

# **Case Study of Waste Management Evolution for Oil and Gas Projects based at Sakhalin Island (Russia).**

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## **ABSTRACT**

Major oil and gas development on the Sakhalin Island (Russian Far East) caused a variety of impacts on the economy, local community and infrastructure of the island. The development boosted local services and businesses. Some local infrastructure received direct upgrades and improvement during the construction phase of the oil and gas projects. This case study describes the evolution of waste management (WM) on Sakhalin following the development of two major oil and gas projects (Sakhalin 1 and Sakhalin 2). The WM strategy proposed by the two Projects included an upgrade of municipal landfills and promotion of waste diversion. The strategy was relatively successful for the construction phase of the projects however a number of outstanding issues still has to be addressed as the Projects move to operation phase.

The overall quality of WM offered outside the scope of the Projects achieved minor improvements but generally still remains low. Some progress has been made on the stakeholder's engagement in WM planning. The government of Sakhalin Island accepted a proposal of WM development on the island which has yet to be implemented.

**Key words:** *Sakhalin, oil, gas, waste, diversion, landfills*

## **1 Introduction**

The Sakhalin Island (Sakhalin), a relatively small territory located in the Russian Far East (Figure 1), has been a subject to massive foreign investments related to the offshore oil and gas projects starting late 90's. More than a decade of intensive development on Sakhalin caused a variety of impacts on the economy, local community lifestyle and infrastructure of the island. Billions of dollars invested in to an isolated territory during a short time period created an oil boom effect. The demands of the new Projects required an upgrade of local infrastructure and development of different services, including waste management (WM).

This case study presents the author's observation and lessons learned from the implementation of WM strategy introduced by Sakhalin 1 and Sakhalin 2 major oil and gas international Projects (the Projects). The study has two objectives:

- Describe how international companies managed their waste using the available WM infrastructure and services
- Demonstrate how these services and infrastructure evolved in the result of the Projects.

The quality of existing WM services and available infrastructure was sub-standard on Sakhalin. To ensure that their waste is managed in a responsible fashion the Projects proceeded with an upgrade and development of the local facilities to bring their operations to the standards typical of Organization for Economic Co-operation and Development (OECD) countries.

## **2 Background**

### **2.1 Oil and Gas Development on Sakhalin**

The Sakhalin Island has a history of oil and gas development. The onshore oil exploration started in the north of Sakhalin in 1888. Major oil and gas production started in 1923 and continued until now although the onshore production is currently declining.

In the late 90th Sakhalin Island has become a hot spot for the international offshore oil and gas development for a number of reasons.

- There are several large oil and gas deposits discovered offshore with a total potential of 3.8 billion tonnes of oil (7 fields) and 2.5 billion tonnes of natural gas (10 fields) (Strategy, 2010; Khoroshavin, 2009).
- The Sakhalin Island is located close to China, Korea and Japan which grants relatively easy access to an Asian energy market.
- Russia did not have proper technology and specialists to develop oil and gas offshore or Liquefied natural gas (LNG) capability at the time and desperately needed foreign investment due to the economic difficulties in 1990's.
- The economic policy of the Russian Federation at that time promoted investment of foreign capital in resource development, resulting in two Production Sharing Agreements (PSA) that were put in place in 1996 to develop Sakhalin 1 and Sakhalin 2 Projects. There was a potential for foreign investments in other projects as well.
- In spite of low oil price (\$13 US per barrel in 90's) that caused some risks for foreign investments, several international companies decided to proceed with offshore development on Sakhalin under the PSA conditions.

In addition to the large Sakhalin 1 and 2 projects described in more detail below, the first offshore project started in 1998 by Rosneft (Russia) and oil production was active in 2000 – 2004 for Sakhalin 6 Project (originally called Petrosakh, currently Urals Energy).

Several other projects (Sakhalin 3-9) are potentially available for development and are currently at the exploration stage. The companies participating in the exploration are Sinopec (China), BP (UK), Gazprom and Rosneft (Russia).

