NO. 1

A STUDY ON LAND SELECTION AND REGIONAL DEVELOPMENT FOR CLOSED SYSTEM DISPOSAL FACILITIES

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ABSTRACT

The Research Committee for Closed System Disposal Facilities has proposed a closed system disposal facility (herein after called “CSDF”) as a landfill that would contribute to improvement in the safety and preservation of the environment and facilitate exchange of information with community residents. In addition to research and surveys, the committee has engaged in public relations activities in order to promote the proposal.

Isolated from its external environment by covering facilities and seepage control facilities, the CSDF is characterized by the following advantages.

- The dispersion and spread of waste and odor can be prevented.
- The leachate volume and reclamation work are free from the effects of weather condition.
- It can be used as a storage facility for recycling of used materials.
- The consent of residents can be formed more easily on the construction of the facilities.

At the same time, however, the CSDF requires covering facilities and additional incidental equipment, and thus the construction of such facility is believed to be highly costly compared with a conventional opened-type landfill site (herein after called “OPLS”).

The authors have studied the potential for the regional development of a CSDF and land selection for its site in such a way as to make the best use of the facility while minimizing construction costs.

Photograph 1. Examples of Closed System Disposal Facilities

INTRODUCTION

In recent years, a number of regional development projects have been under way in Japan for such intermediate processing facilities of waste as incineration facilities and recycling facilities. Nevertheless, there have been few intensive and extensive projects with landfills. In addition, an increasing number of local governments are operating more than one landfill as a result of recent mergers of cities and towns promoted under a government incentive.

Under these circumstances, it is becoming more important to select an optimal development pattern when a local government is to plan the construction of a regional landfill. A development pattern refers to a form of development of a landfill based on considerations of regional conditions specific to each local government. The selection of a development pattern is to determine the basic structure of a landfill (OPLS or CSDF) and the number of facilities to be built.

Once a development pattern is selected, the site for the landfill needs to be determined. Conventionally, land selection is based on the development of an OPLS. However, it is required now to select a site for a CSDF also, as this type of facility, having a number of advantages over the OPLS, is increasingly employed on various scales and under a variety of locational conditions.

Focusing on the cost reduction issue for landfill systems as a whole, the authors have conducted research on the development of landfills under a regional development project and the land selection approach applicable to the CSDF, as well as the OPLS. A proposal will be made in the future for planning the development of landfills based on a feasibility study that utilizes the results of the cost reduction research for landfills construction.

CONSTRUCTION OF FACILITIES UNDER A REGIONAL LANDFILL DEVELOPMENT PROGRAM

This section discusses the classification and evaluation of regional landfill development patterns.

(1) Classification of development patterns

The regional landfill development patterns can be classified as centralized and decentralized types. In a centralized pattern, a single landfill is developed, while in a decentralized pattern, multiple landfills are constructed.

A total of 10 patterns are obtained when landfills are classified further by basic structure (Table 1).

Table 1. Classification of development patterns

	No.	Classification
Centralized (single facility)	1	OPLS
	2	CSDF
	3	OP-CS combined disposal facilities
Decentralized (multiple facilities)	4	OPLS
	5	CSDF
	6	OP-CS combined disposal facilities
	7	OPLS + CSDF
	8	OPLS + OP-CS combined disposal facilities
	9	CSDF + OP-CS combined disposal facilities
	10	OPLS + CSDF + OP-CS combined

(2) Classification of regional conditions

The regional conditions consist of the regional characteristics and locational conditions of a certain local government or an extended association of local governments formed to promote the efficiency and shared management of waste. The regional characteristics under our study are the population and area of a district for processing of waste and the number of intermediate processing facilities in the district. As locational conditions, the amount of rainfall and snowfall and the degree of urbanization were selected.

Each of these regional conditions was categorized using a relevant threshold (Table 2).

