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Proposed sector-specific inventorying and ranking of potentially contaminated sites: The case of the Armed Forces in Greece

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ABSTRACT

Considering Greece's lack of specific regulations for polluted land as an opportunity for the Ministry of Defense (MoD), the project reported herein started with the following question: "how can the MoD develop a custom-made methodology to (A) put together an inventory of its own potentially contaminated sites and (B) identify priority sites for further study?" In order to tackle the logistical aspects of the question and ensure the fit-for-purpose of the inventory, it was decided to consider all types of active military units. Site information was collected through a questionnaire developed specifically for the installations of the Greek Armed Forces, which was to be filled by the environmental protection officer of each military unit. The questionnaire includes nine screening indicators grouped in three categories: contaminant, migration potential and receptor. Each indicator was evaluated with a set of possible answers-parameters and each parameter was assigned a grade (from zero to 18), resulting in a total maximum site score of 100. The questionnaire was initially tested at two sites, phrasing improvements were made and the final questionnaire was piloted at three more sites. The final scores of the five sites ranged from 59 to 90, i.e. the assigned grades appear to be capable of differentiating sites in terms of high or medium pollution potential, supporting thus the applied promise of the methodology.

Keywords: Contaminated land, Contaminated site inventories, Site ranking systems

1 INTRODUCTION

While many Member States of the European Union (EU) have put together a national inventory (or register) of potentially contaminated sites, EU lacks a common policy for polluted land. Member States could not agree on a proposed directive for soil protection (COM(2006)232 final), which addressed contaminated sites and the obligation of each Member State to compile a national site inventory, hence it was repealed in 2014. Greece lacks regulations for polluted land, but it has put together a partial inventory of potentially contaminated sites (Tsompanidis et al., 2017) as part of its hazardous waste policy. However, Greece is not among the countries reporting on land pollution to the European Environment Agency (EEA, 2022). Recently, the European Union has renewed interest in soil protection with a communication on EU soil strategy for 2030 (COM(2021)699 final), which is likely to entail a requirement for every Member State to create and maintain an inventory of potential contaminated sites.

Considering the current lack of specific regulation as an opportunity for the Greek Ministry of Defense (MoD) to be proactive, the project reported herein started with the following dual question: "how can the MoD develop a custom-made methodology to (A) put together an inventory of its own potentially contaminated sites and (B) identify priority sites for further study?" An administrative infrastructure is necessary for data gathering in order to address question (A), while question (B) requires specialized technical knowledge. Guidance for answering the technical aspects of the question asked was mainly sought in already applied country-wide inventorying frameworks based on the source-pathway-receptor model (CCME, 2008; Gidarakos et al., 2009) and in one proposed sector-specific inventorying framework (Pitsaki et al., 2014). In order to tackle the logistical aspects of the question, it was deemed necessary to first delineate the administrative structure of the military for environmental issues and identify all the types of military installations and activities, as discussed in Section 2. Then, Section 3 presents the development of a questionnaire meant to be completed by the environmental protection officer at each active military unit and a grading system of the collected data that assigns a score to each site, in order to set priorities for further site characterization.

2 METHODOLOGY – KEY COMPONENTS

2.1 Greek Armed Forces & administrative structure for environmental protection

Knowledge of the administrative structure for environmental protection of the Greek Armed Forces is necessary in order to propose the department(s) sending the questionnaire and collecting the answers, as well as the department analyzing the collected data. The complete organization chart of the environmental protection departments and units of the Greek Armed Forces and the descriptions of their function are given by Tzannes (2021). Herein it suffices to present the hierarchical relationships depicted in Figure 1 and the short names of key departments. The Hellenic National Defense Staff / Environment Department (ΓΕΕΘΑ/Γ2/ΤΜΗΜΑ 4) oversees the Environment Departments of the three Armed Forces (Army, Airforce, Navy), which in turn oversee procedures and activities related to environmental protection at each military unit. To ensure the completeness of the inventory, it is recommended that the questionnaires be distributed and collected by the Environment Departments of the three Armed Forces (Army: ΓΕΣ/Γ2/ΤΜΗΜΑ 5, Airforce: ΓΕΑ/Γ2/ΤΜΗΜΑ 7, Navy: ΓΕΝ/Γ2/ΤΜΗΜΑ 4) and that the analysis of the data be performed by the central Environment Department of the Ministry of Defense.

