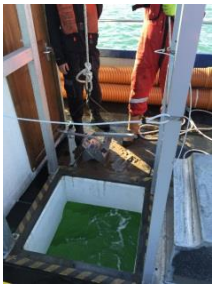
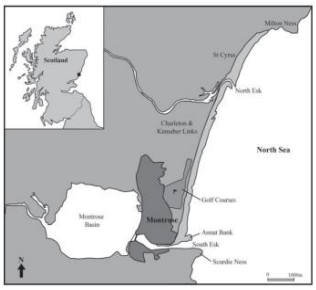
PARTRAC

Sediment Transport Studies

Mapping Onshore and Alongshore Coastal Sand Transport Montrose Bay

Client: Angus Council





Angus Council has been working with the University of Dundee and other stakeholders to assess on-going erosion at Montrose Bay. There is some support to the idea that sedimentary material, dredged from the South Esk channel that drains Montrose Basin, might have some value in mitigating the observed erosion if emplaced just offshore from the beachface. The concept is that the dredge material will trickle feed and replenish the beachface through time via onshore transport. Montrose Port Authority are concerned that any dredged material placed in the shallow subtidal zone may fill the channel quicker and resulting in a second dredge within a year, which is a costly exercise and affects the commercial viability of the port's activities. Thus, there has been support from several parties to conduct a study to map the movement of sand which is deposited in the shallow subtidal.

Partrac was commissioned to conduct a tracer study to inform this issue. Two tonnes of fluorescent magnetic sand, equivalent hydraulically to the dredge material, was introduced into an area approximately 300-400 m offshore from the beach; a series of sampling visits were undertaken to collect samples of the sediment from both the beach face and the subtidal zone to the south of the drop zone. Beach night-time surveys using blue lamps were also conducted to assess tracer presence on the beach face.

Benefits: The mapping of sand movement on a geospatial basis has helped inform the stakeholder community on delivering coastal management strategies. The conflict of benefits associated with beach replenishment versus return of material to the port channel area can now be better evaluated from the results obtained from the study, which showed sand transport in both directions (southward and onshore).

Scarborough Beach Sand Tracking Study

Client: Scarborough Council
Royal Haskoning DHV

The longshore drift along the North East England coastline is generally in a North to South direction. At Scarborough (North Yorkshire) however, on the South Bay frontage, there are issues associated with the return of excavated/recycled beach material to its source, due to a presumed northward current recirculation. The return of the material leads to localised buildup of sand which periodically overtops the wall at the back of the beach onto the promenade road. There was interest in whether material is transported to a shallow offshore bar, and if it is, whether there is ensuing transport northeastward into the area of the Scarborough Harbor mouth. Partrac tracked beach sand on the shoreface to determine movement. 750 kg of fluorescent (green), enhanced para-magnetic tracer sand, hydraulically similar to the native beach sand, was introduced onto the beachface at three separate locations. Recurrent sampling visits assessed the longshore transport of the tracer; night-time blue light walkover surveys were used to assess tracer redistribution in advance of collection of surface cores to enable quantitative assessment of tracer concentration. Deep cores established the mixing depth. Offshore wave conditions were recorded using a wave buoy. The data show a distinctive drift northward from a certain (specific) point on the beach, and southward transport to the south of this point (a divergence zone). Rates and maximum transport distances, as well as some information on the threshold wave climate required to induce longshore transport, were reported.

Benefits: The results are being used to draw up a beach management plan by Scarborough Council, and also to feed into the regional Shoreline Management Plan.

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Department of Defence – US Tracer Demonstration for Pollutant Discharges

Client: US Navy (SPAWAR Systems) San Diego, USA

Contaminated sediments are a continuing regulatory issue, particularly if discharged into aquatic environments. Both the Department of Defence (DoD) and Environmental Protection Agency (EPA) have great interest in determining which nearshore discharges contribute contaminated sediments to the environment to allow for effective control.