Table 2. Classification of regional conditions

Regional conditions		Classification
Regional characteristics	Population	1) Up to 50,000 2) 50,000 to 100,000 3) 100,000 to 200,000 4) 200,000 or more
	Area	1) Up to 400km^2 2) 400km^2 to 1,000km^2 3) 1,000km^2 or more
	Intermediate processing facilities	1) Single 2) Multiple
Locational conditions	Amount of rainfall	1) Heavy-rainfall area 2) Low-rainfall area
	Amount of snowfall	1) Heavy-snowfall area 2) Low-snowfall area
	Degree of urbanization	1) High 2) Intermediate 3) Low

(3) Evaluation of development patterns

To evaluate the development patterns, the evaluation items were categorized into 7 evaluation criteria. These criteria were further subdivided as shown in Table 3.

When Table 3 is applied to a combination of a development pattern in Table 1 and a regional condition in Table 2, it becomes possible to quantitatively evaluate and compare one development pattern with another.

1) Economy and efficiency: In development of a landfill, its economy and efficiency are among the most important factors to be considered. In our study, construction costs, maintenance management cost, and combined construction and maintenance management costs were evaluated to determine the economy of a landfill. To measure the efficiency of a landfill, the efficiency of operation, maintenance, and management of the facility was evaluated.

2) Living environment and natural environment: The regional environment is affected by the presence and operation of landfills, traffic of waste-carrying and other vehicles, reclamation work, and other factors. The degree of effect of a landfill is largely determined by its size. In our study, the maintainability of the living and natural environments was evaluated.

3) Safety: Generally, the construction of a landfill causes a change in the existing topography. The larger the change in the topography, the higher the risk of disaster taking place during a torrential rainfall and by an earthquake. And the larger the landfill, the larger the degree of pollution of underground water in the event of water leakage or other accidents. The degree of risk of pollution and disaster was evaluated in our study.

4) Consensus building: In panning a landfill development program, it is essential to build consensus with the community residents. Evaluation was made on the ease of consensus building.

5) Others: Other evaluation items included the smoothness of facility development, the ease of bringing in disaster debris to the landfill, and the effectiveness of returning landfill benefits to the local community.

LAND SELECTION METHOD FOR LANDFILLS

Discussion is made below on land selection methods applicable to both the OPLS and the CSDF.

(1) Land selection process

In the selection of landfill sites, it has been increasingly difficult in recent years to build the consent of residents under an administrative initiative. In consensus building, it is indispensable to deepen understanding between the authorities and community residents through disclosure of relevant information. For this purpose, a committee is often established to gather, and act based on, public comments.

Figure 1 shows the land selection process.

1) Identification of the landfill system: The evaluation results for the development patterns are scrutinized and the following actins are taken.

- Identification of the remaining service period of the existing landfill and its remaining waste disposable capacity.
- Confirmation of the reason for the construction of a landfill being deemed necessary after all efforts are made concerning the 3R (Reuse, Reduce and Recycle) measures.
- Identification of the volume and type of waste to be disposed of at the landfill.