Infrastructure Department	→ Environment Department (ΓΕΕΘΑ/Γ2/ΤΜΗΜΑ 4)	→ Army Env. Dept. (ΓΕΣ/Γ2/ΤΜΗΜΑ 5)	→ Army Units
		→ Airforce Env. Dept. (ΓΕΑ/Γ2/ΤΜΗΜΑ 7)	→ Airforce Units
		→ Navy Env. Dept. (ΓΕΝ/Γ2/ΤΜΗΜΑ 4)	→ Navy Units

Figure 1. *Ministry of Defense: Organization chart for environmental issues and short names of key departments in Greek*

2.2 Military installations and activities

To ensure the completeness of the inventory, it is also recommended to consider all active installations hosting any type of military unit, without a priori excluding any category. A unit is an administrative entity residing at a particular location, typically within a military camp. In the case of the Armed Forces, a site corresponds to a military camp, which may include one or more military units. Military units were found to belong in only nine categories (Table 1): 1) Military camp-training, 2) Military camp-factory ("factory" herein refers to both manufacturing and maintenance), 3) Supply center, 4) Fuel storage facility, 5) Ammunition storage facility, 6) Military airfield, 7) Firing range, 8) Naval base and 9) Hospital. Technically, firing ranges are not independent units (with only one exception), but are being overseen by another military unit. Some firing ranges are physically located outside the military camp of the overseeing unit. Similarly to the number of types of military units, the number of potentially polluting activities taking place at military installations is also small. Specifically, eight categories of such activities were identified (Table 1): 1) Storage and handling of hazardous raw materials and wastes, 2) Storage and handling of fuels, 3) Storage and handling of ammunition, 4) Maintenance, 5) Parking, 6) Manufacturing, 7) Firing activity (antitank firing, tank firing, missile firing, artillery firing), and 8) Material quality control. As shown in Table 1, some units may involve most activities, e.g. a supply center may involve all activities except firing. Some activities, e.g. parking, concern all units, while others, e.g. storage and handling of hazardous raw materials and wastes, take place at all sites with the exception of firing ranges. With the exception of the two activities that are strictly military (storage-handling of ammunition and firing), the remaining activities were matched to the six-digit designations of respective waste types and chemical groups as defined in the European harmonized list of wastes (2014/955/EU), as shown in Table A1 in the Appendix. It is recommended that the Armed Forces perform a further breakdown of waste types and chemical groups into the specific chemical compounds associated to each activity, as well as identify the chemical compounds involved in the two strictly military activities, in order to expedite further site characterization and remediation should the need arise.

2.3 Focus on questionnaire respondents

A review of the administrative structure of the Ministry of Defense indicated that officers assigned to environmental protection duties at each military unit do not necessarily have formal qualifications in environmental science or engineering. What is more, because these assignments are not permanent, they do not permit environmental protection officers to develop an in-depth knowledge of the unit and its environmental history. This actuality guided the selection of the indicators included in the questionnaire from those that are known to be available to environmental protection officers at every

military installation. For the same reason, questions involving judgement of probability of contaminant releases or knowledge of history of contaminant releases were excluded from the questionnaire.

Table 1. *Activities associated with military installations*

No	Activity	Categories of military units								
		Military camp-training	**Military camp-factory**	**Supply center**	**Fuel storage facility**	**Ammunition storage facility**	**Military airfield**	**Firing range**	**Naval base**	**Hospital**
1	**Storage and handling of hazardous raw materials and wastes**	✓	✓	✓	✓	✓	✓		✓	✓
2	**Storage and handling of fuels**	✓	✓	✓	✓	✓	✓		✓	✓
3	**Storage and handling of ammunition**	✓		✓		✓	✓	✓	✓	
4	**Maintenance**	✓	✓	✓	✓	✓	✓		✓	
5	**Parking**	✓	✓	✓	✓	✓	✓	✓	✓	✓
6	**Manufacturing**		✓	✓						
7	**Firing activity (antitank firing, tank firing, missile firing, artillery firing)**							✓		
8	**Material quality control**		✓	✓						