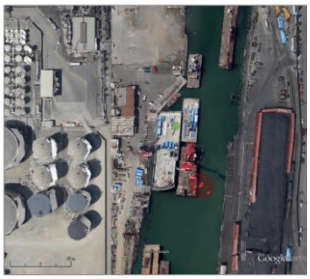
Partrac undertook a particle tracing study at a US Navy base with 850 kg of tracer silt (d_{50} 30 microns) being introduced into the sea to mimic a flash flood outfall discharge.

A 3D network of subsea magnets was deployed, in addition to water sampling, sampling by dipping magnets and in situ fluorimetry, to generate an understanding of tidal transport over four tides. The direction of transport was established, and the various sampling activities enabled a detailed understanding of the plume and its dynamics through time, including the net (tidally averaged) deposition.

Benefits: The study demonstrated the use of the sediment tracer and tracking methodology to the DoD, a number of consultants active in the contaminated sediments sector, and to the EPA. The range of sampling approaches (*in situ*, magnets, grabs, in situ fluorimetry) were found to map suspended sediment transport.

Propeller Wash Impacts on Contaminated Sediments, San Francisco

Client: Sea Engineering, Inc (Santa Cruz)



Contaminated sediments are found in numerous ports and harbour environments world-wide, where they comprise legacy deposits from historical industrial activities as well as more recent deposits from on-going contamination. Management approaches directed towards decontamination of seabed sediments require information on the range of processes governing the transport and fate of the contamination.

Partrac was contracted by Sea Engineering, Inc (Santa Cruz) to provide sediment tracking services for the Heckathorn Superfund Site in the Lauritzen Channel, Port of Richmond, California, to assess the fate of silt bottom sediments impacted by high mean flows and turbulence associated with local vessel propeller wash.

Partrac developed a dual signature silt tracer of two colours (green and red). 175 kg quantities of each were released in the form of specialised low profile, frozen blocks onto the seabed at two locations in the central region of the Lauritzen Channel.

Mobilisation and transport were measured by using powerful, *in situ* moorings of permanent magnets arranged concentrically around the tracer drop zone and through collection of sediment grabs.

Benefits: The study showed that local vessel movements coupled to the relatively shallow depths promoted resuspension of the bottom sediments. Local water movements then distributed the tracer across and within the basin, with limited transport into the main channel. The results were considered further in developing management strategies, in particular the necessity for additional dredging, for the region of the port.

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Moloka'i, Hawaii – Sediment Transport Impacts on a Coral Reef System

Client: United States Geological Survey

Island-associated fringing reefs in tropical and sub-tropical oceanic environments are an important and fragile ecosystem. Their juxtaposition to land, frequently hilly and volcanic in nature, gives rise to a range of sediment impacts associated with deposition of terrestrially derived soil material during and following rainfall events. Excessive deposition can lead to degradation of a reef, reducing calcification rates, biological recruitment, altering species composition and depth distribution limits, and contributing to a general loss of biodiversity.

Partrac undertook sediment tracing studies on the reef flat of the Moloka'i southern shore to establish (alongshore-on/offshore) dispersion pathways for terrestrial soil material and to map depositional footprints. Two colours (green and red) of Partrac's bespoke dual signature silt tracer, was released at two locations on the reef frontage.

An extensive network of in situ magnets, grab sampling and deployments of a novel underwater fluorescence camera (the USGS Flying Eyeball, modified to view fluorescent tracers) mapped dispersion. The study quantified rates and directions of transport of suspended sediments, and delimited the footprint for both origins, confirming that much of the terrestrial soil material deposited on the reef is largely trapped and remains local to its original depositional site, even under energetic conditions.

Benefits: An improved understanding of the local sediment transport on reef environments. The information is being used by reef managers, policy makers and scientist to conserve reef environments.