Table 3. Evaluation items for development patterns

Evaluation criteria		Evaluation items	Evaluation details		Example of allocation of marks		Explanation
Direct cost reduction factor	Economy	Construction costs	Economy in construction cost by centralized/decentralized landfill		20	5	The centralized landfill is given higher marks because it has a greater advantage of scales.
		Maintenance management cost	Economy in maintenance management cost by basic structure (OPLS/CSDF) and by centralized/decentralized landfill			5	The CSDF is given higher marks because it needs only a smaller water treatment facility, and without the need for covering soil on the same day. The centralized landfill system is given higher marks because it does not require distributed maintenance management activities, while having an advantage of scale.
			Superiority of a centralized/decentralized landfill by population (the scale of the landfill)	Up to 50,000		5	In case of a small population, the centralized landfill system is given higher marks. In case of a medium-sized population, the centralized landfill system is given higher marks if the intermediate processing facilities are consolidated. In case of a large population, the decentralized landfill system is given higher marks if the intermediate processing facilities are distributed.
				50,000 to 100,000			
				100,000 to 200,000			
				200,000 or more			
		Construction cost +maintenance management cost	Economy by amount of rainfall	Low-rainfall area		5	In case of a heavy rainfall area, the CSDF is given higher marks because lower cost is needed for the construction and maintenance management of the water treatment facility.
				Heavy-rainfall area			
	Efficiency	Efficiency in maintenance management	Superiority of the singularity/plurality of intermediate processing facilities	Superiority of a single facility	15	5	If multiple intermediate processing facilities are operated at distributed locations, the decentralized landfill system is given higher marks.
				Superiority of multiple facilities			
			Size of the area covered by waste collection services	Small area (up to 400km^2)		5	The larger the area, the higher marks are given to a decentralized landfill system having multiple intermediate processing facilities.
				Medium-sized (400 to 1,000km^2)			
				Large area (1,000km^2 or more)			
			Operational efficiency affected by snowfall	Low-snowfall area		5	In heavy snowfall areas, the OPLS is given lower marks because the disposal of waste is extremely difficult in the winter.
				Heavy-snowfall area			
Indirect cost reduction factor	Living environment	Maintainability of the living environment	Degree of impact of landscape changes		20	5	The CSDF is given higher marks because it can preserve landscape with its covering facilities and is free from crow damage. The centralized landfill system is given lower marks because it causes a substantial landscape change due to its size.
			Maintainability of the living environment affected by crow damage and waste dispersion			5	The OPLS is given lower marks because it is subject to damage from crows and harmful insects and animals and also from waste dispersion. The decentralized landfill system is given moderately higher marks because each landfill is small and also because the system can better preserve the environment.
			Maintainability of the living environment along roadways used by waste-carrying vehicles			5	The centralized landfill system is given lower marks because waste-carrying traffic concentrates on a specific road.
			Effects on the utilization of neighboring land			5	The OPLS is given lower marks because it causes a substantial landscape change and poorly maintains the living environment. The centralized landfill system is given slightly lower marks because it causes substantial landscape changes and is less capable of preserving the living environment.
	Natural environment	Maintainability of the natural environment	Degree of impact of changes in the natural environment		10	5	The OPLS is given lower marks because it is subject to damage from crows, harmful insects and animals, which may change the natural environment. The larger a landfill, the lower marks are given because it may change the natural environment.
			Effects on downstream areas of change in treated water discharge			5	The CSDF is given higher marks because it can control the generation of leachate. The centralized landfill system is given lower marks because a single landfill generates a larger amount of leachate, thus affecting its downstream waters.
	Safety	Risk of potential pollution and disasters	Degree of disasters and risks caused by torrential rainfalls, earthquakes, and other events		10	5	The CSDF is given higher marks because it is free from overflows of retained water or other events in torrential rainfalls. The decentralized landfill system is given higher marks because the degree of a disaster or risk is diluted.
			Degree of risks and underground water pollution caused by water leakage			5	The CSDF is given higher marks because it can reduce pollution in underground water by controlling the amount of sprinkled water. The decentralized landfill system is given higher marks because the degree and the risk of pollution in underground water are diluted.
	Consensus building	Ease of consensus building	Ease of consensus building by basic structure		10	5	The CSDF is given higher marks where there are many urbanized areas or in a community where there is strong resistance to a landfill.
			Ease of consensus building and land acquisition by centralized/decentralized landfill system	Many urbanized areas		5	Where there are many urbanized areas, the centralized landfill system is given higher marks because building lots are extremely difficult to acquire in these areas.
				Moderate number of urbanized areas			
				Few urbanized areas			
	Other	Smoothness of development	Smoothness of development by centralized/decentralized landfill system		15	5	To utilize the existing landfills, the decentralized system is given higher marks. The decentralized system is given higher marks in a community that is more in favor of a decentralized one for geographical or historical reason. The centralized system is given higher marks in a community that is more in favor of a centralized one for economic reason.
		Disaster debris	Ease of acceptance and disposal of disaster debris by centralized/decentralized landfill system			5	The centralized system is given higher marks when disaster debris is to be accepted.
		Measure for returning benefits to community	Effectiveness of measures by basic structure for returning benefits to the community			5	Any basic structure is given high marks to the extent that it commits to its development policy of returning to the community benefits gained from the utilization of the landfill.
Total score					100		