## 2.2 Sakhalin 1 Project

The Sakhalin-1 is a consortium comprised of the following participants (Exxon Neftegas Limited, undated):

- Exxon Neftegas Limited (U.S ExxonMobil, the operator, 30 percent share)
- Rosneft (Russia, 20 percent)
- SODECO (Japan, 30 percent)
- ONGC Videsh Ltd. (India, 20 percent)

The Sakhalin-1 Project involves development of three oil and gas fields (see Figure 2) in two phases. The Project Phase 1 includes an offshore platform, onshore well site, onshore and offshore pipelines, onshore processing facility (OPF) and marine oil terminal, located in the Russian mainland. Extended Reach Drilling technology is used for both onshore drill sites and the offshore platform.



Figure 1: Location of the Sakhalin Island

Phase 1 of the Project is based on projected production of 307 million tonnes of oil and condensate and 485 billion m<sup>3</sup> of gas. In 2007 the Project reached its production goal of 250,000 barrels (40,000 m<sup>3</sup>/d) of oil per day. In addition natural gas production for the peak winter season in 2007 has been 140 million cubic feet (3.92 million cubic meters) per day. Phase 2 includes two more offshore platforms and extended capacity of the OPF and pipelines.

Capital investment of the Project reached 18 billion USD in 2009. Workforce in the construction peak reached more than 10,000 people in the field and offices.

The Sakhalin 1 Project schedule is as follows: Phase 1 production started in 2006, Approval for the Phase 2 of the Project was received in 2010 and Phase 2 production is expected in 2014.

### 2.3 Sakhalin 2 Project (Sakhalin Energy Investment, undated)

Sakhalin 2 Project is run by Sakhalin Energy Investment Co. Under the shareholding structure of Sakhalin Energy, Russian company Gazprom holds 50% plus 1 share, Shell has 27.5%, Mitsui - 12.5% and Mitsubishi - 10%.

Sakhalin Energy developed an oil field and a gas and condensate field that were discovered in 1980s (see Figure 3). These fields have more than 1 billion barrels of oil, more than 600 billion m<sup>3</sup> of gas. Phase 1 of the Project included the offshore platform Molikpaq which initially operated 7 months a year, producing 70,000 barrels of oil a day.

In addition to the Phase 1 Molikpaq platform, the Phase 2 of the Project includes two new offshore platforms, oil and gas pipelines, onshore processing facility (OPF), an LNG plant and marine terminals for crude oil and LNG.

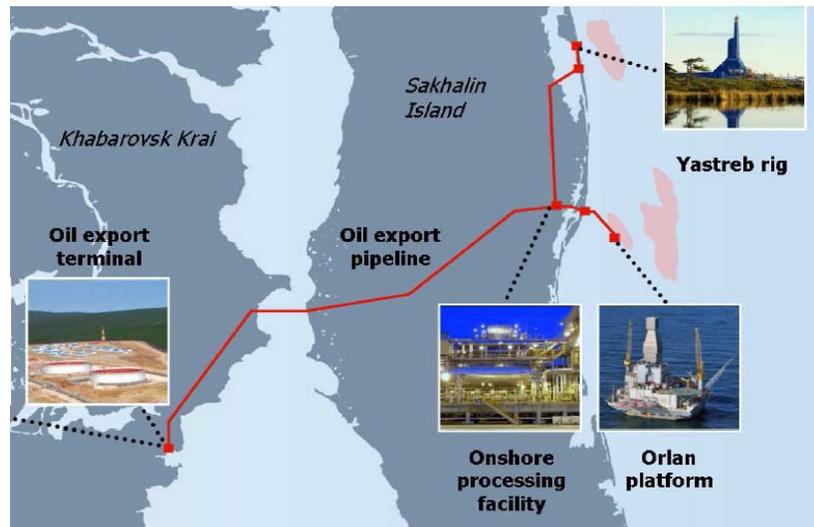


Figure 2: Location of the Sakhalin 1 Project, Phase 1

(source: [www.sakhalin1.com/Sakhalin/Russia-English/Upstream/Files/facilities\\_map\\_ENG.pdf](http://www.sakhalin1.com/Sakhalin/Russia-English/Upstream/Files/facilities_map_ENG.pdf))

The total investment in the Project construction is more than 25 billion USD. Workforce in the peak of construction reached more than 25,000 people.