Re-Contamination in the Lower Duwamish Waterway

Client: Washington State Department of Ecology

Source control i.e. the reduction of contamination from upstream or diffuse sources, is a critical element in any management plan for contaminated waterways. If source control measures are not successfully implemented then a situation exists in which contamination will continue through time, and the clean-up of waterway segments becomes increasingly problematic. Partrac was contracted by the State Department of Ecology to conduct tracer studies to assess the fate of sediments entering the Lower Duwamish estuarine system from the green River. A sand and silt tracer were released from a mid-channel location at the confluence of the estuary-Green River at River Mile 4.4 upstream from the ocean. An extensive sampling programme which included magnets fixed to port structures, pumped water sampling and bed sampling using a specialised magnetic sampler collected data on tracer presence after the first day, after one week, one month and two months showed the redistribution of the tracer within the system. The findings indicated rapid deposition of sand size material (within 400 m of the drop zone), and a trapping of the silt, and a thorough mixing vertically and laterally, within the port area by the estuarine circulation. A longer term gradual fining was observed for the silt fraction, representing marginal deposition.

Benefits: The data indicated conclusively that re-contamination by upstream contaminant sources is a factor that requires consideration for any strategic clean-up, and incoming sediments are not simply transported through the estuary without mixing and deposition. The findings broadly supported inferences in the regional sediment transport model (STM), and were use to develop source mitigation strategies for the waterway.

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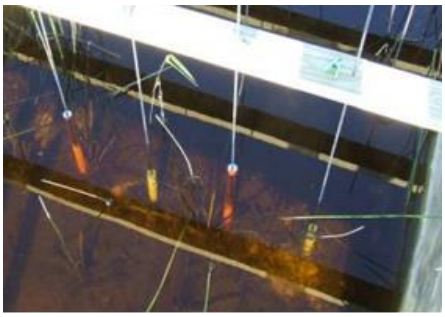
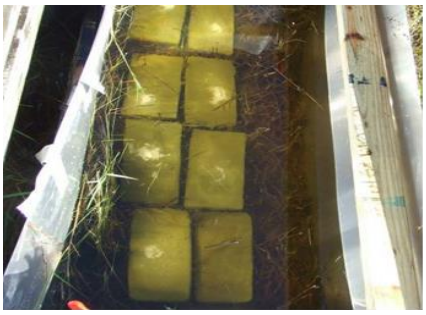
Florida Everglades - Floc Transport in Vegetated and Non-vegetated Habitats

Client: South Florida Water Management District





The Florida Everglades, USA is a vast, low gradient, wetland and one of the world's premier areas of outstanding natural beauty with unique biodiversity. It is the principal source of clean drinking water in the state of Florida. Management for flood control and water supply during the twentieth century affected water levels, distribution, and seasonal timing.

Efforts to restore the Everglades (such as the ongoing Comprehensive Everglades Restoration Plan, CERP) have focused on re-establishing more natural hydro-patterns. However, although extremely important, much less attention has been paid to the importance of the actual movement of water, especially the physical and geomorphological effects, and of the likely range of consequences flow restoration efforts may produce.

Partrac's tracer was used to assess how the organic rich, flocculated sediments now found overlying the Everglades limestone pavement are re-suspended and transported by enhanced flows, and to assess how the suspended floc material behaves in open water areas, and in semi and fully vegetated areas.

A series of artificial channels (~8.5 m long x 1.5 m wide) were constructed in an area known as the Loxahatchee Impoundments Landscape Assessment (LILA), each corresponding to a differing vegetation density with a single flow discharge.

A special, ultra-low density tracer (1050 kg m-3), hydraulically matched to the floc material, was designed and deep frozen ('ice encapsulation') and laid in a strip across the upstream zone of the channel. Tracer re-suspension was recorded using a 3D array of submerged magnets, and optical backscatter sensors; flow was measured using a flush mounted ADCP.

The studies directly showed differences in floc transport laterally and with height in the flow, and clearly delimited the influence of vegetation on net floc transport. Quantitative estimates relating vegetative density to net flow transport were derived, and some 'skimming' flow was observed.

Benefit: Results informed the CERP programme directly. Specifically, the data showed that re-suspension of bottom floc material would occur during only slightly elevated flows, and the low density of the flocs exacerbated advective transport. Should restored flows induce re-suspension, then serious ecological consequences may arise should many thousands of tonnes of flocs start to be mobilised into the water column and transported downstream.