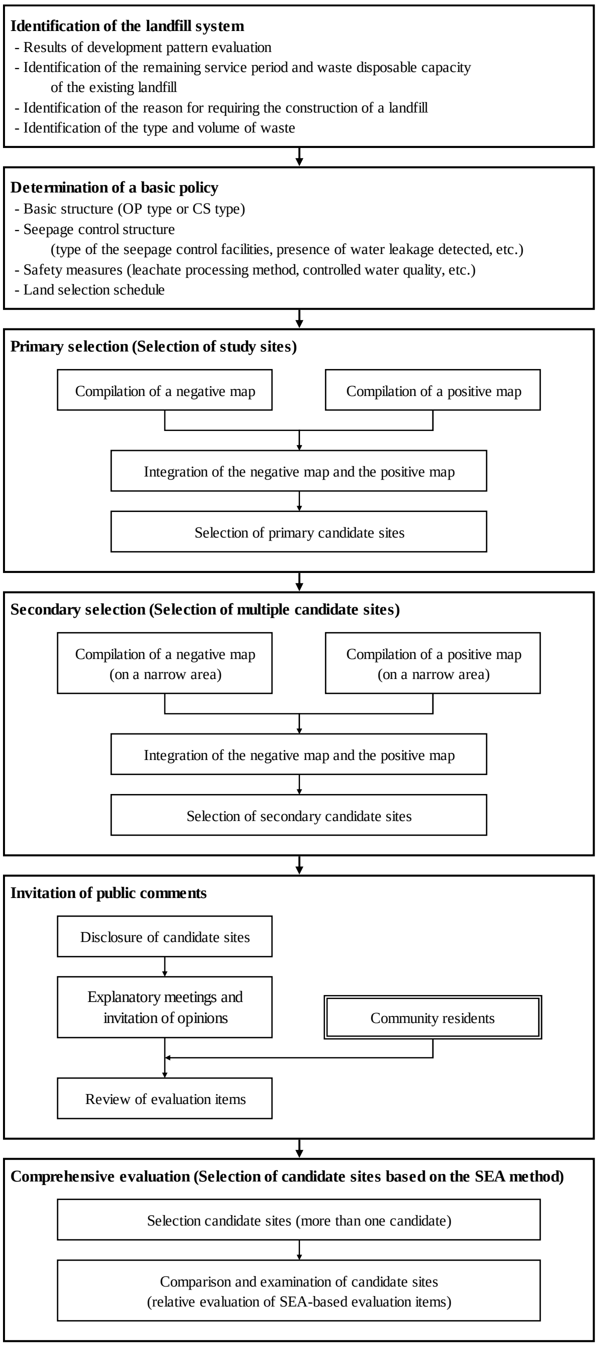

Figure 1. Land selection process

2) Determination of a basic policy: A basic policy is determined concerning the development of a landfill.

- Basic structure (OPLS or CSDF)
- Seepage control system (type of seepage control facility, presence of water leakage detection, etc.)
- Safety measures (leachate processing method, controlled water quality)
- Land selection policy and process

3) Primary selection: A negative map is produced in accordance with laws and regulations concerning the preservation of the natural environment and the control of land utilization, while a positive map is prepared by using transportation cost simulation and other techniques. The two maps are superimposed on each other to identify primary candidate sites.

4) Secondary selection: As in primary selection, the positive and negative maps are superimposed on each other, while adding other conditions, including the basic landfill structure (OPLS or CSDF), in order to further narrow down the candidate list. Figure 2 provides an example of compiling a map.

5) Invitation of public comments: The selection process and results are made public with respect to the candidate sites, the public is invited to make comments, and explanatory meetings are held.

6) Comprehensive evaluation: Taking public comments into consideration, final candidate sites are selected using the strategic environmental assessment (SEA) method.

(2) Evaluation items for land selection

The following shows evaluation items applied in the primary selection, secondary selection and comprehensive evaluation processes.