3 QUESTIONNAIRE DEVELOPMENT AND RANKING RESULTS

3.1 Decisions for questionnaire input & site screening

Guidance for the basic structure of the questionnaire was obtained from the Canadian system for classifying contaminated sites (CCME, 2008) and its significantly simpler version of Gidarakos et al. (2009), which was used to put together the aforementioned partial inventory of potentially contaminated sites in Greece (Tsompanidis et al., 2017). They are both based on the three-part model for assessing environmental impacts commonly known as the “source-pathway-receptor” model. The Canadian system requires a significant quantity of information, including site characterization data, and scores characteristics classified into the following three categories: (1) contaminant characteristics; (2) migration potential in all media (groundwater, surface water, soil, soil gas and sediments); and (3) exposure (combines information on exposure pathway and receptors). Gidarakos et al. (2009) also specify three groups of characteristics: contaminant, migration potential and pollution impacts. Herein, the three groups were expressed as: contaminant, migration potential and receptor. The structural differences among the systems arise from the selection of the key impact-related characteristics assigned to each group, referred to as “screening indicators” or “indicators” hereafter. The interested reader will find a comparison of the basic structure of the three systems (i.e. the screening indicators) in Tzannes (2021: Figures 2.1 to 2.3). Figure 2 presents the nine screening indicators adopted herein together with their maximum scores.

Similarly to Gidarakos et al. (2009), the contaminant group includes two indicators, quantity and type of wastes, with the addition of raw materials. The choice of the indicators of the other two groups draws partial inspiration from the sector-specific ranking system by Pitsaki et al. (2014) and takes into account the information available to the questionnaire respondents, as discussed in Section 2.3. Similarly to Pitsaki et al. (2014), the proposed methodology emphasizes protection of soil and groundwater, i.e. the least regulated environmental media, especially in Greece. To this end, the migration potential group does not address separately each environmental medium, but instead assesses the potential of contaminant release by considering the types of storage facilities and media. In addition, it places more emphasis on contamination of groundwater and especially any nearby drinking water source, which is of major concern for military installations. Lastly, the receptor group assesses potential impacts through two indicators, the type of the military unit discussed in Section 2.2 and the land use of the areas surrounding the military camp as defined by the Presidential Decree 59/2018.Table 2 provides details on the parameters selected to represent the indicators and scores assigned to each parameter.