Gasprom (Russia) became a Project operator in 2007 (Sale and Purchase Agreement triggered share transfer to Gazprom) replacing Shell.

Project schedule is as follows: Phase 1 – started 1996, Phase 2 – construction started 2004, Project commissioned in 2009. Operation will continue until 2045, with production of oil reaching 180,000 barrels per day and LNG production reaching about 9.6 million tonnes per year.

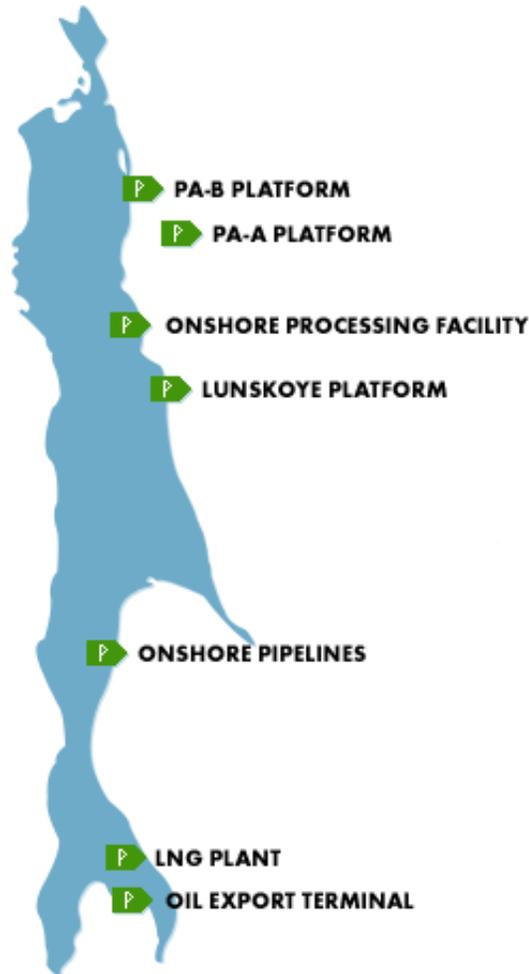


Figure 3: Location of the Sakhalin 2 Project

(source: [http://www.sakhalinenergy.com/en/project.asp?p=explore\\_phase2](http://www.sakhalinenergy.com/en/project.asp?p=explore_phase2))

### **3 Projects Conditions and Challenges**

Sakhalin Island is an isolated territory and transportation to and from the island is a logistical challenge with the northern part ice bound up to five months per year. Projects' facilities are located in the remote areas, with unfavorable natural conditions, including extreme arctic conditions and high seismic activity. The Projects' territory is characterized by a unique variety of commercial bio-resources, diverse and fragile ecosystems (grey whale migration, prolific salmon spawning rivers, and endangered wildlife), undeveloped infrastructure, and a variety of social and economic problems, including needs of indigenous people living in the north part of the island.

Oil and gas Projects are developing simultaneously (Sakhalin 1, Sakhalin 2, exploration for Sakhalin 3 - 9) competing for the workforce and available infrastructure. Upgraded infrastructure was required to meet external (i.e. Lenders and Russian Government) and internal commitments and requirements. WM practice of the Projects has been identified as one of the high profile issues that had to be addressed.

#### **3.1 Socio-Economic Conditions of Sakhalin**

Sakhalin has been one of the Russian regions suffering economic depression in late 90's. It has a classic "resource economy" relying on oil and gas exports, coal mining, forestry, and fishing. Before 1990's the Sakhalin Island was "stuffed" with military bases and facilities that were abandoned as the Soviet Union collapsed in 1991. With population rapidly declining due to the outflow migration in 90's, the island infrastructure deteriorated as well.