1) Evaluation items in primary selection: Sites on the negative map are excluded from the selection process if they are judged to be inappropriate for the introduction of a landfill due to legal restriction on land utilization or other reason. Sites are selected from the positive map if they are deemed to be advantageous in terms of transportation costs or for other reasons, or if there is strong demand for a landfill from community residents. The same evaluation items are used for the OPLS and the CSDF in the compilation of these maps.

Table 4. Example of evaluation items for primary selection

Negative factors	• Legal restriction on land utilization. • Physical difficulty with construction. • Land utilization policy already established.
Positive factors	• District where transportation costs are low. • Strong demand of community residents for the introduction of a landfill. • District where landfill sites are available.

2) Evaluation items in secondary selection: Using evaluation different items between the OPLS and the CSDF as shown in Table 5, the negative and positive maps are superimposed on each other to select a few candidate sites.

Further, the candidate list is narrowed down based on the evaluation items as shown in Table 6.

Table 5. Example of evaluation items in secondary selection (1)

<table>
<tr><th></th><th>OPLS</th><th>CSDF</th></tr>
<tr><td rowspan="2">Negative factors</td><td colspan="2">• Proximity to a residential area
• Proximity to schools, libraries, and parks
• Proximity to a funeral center and other facilities that residents tend to avoid
• Proximity to designated cultural assets</td></tr>
<tr><td>• Upstream of the point of water-use activities (except when treated water is discharged to the sewage system)
• Proximity to waste or sewage processing facilities
• Existence of a planned railroad or roadway construction project</td><td>• Upstream of the point of water-use activities (except when treated water is discharged to the sewage system or when treated water is not discharged externally)</td></tr>
<tr><td rowspan="2">Positive factors</td><td colspan="2">• Periphery of the center of population gravity
• Area where a sewage development project will start or has been completed</td></tr>
<tr><td>• Mountainous area having a valley</td><td>• Flatland or tableland
• Proximity to waste or sewage processing facilities
• Existence of a planned railroad or roadway construction project (having the possibility of ultimate land being utilized)</td></tr>
</table>

Table 6. Example of evaluation items in secondary selection (2)

<table>
<tr><th colspan="3">Evaluation criteria</th><th>Evaluation items</th><th>Evaluation details</th><th colspan="2">Example of allocation of marks</th></tr>
<tr><td rowspan="5">Direct cost reduction factor</td><td colspan="2" rowspan="3">Economy</td><td colspan="2">Construction cost</td><td rowspan="3">21</td><td>7</td></tr>
<tr><td colspan="2">Development cost for social infrastructures</td><td>7</td></tr>
<tr><td colspan="2">Maintenance management cost</td><td>7</td></tr>
<tr><td colspan="2" rowspan="2">Efficiency</td><td>Cover soil</td><td>High availability of cover soil</td><td rowspan="2">20</td><td>10</td></tr>
<tr><td>Roadways used to transport waste</td><td>Development length of roadways used to carry waste</td><td>10</td></tr>
<tr><td rowspan="22">Indirect cost reduction factor</td><td colspan="2" rowspan="5">Locational characteristics</td><td>Reclamation</td><td>Efficiency of the waste disposal process</td><td rowspan="5">20</td><td>4</td></tr>
<tr><td rowspan="2">Utilization of ultimate land</td><td>Flatness of ultimate land after reclamation</td><td>4</td></tr>
<tr><td>Presence/absence of a concrete plan</td><td>4</td></tr>
<tr><td rowspan="2">Water utilization</td><td>Public water sources</td><td>4</td></tr>
<tr><td>Agricultural water</td><td>4</td></tr>
<tr><td rowspan="17">Environmental characteristics</td><td rowspan="4">Natural conditions</td><td rowspan="4">Geological features</td><td>Strength of the ground</td><td rowspan="4">12</td><td>3</td></tr>
<tr><td>Underground water level</td><td>3</td></tr>
<tr><td>Active fault</td><td>3</td></tr>
<tr><td>Landslide</td><td>3</td></tr>
<tr><td rowspan="13">Social conditions</td><td rowspan="2">Land utilization</td><td>Countryside, fields (cultivated land)</td><td rowspan="13">27</td><td>3</td></tr>
<tr><td>Forest (afforested area)</td><td>3</td></tr>
<tr><td>Cultural assets</td><td>Designated cultural assets</td><td>2</td></tr>
<tr><td>Dwelling</td><td>Densely settled areas, residential complexes</td><td>3</td></tr>
<tr><td rowspan="7">Urban facilities</td><td>Intermediate processing facilities of waste</td><td>3</td></tr>
<tr><td>Sewage processing facilities</td><td>3</td></tr>
<tr><td>Railroads and roadway facilities (planned development project)</td><td>2</td></tr>
<tr><td>Funeral center</td><td>2</td></tr>
<tr><td>Community hall, library</td><td>2</td></tr>
<tr><td>Schools, hospital</td><td>2</td></tr>
<tr><td>Park</td><td>2</td></tr>
<tr><td colspan="5">Total score</td><td colspan="2">100</td></tr>
</table>