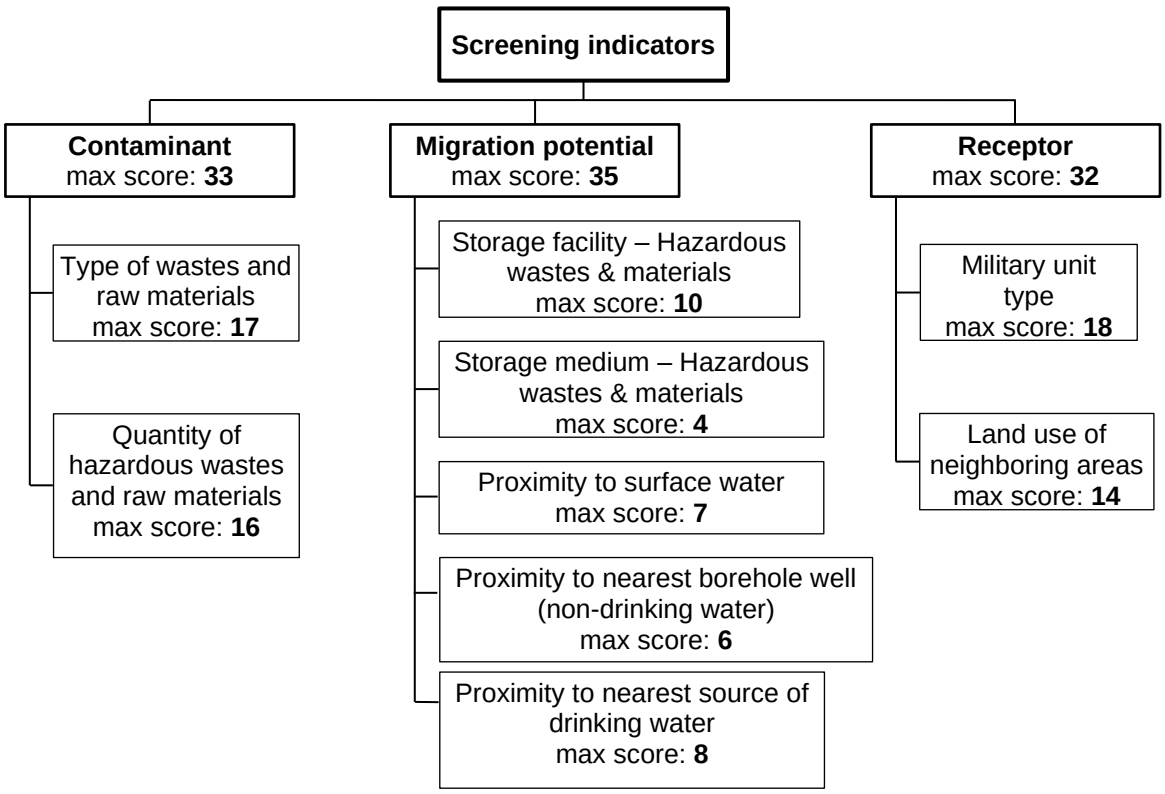


Figure 2. *Site screening indicators and respective maximum scores*

Choosing a maximum total score of 100 and the maximum contribution of each group to be about 1/3 of the total (see Figure 2) is consistent with CCME (2008) and Gidarakos et al. (2009). The maximum score assigned to each indicator, denoted with bold in Table 2, ensures that none is dwarfed by indicators of the same group. When multiple parameters correspond to the same indicator, e.g. for storage medium both underground and above-ground tanks, the scores of the parameters are not additive, i.e. the indicator is assigned the score of the most impactful parameter (4 in this example). The minimum score assigned to each indicator reflects an element of conservatism, e.g. the contaminant group receives a zero score only in the absence of any wastes or hazardous materials, the migration potential group has a minimum score of two and the receptor group a minimum score of 10. Lack of information on the possible existence of a drinking water source is penalized with a grade that corresponds roughly to a known source at a distance of 2-3 km from the location of a potentially polluting activity (Section 2.2), in order to underscore the importance of this indicator for the Armed Forces.

The score obtained on the basis of the characteristics of the unit is assigned to the military camp, i.e. the site hosting the unit. When a military camp hosts two units or more, the camp is assigned the highest score of its units. In the case where a unit oversees a firing range located outside the camp hosting the unit, then the unit will be asked to also complete a second questionnaire for the firing range.

A conceivable best case scenario is represented by a military camp-training (10) that handles no wastes or hazardous materials (0), has no source of drinking water (0) and is surrounded by production facilities of low-medium nuisance (10), which has a total score of 22. Hence a site evaluated with the proposed methodology might realistically accumulate a total score from 22 to 100. Assuming a linear relationship between site scores and priorities, a possible classification scheme to prioritize the need for site characterization is as follows: 100–76: potentially contaminated site of high priority, 75–51: potentially contaminated site of medium priority, 50–25: potentially contaminated site of low priority, 25 > : site likely to pose no contamination threat.

3.2 Testing the draft questionnaire

The first draft of the questionnaire was tested at two units, selected with two criteria: to be representative of most military installations and to involve hazardous chemicals in their operation. The two units thus selected were a military camp-training, a military unit type representing 70% of all units, and a military camp-factory, a military unit type involving more hazardous substances compared to the other types. In

the first case, the unit was located in a military camp hosting other units. The questionnaire was tested at the unit with the highest anticipated pollution potential, since the screening outcome of this unit would characterize the entire site (i.e. the military camp). In the second case (camp-factory) only one unit was located in the site of the military camp.

Table 2. *Site screening indicators, respective parameters and assigned scores*

	Indicator	Parameter	Score
Contaminant	Type of wastes and raw materials	hazardous wastes (with asterisk, 2014/955/EU), hazardous materials	**17**
		wastes (without asterisk, 2014/955/EU)	5
	Quantity of hazardous wastes and raw materials	tones	**16**
		tens of kg	5
Migration Potential	Storage facility – haz. wastes & materials	non-covered facility	**10**
		covered facility, unpaved floor	6
		covered facility, concrete floor	5
		covered facility, industrial grade floor	4
		facility complying to regulations for permanent storage of haz. wastes	1
	Storage medium – haz. wastes & materials	underground tank	**4**
		above-ground tank	3
		metal container, container pallet	2
		drum, intermediate bulk container, plastic container	1
	Proximity to surface water	< 1km	**7**
		1 – 4km	5
		> 4 km	1
	Proximity to nearest borehole well (non-drinking water)	< 1km	**6**
		1 – 3km	4
		> 3 km	1
	Proximity to nearest source of drinking water	< 100 m	**8**
		100 – 300 m	5
		300 – 1000 m	4
		1000 – 5000 m	2
		unit has no source of drinking water	0
		unknown	3
Receptor	Military unit type	• military camp-factory, fuel storage facility	**18**
		• military camp-training, supply center, ammunition storage facility, military airfield, firing range, naval base	10
		• hospital	5
	Land use of neighboring areas (Presidential Decree 59/2018)	• residential, town center – district/neighborhood center, tourism – recreation, public utility facilities, free spaces – urban parks, technology & research parks, agricultural – forestry – livestock – fishing and other agricultural holdings	**14**
		• production facilities of low and medium nuisance, industrial and craft park, production facilities with high traffic, wholesale trade, urban infrastructure facilities	10
		• special uses (e.g. recycling facilities, waste treatment facilities)	5