Local government supported foreign investments in the offshore oil and gas development. The government strategy was to use the Projects to drive local economy out of decline and develop local technical capacity, businesses and services capitalizing on the success of the oil and gas Projects (Shubina, 2009).

The quality of WM services was low on Sakhalin, reflecting overall status of the economy and social conditions at that time.

#### **3.2 WM Challenges on Sakhalin Island**

The existing WM on Sakhalin Island was as following when the Projects started (IT Russia Services, 2002):

- Sub-standard municipally operated disposal facilities (Figures 4 and 5)
- Waste collection and disposal provided by the State owned municipal company to the most of population and businesses
- Some informal recycling at the municipal solid waste (MSW) landfills
- Limited re-use/resource recovery/recycling capacity with exception of metal scrap
- No oil spill waste treatment capacity
- No hazardous waste management capacity. Hazardous waste was commonly disposed of in the MSW landfills

- Significant waste legacy from the onshore oil and gas development
- Likely site contamination legacy from past military operations and abandoned chemical stores (obsolete pesticides)
- Two licensed private WM companies that operate locally since 1999. Limited competition resulted in a very high price for the services.

Development of WM infrastructure was a priority for the local government. For the project's, one of the challenges was to deal with the complex environmental regulations that existed but were being selectively enforced on Project operations such as zero discharge requirements for the offshore platforms.

Another example of the problems WM had to deal with is the Production Sharing Agreement (PSA) implications. The imported materials and goods were exempted from an import tax under the PSA. When the materials and goods became waste there had to be an approval granted by the Russian Custom office to write off an "unpaid" tax. The requirement was not easy to fulfill since there was no procedural order in place to compete such a write off. The bureaucratic hassle created major delay in waste removal from the waste storage facilities and caused a number of legal and economic implications. The adequate solution in this case could have been a waste export to the country of origin but this would require an approval under the Basel Convention which is a long and complex procedure.



**Figure 4: Burning landfills are common on Sakhalin (photo by A. Chaikine)**



Figure 5: Metal recycling at the scrap yard (photo by A. Chaikine)

## 4 WM Strategy for Sakhalin 1 and Sakhalin 2 Projects

### 4.1. Expected WM Impact of the Projects

The estimate of Projects waste generation volumes is provided in the Tables 1 and 2 in comparison to the waste generated by other sources, including general public (Exxon Neftegas Limited, 2003; IT Russia Services, 2002). The most labor intensive construction phase, that generates bulk of the waste, takes four to five years. The operation phase, that continues for another 35-40 years, generates mostly drilling waste, that are injected in the deep wells, and relatively small amount of solid waste, compare to the construction phase of the Project.

The following conclusions were made based on the results presented in the Tables 1 and 2 and following the outcome of WM study performed by the Projects at the early stages of the development (IT Russia, 2002):

- Hazardous waste generation from the Projects is potentially comparable with the existing generation on the island
- Drilling waste generation expected from the Projects exceeds the existing generation from other sources
- Overall generation of nonhazardous waste will be less than 10% of the existing level on Sakhalin
- MSW generation is comparable with local level in the areas of Project development (south and north for Sakhalin 2 and north for Sakhalin 1)
- MSW generated by the Project offices in the capital of Sakhalin contributes to adverse environmental situation (burning landfill in the center of the city)

- Oil spill waste has no disposal facility and has to be stored onsite until the treatment solution is developed.