3) Evaluation items in comprehensive evaluation: SEA based evaluation items as shown in Table7 are used to narrow down the candidate list. At this stage, relative evaluation is performed on these items. More than one candidate site may be selected.

Table 7. Example of SEA evaluation items

Environmental factors	Evaluation items	Indicator
Environmental load	Global warming	CO_2 emissions
	Waste	Emissions from work
Air quality, water quality, soil environment, etc.	Hazardous substances, etc.	NO_X emissions (during construction work) Emissions of suspended particulate matter (during construction work)
	Noise	Noise from roadway traffic (during construction work) Noise from facility operation
	Vibration	Vibration from roadway traffic (during construction work) Vibration from facility operation
	Odor	Degree of odor dispersion
	Water quality	Water quality of rivers (during construction work) Degree of effect on underground water
	Soil	Increased pollution due to construction work
Biological diversity	Topography, geological features	Degree of effect on essential topography and geological features
	Plants, animals, ecological system	Important plant communities and species Identification of effects on major habitats and ecological systems
Interaction with nature	Interaction with landscape, humans and nature	Degree of effect on major landscape resources Degree of effect on interactions between humans and nature

PROPOSAL FOR LANDFILL DEVELOPMENT PLANNING

In the paragraphs above, as part of the study on regional development, the authors have analyzed development patterns and evaluation methodology for landfill construction. At the same time, the OPLS and the CSDF have been examined for selection of landfill sites. The study is still under way to build a more detailed view of our own concerning this issue.

In the near future, a feasibility study will be conducted on a virtual model area. In the study, several landfill development patterns will be selected and evaluated. Then, actual candidate landfill sites will be selected. Finally, an optimal development form will be established through cost effectiveness comparison. Figure 3 shows the flowchart of the planned feasibility study.