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Contaminated Sediment Transport Study
Falkirk Wheel Basin

Client: British Waterways

The Falkirk Wheel in Scotland is the world's first and only rotating boat lift, linking the Forth-Clyde and Union Canals. Sediments in the Forth Clyde were contaminated with mercury from an historic weapons munitions factory.

Partrac's sediment tracer was used to determine whether there is a longitudinal, vessel-induced migration of contaminated sediments into the new sections of canal, and in particular into the new Falkirk Basin.

The tracer was deployed onto the canal bed in frozen blocks and a sampling framework devised using in-water magnet moorings and sediment traps.

Benefits: Bi-directional transport was found to occur due to the passage of canal narrowboats, confirming an ongoing contamination of the new canal sections and proximal basin areas. Transport rates were also obtained. The study informed local sediment management of the contamination and clean-up process.

Highway runoff – Contaminated Sediments in a River Reach

Client: Highways Agency / Environment Agency
(Integrated Research Programme)

Highway runoff is episodic and its composition varies over short temporal scales with most contaminants being washed off at the start of storm events. The loads and particle sizes of sediments in highway runoff are dependent upon storm characteristics (such as antecedent period, storm intensity and duration) combined with the hydraulics of the highway drainage system (pavement area, carriageway slope and the presence and maintenance of sediment traps). Particle tracking offers a means of assessing contaminated sediment runoff to adjacent watercourses. A study was designed to utilise uniquely labelled (fluorescent-magnetic) tracer particles of two differing size fractions (<63 microns and 63-150 microns) to determine how different sediments are transported through the drainage system and into and down the reach sections. Tracers (mixed together as a slurry) were flushed in a series of pulses down a drain mimicking a flash flood. A range of sampling activities, including visual assessment of the pipe network, in situ magnets, in situ fluorimetry and collection of cores were deployed to map the distribution of the two fractions in the system.

Sand tracer was found predominantly within the pipe network and in the nearfield of the discharge pipe, whereas the silt tracer was flushed down and into the river reach, remaining almost wholly in suspension for up to 80 m. A mass budget for both sediment fractions was an outcome of the project.

Benefits: The tracer data were used to directly validate the predictions from a numerical water quality model. In addition the study was used to inform regulatory policy on the key issues of how stream organisms are exposed to accumulated highway-derived particulate matter, and what processes produce and control the observed impacts and how are they mediated.

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Assessment of Agricultural Buffers to Control Soil Loss to Water Courses

Client: Defra (Department for Environment Food & Rural Affairs) via ADAS

Soil runoff from agricultural land can impact water quality in rivers, lakes, and coastal waters by increasing sediment load, nitrogen, phosphorus and pesticide levels. It also fills roadside drains and covers roads and can cause flood issues.

There is general agreement that riparian buffers help to reduce sediment loss to watercourses, but a comparison of study results to date is hampered by contrasting sites, study periods and technologies. Partrac provided dual signature soil tracers to assess effectiveness of riparian buffer strips for sediment loss mitigation in three sub-catchments (Avon, Wensum and Eden).

Partrac designed three custom fluorescent-magnetic silt-sand tracers, each hydraulically matched to the catchment specific soil properties. Tracer was introduced to the field surface and integrated with the soil matrix. For the first time, a magnetic susceptibility instrument (see photo) was used to rapidly spatially map tracer concentration on the soil and buffer strip surface pre-tracer introduction, following tracer introduction and for a two year period. Mapping was supplemented by small cores and the use of in situ magnets implanted in the soil.

Benefits: Riparian buffer strips were shown to be effective in controlling soil loss to water courses. The results informed UK policy to deliver a new sediment sourcing framework for supporting the England Catchment Sensitive Farming Delivery Initiative (ECSFDI), resulting in a publication:

Collins, A.L., Zhang, Y.S., Duethmann, D., Walling, D.E. and Black, K.S. 2013. Using a novel tracing-tracking framework to source fine-grained sediment loss to watercourses at sub-catchment scale. Hydrological Processes 27, 959-974).

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