Table 1. Estimate of annual waste generation during the four years of construction

Waste, tonnes	Sakhalin 1	Sakhalin 2	Others
Hazardous waste, excluding oily waste	100	100	300
Oily waste	250	400	1000
Metal scrap	200	600	
Construction waste	4500	9000	
Municipal solid waste	3500	5000	250,000
Workforce/population	10,000	25,000	250,000

Table 2. Estimate of annual waste generation during the operation phase

Waste, tonnes	Sakhalin 1	Sakhalin 2	Others
Hazardous waste, excluding oily waste	20	10-30	300
Oily waste	100	100	1000
Municipal solid waste	800	400	250,000
Drilling waste	40,000	Same as Sakhalin 1	30,000

#### 4.2 WM Strategy

The Sakhalin 2 Project played a leading role in WM development on the Sakhalin Island. The Sakhalin 1 Project generally followed Sakhalin 2 strategy, providing financial contribution to the landfill upgrade in the northern part of Sakhalin and promoting waste diversion.

The following WM strategy has been accepted and implemented for the Sakhalin 2 Project. It generally aligns with the strategy accepted by Sakhalin 1.

- Promote direct and proactive control of hazardous wastes, inclusive of no disposal of hazardous waste on Sakhalin
- Promote cooperation and sharing information between the Projects
- Inject drilling waste into the deep wells
- Employ limited use of non-hazardous waste incinerators
- Develop oil spill waste treatment capacity onsite
- Promote development of local waste management infrastructure through funding the sustainability projects (Sakhalin 2)
- Upgrade selected local landfills to OECD standards and co-dispose Project waste with waste from local municipalities (Sakhalin 2)

- Avoid co-disposal of Project waste and waste from local municipalities (Sakhalin 1)
  - Initially pursuing opportunity to build dedicated Project landfills
  - Eventually agreeing to participate in the upgrade of the local landfills and use separate cells for disposal of the Project waste in these landfills
- Prioritize and promote waste minimization through source reduction and diversion from conventional disposal to reuse, and recycling
- Implement effective lifecycle tracking of waste.

Operation of the upgraded landfills was financed by the Projects via direct regular contributions and by paying tipping fee much higher than fee that would normally apply to the community waste disposal. Tipping fee for the waste disposal received from local sources was not sufficient for keeping the landfills operational.

The WM strategy, including the landfills upgrade projects, was implemented through the Framework Agreement between the Sakhalin Government and Sakhalin 2 Project (Framework Agreement, 2003). The Framework Agreement made some provisions for development of the local waste diversion capacity.

The following activities were performed during the construction phase of the Projects:

- Upgrade of three municipal waste landfills (Figure 6)
  - Landfills in the north, center and south of the island commissioned in 2005 – 2006
  - Landfills operated by local companies, operator's training provided
- Contracts with local recycling outlets and waste management service providers
- Both Sakhalin 1 and Sakhalin 2 Projects are using licensed local waste management companies for waste collection and transportation to the recycling and treatment facilities and to the landfills
- Licensed companies are also managing waste storage facility located onsite
- Waste is directed to the qualified outlets only, qualification of the recycling outlets continued
- Sakhalin 2 personnel working in the capital of Sakhalin took part in the annual cleanup activities conducted at the popular recreation areas around the city.

The WM Review conducted in 2003 (AMEC, 2004) showed that there were several recycling companies mostly exporting waste to the mainland for recycling and treatment. The competition between licensed companies was limited.



**Figure 6: Synthetic liner at the landfill in the north of Sakhalin (photo by A. Chaikine)**

In 2005 there was more than 15 actively functioning waste recycling and transportation companies on Sakhalin, including plastic, paper, used oil/oily water. There was still no capacity for chemical waste treatment and paint waste recycling. Development of recycling and treatment capacity occurred on the Russian mainland (used tires, acid lead batteries, etc.). Waste management companies become competitive in bidding for major WM contracts. There is a continuous natural growth of the recycling companies performing services for the Projects as well as other companies and the public. As communicated to the authors recently, at least five new companies are in business now (January, 2011) in addition to fifteen in the 2005.

WM strategy was committed to waste diversion and no disposal of hazardous waste on Sakhalin. The performance indicators such as percent of waste diversion were set. The waste diversion continuously improved reaching overall 40 % in 2009 for the Sakhalin 2 Project (Sakhalin Energy, 2009).