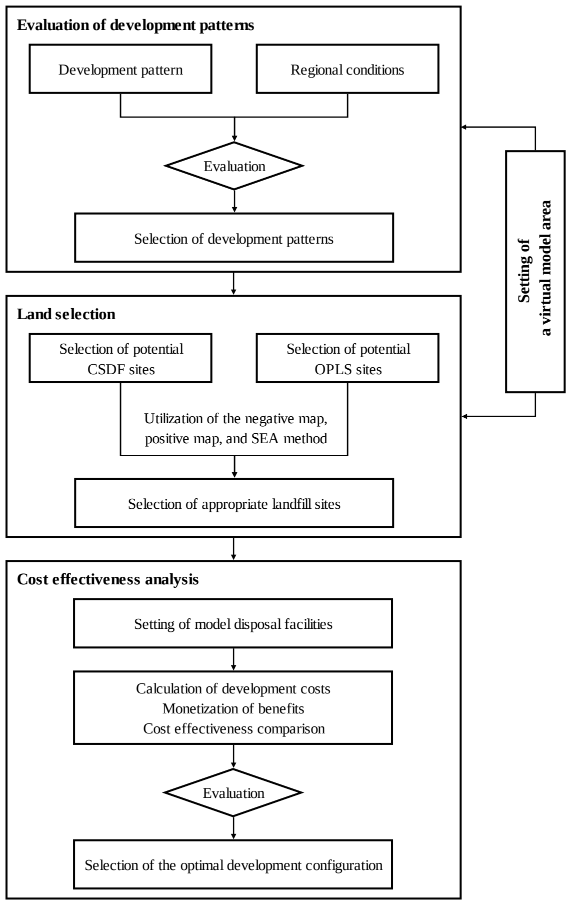

Figure 3. Study flowchart

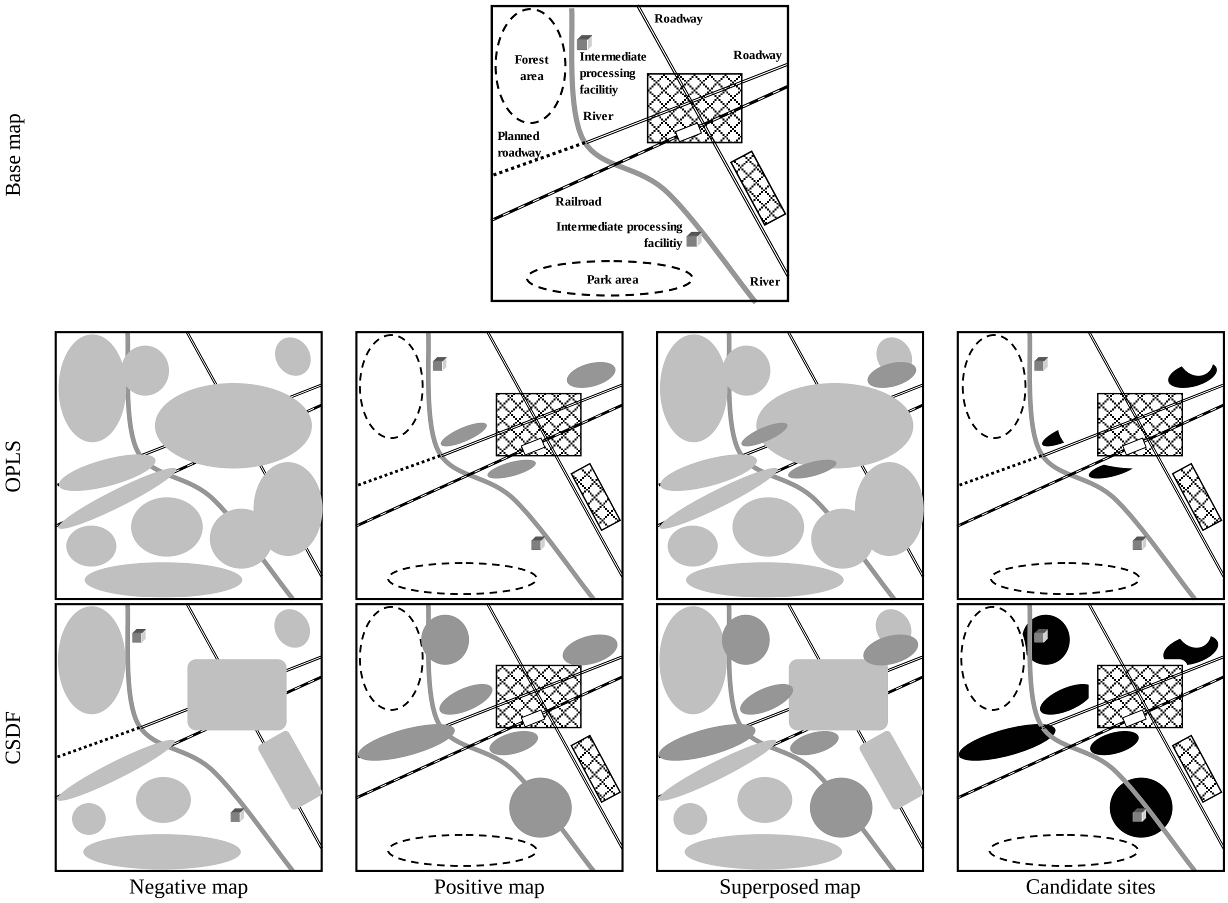

Figure 2. Example of compiling a negative map and a positive map

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