research on aquatic ecosystems, established in 1967 by the Canadian authorities, funded by the Ontario provincial government and the federal government (via Fisheries and Oceans Canada), and operated for some years now by the International Institute for Sustainable Development (IISD), a Winnipeg-based NGO.

After 10 days of weathering, due to the evaporation of the lighter compounds, a progressive submergence of the dilbit was observed for the mesocosm with the lowest volume of the substance (1.6 litres). After 30 days, the photo records showed the presence of balls of dilbit in the midwater or on the bottom for all of the conditions studied.



***Left**: spilling of dilbit into a mesocosm; **Right**: weathered dilbit in a mesocosm with fragmentation into balls and submersion/sedimentation (source: Stoyanovich et al., 2019)*

The results of the density measurements showed an increase from 0.9215 at T_0 to 1.0007. At the end of the testing, some of the dilbit could still be observed on the surface due to adhesion to the walls of the mesocosms.

For further information:

Shah, K., Watson K., Hollebone B.P., Yang Z., Lambert P.G., Faragher R.J., Aljawahari M., Dey D., Mirnaghi F.S., & Stoyanovich S., 2019. *The BOREAL Project: The Design and Execution of a Controlled Oil Spill Study in a Canadian Freshwater Lake.* Proceedings of the Forty-second AMOP Technical Seminar, Environment and Climate Change Canada, Ottawa, ON, Canada, pp. 276-294

Stoyanovich S., Rodríguez-Gil J.L., Hanson M., Hollebone B., Orihel D., Palace V., Faragher R.J., Mirnaghi F.S., & Blais J., 2019. *The BOREAL Project: The Physical Fate and Behaviour of Diluted Bitumen Spilled into Freshwater Limnocorrals.* Proceedings of the Forty-second AMOP Technical Seminar, Environment and Climate Change Canada, Ottawa, ON, Canada, pp. 295-300.

Pipelines and pipes: biosensors for the early detection of oil leaks

Scientists at Mississippi State University (US) have developed a biosensor technology designed to be deployed along the outer wall of pipelines as an early warning device to alert operators to the occurrence of an oil leak.

Presented at the 255th meeting of the American Chemical Society (ACS), this biosensor concept is based on the use of heterotrophic bacteria known as exoelectrogens, a term that describes their electron-emitting properties when they break down organic matter in the absence of oxygen. In general terms, the principle is one of a bacterial battery, the anode of which is covered with a biofilm composed of the necessary exoelectrogenic species (previously identified and selected). In the presence of an organic substrate (in this context, an oil), these bacteria release electrons that, when transferred to the cathode (composed of a group of autotrophic (phototrophic) or sulphate-reducing bacteria), ultimately power an electrical circuit, the resulting voltage being detected at the terminals of a resistor – an increase in voltage indirectly indicating possible pollution (i.e. a leak).

This project involves the search for bacterial strains that (i) generate sufficiently high cathodic voltages, and (ii) can withstand a range of salinity, pressure, and other factors, particularly with a view to extending the principle to the monitoring of offshore oil facilities.

For further information:

Nandimandalam H., Ghimire U. & Gude V.G., 2018. Microbial biosensors for the early detection and prevention of hydrocarbon pipeline releases. *HDIAC Journal*, 5 (**3**), pp. 16-21.