#### **4.3 Lessons learned**

The following are main observation made during the implementation of the WM strategy:

##### Waste Disposal

- The bulk of construction waste was disposed of at the upgraded landfills.
- The capacity of the upgraded landfills was quickly exhausted since the volume of waste coming from local municipalities has been underestimated.

- The upgraded landfills were commissioned late, so the pipeline construction companies disposed waste in a number of substandard landfills located close to the pipelines Right of Way thus contributing to legacy waste issue (Figure 7).

#### Waste Diversion

- Waste diversion program was not implemented until 2006 due to the slow progress in the qualification and approval of waste recycling outlets.
- Due to the delay in implementation of the diversion program, hazardous wastes were stored on site in significant quantities until 2006, contributing to the site pollution.
- Insufficient local capacity caused significant cost increase since the transportation to the Russian mainland was required.

Overall WM during the construction phase of the Projects was satisfactory and the WM strategy was implemented in such way so that the bulk of nonhazardous waste generated by the Projects in the north and south parts of the Sakhalin Island ended up in the upgraded landfills. The majority of hazardous waste was directed to the recycling and treatment outlets or transported to the mainland for disposal.



Figure 7: Fly dumping of the Sakhalin 2 Project waste (photo by A. Chaikine)

The implementation of the strategy however was inefficient, waste disposal cost was high compared to the similar projects in developed countries. The construction of the onshore pipelines contributed to the legacy waste issue which has already been quite significant and will likely remain on the public agenda in the future as the proper WM systems develops locally.

While the operation phase had started for both Sakhalin 1 and Sakhalin 2 Projects, there is some further construction progressing on both Projects (e.g. Sakhalin 1, Phase 2 and additional LNG train for Sakhalin 2) that will likely to continue for several years. The WM problems not solved to date will remain valid and still need resolution.

## **5 Projects Impact on the Sakhalin Island**

### **5.1 Overall impact**

In 2000, the oil and gas industry accounted for 57.5% of Sakhalin's industrial output. By 2006, it accounted for 80% of the island's industrial output. Sakhalin's economy has been growing rapidly thanks to oil and gas industry. By 2005, the island had become the largest recipient of foreign investment in Russia, followed by Moscow (Khoroshavin A., 2009).

Oil boom improved local economy with significant revenue directed to the local budget. The Projects development boosted local services and businesses. Some local infrastructure received direct upgrades and improvement during the construction phase of the Projects.

Families of the people involved in the Projects enjoyed a significant raise of income. Sakhalin experiences a low unemployment rate (1.4%) (Administration, 2010). The island generally benefits from the inflow migration of qualified personnel. The Projects promoted technology, education and culture transfer.

There is a potential for petrochemical development related to the oil and gas processing on Sakhalin as a result of the Projects. There is a plan to provide natural gas to the local population and businesses in the south part of the island in the near future.

Oil boom caused negative social impacts, including a skyrocketing inflation (double compared to already high average inflation rate in Russia). Rapid economic development aggravated the social inequality and increased crime, alcohol and drug abuse. The infrastructure development does not keep up with the requirements of the rapid growth. In particular the quality of WM performed by municipal companies that serves the majority of the population on Sakhalin remains low.

The Projects caused some adverse effects to the marine and terrestrial environment. The effects are primarily related to biodiversity and protected species, and landscape reinstatement for the onshore pipelines. The Projects contributed to the legacy waste which is becoming an issue for future development on the island.

The most labor and money intensive phase of the Projects is coming to the end and although there is still some continuous construction activity expected for a number of years, the time for internal economic and social development of the Sakhalin Island has already begun.

In general, the original strategy of the Sakhalin Government, in spite of certain lost opportunities and inefficiencies, worked out successfully and the island's economy has been improving. Sakhalin as well as Russia exited the economic depression. The ongoing operation provides a continuous source of revenue to the local budget. However, the Sakhalin oil boom is coming to an end and the local Government has to adjust now to a different environment to ensure a sustainable natural growth of local economy. The Government and the society it represents are still on the learning curve. The experience gained from the oil boom, if studied carefully, may help to avoid inefficiencies and lost opportunities in the future.

## **5.2 Impact on WM**

The quality of WM services gives a good insight into standards of living of local population and effectiveness of the local governance (UN-Habitat, 2010). The results of the development of WM infrastructure and services reflect the overall Projects impact on local economy, social conditions and environment.

Three municipal landfills have been upgraded during the construction phase of the Projects and some training was provided to the landfills operators. In spite of inefficiencies and lack of performance the landfills served their purpose in receiving waste from the Projects and accepting waste from local communities. The original capacity of the upgraded landfills is almost exhausted and there is a need for construction of new phases at these landfills. With the Project's waste volumes decreasing, the operation of the upgraded landfills is becoming not sustainable. Tipping fee for the disposal of the waste from local sources is not adequate to keep the landfills operational. The future of these landfills is under question and this issue will have to be addressed soon.

There is some improvement in landfills' operation in the capital of Sakhalin, although some waste burning still occurs. There is a natural growth of the number of recycling companies performing services both for the Projects and other companies and the public. At least five new companies are in business now in comparison to the year of 2006. High competition of WM companies has been reported in 2008, so the price for WM services decreased due to the competition on the market.

WM is still high on the public agenda and current situation is frequently discussed in the media. Recently the Sakhalin Government accepted a Program of WM development on Sakhalin for 2009 – 2015 which includes (Integral Program, 2008):

- Transfer of obsolete pesticides to the waste treatment facility on the mainland
- Construction of the new MSW landfill in the capital of Sakhalin
- Diversion of 50% of MSW through waste sorting at the future landfill site
- Design of four MSW landfills in other towns across the island.

At the same time, the WM development on Sakhalin does not appear to be consistent and successive. No WM regulation has been developed and accepted on Sakhalin so far. Although some limited drink containers recycling was started recently, no stewardship programs have been implemented to support any kind of waste diversion. Informal recycling and composting programs that have success in other countries are not

even considered as a viable option to clean up the streets and parks, and ease up the burden to the landfills.

In spite of all plans and programs proposed so far, the progress of WM development is still very limited. The overall WM quality remains low on Sakhalin and there is a long way to go before the high standards introduced by the Projects will be implemented across the WM services on the island.

## **6 Conclusion**

The international oil and gas Projects that have been recently developed on Sakhalin brought some direct and indirect changes to the local infrastructure and services, including WM. Upgrade to OECD design standards and improvement of the operation of three landfills, promotion of waste diversion through the contracts with WM service providers, as well as transfer of business culture and technical knowledge resulted in a generally successful implementation of WM strategy for construction phase of the Projects.

There has been an increase in the number of waste collection, recycling and treatment companies offering their services to the Projects as well as to other businesses and the public. General quality of services and overall business culture improved in the result of the Projects.

As the Projects continue to develop and move to the operation phase, the unsolved problems and challenges in WM remain valid and will have to be addressed. This includes creation of additional landfill capacity for the Projects needs, design and construction of oily waste treatment facilities and further development of hazardous waste treatment facilities and services. Legacy waste issue may become critical as the Sakhalin territory develops and new projects appear.

The overall quality of the services offered outside the scope of the Projects remains low. Most of the MSW landfills on the island are substandard and are not operated properly. The WM plans and programs declared by the local government are not being implemented. No serious consideration has been given to stewardship programs promoting waste recycling.

The gap between relatively high quality of WM services provided to the Projects and the services used by the general public have not been bridged and the examples of good WM performance are not sustainable. Judging by that, the overall quality of life on the Sakhalin Island remains low and efficiency of the local governance has a lot of room for improvement.

There is a continuous discussion in the local media about WM situation on the island. General public, officials and specialists are engaged in the discussion and express serious concerns about environmental performance of WM system. The population realizes that there is an urgent need for improvement and the government feels this pressure.

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