The selected military camp-training unit includes locations where military training is taking place, as well as other military activities, including maintenance. There are no personnel with specialized environmental training serving at “Military camp-training 1”. The environmental protection officer performs his duties by consulting documents for environmental protection internal to the Armed Forces and with input received during inspections by the overseeing Environment Department of the Army (ΓΕΣ/Γ2/ΤΜΗΜΑ 5). Completion of the questionnaire required two working days and revealed that the officer was not adequately familiar with the European harmonized list of wastes (2014/955/EU) and its six-digit designations for hazardous waste streams. As a result, an explanatory paragraph was added to the introduction of the questionnaire. The selected military camp-factory unit produces industrial

gases and paints, shoe varnishes and plastics. It stores large quantities of raw materials and generates hazardous wastes. The environmental protection officer at “Military camp-factory 1” is a chemical engineer with specialization in environmental management, who completed the questionnaire in one working day.

The questionnaire was finalized taking into account the input from the two environmental protection officers. Apart from expanding the introduction, as already mentioned, the questions were arranged in the four groups described in the next section. One question was added to allow for cases where two or more units operate at the same military camp. This is important because the methodology proposed evaluates sites and not units. Three questions asking for additional information were omitted, one because it was unclear and two because they partly overlapped with the rest.

3.3 Final questionnaire structure & pilot applications

The questionnaire includes questions seeking the input required by the site screening system shown in Table 2, but in the different arrangement shown compactly in Table 3. It is anticipated that this arrangement will be more user-friendly for respondents, i.e. the environmental protection officers at military units, who should be unencumbered by considerations related to the scores assigned to the information they provide. After a one-page introduction with clarifications on terminology, the final version of the questionnaire includes 15 questions, five open ended and 10 multiple choice. It is divided in four parts: unit information (Part 1), which provides the “identity card” of the unit, storage of raw materials and wastes (Part 2), type and quantity of raw materials and wastes (Part 3) and potential pollution receptors (Part 4), where “receptors” herein refers to both humans and environmental media. Part 1 has five questions requesting information on the military unit, the type of the military unit (the first graded indicator in the receptor group) and the types of activities taking place at the unit (this information is not directly evaluated by the screening system but it is necessary for answering the last question of Part 4). Part 2 has two questions about the facilities and the media used to store hazardous raw materials and wastes (i.e. two of the five graded indicators of the migration potential group). Part 3 covers the information on the indicators of the contaminant group and has four questions. The first two request information on raw materials (during analysis of results, this piece of information may require further assessment/confirmation of their hazard status) and the yearly quantity used (actual or estimated). The third question asks the respondent to choose from a list of the 26 six-digit designations of wastes and chemical groups from the European harmonized list of wastes (2014/955/EU) that are associated with the non-strictly military activities taking place at military sites (see Section 2.2). This question has a 27th choice of “other hazardous wastes”, which is open-ended, in order to include the two strictly military activities (storage-handling of ammunition and firing). The fourth question of Part 3 asks for estimated yearly quantities generated. Lastly, Part 4 has four questions. One question requests information on land uses of the surrounding areas (the second graded indicator in the receptor group) according to Presidential Decree 59/2018. The remaining three questions complete the required input for the migration potential group: the distance of the site from surface water and borehole wells (not for drinking water), and the distance of any drinking-water source from the location of the activities selected as answers to the fifth answer of Part 1 (these are the potentially polluting activities presented in Section 2.2, although the questionnaire does not characterize them as “potentially polluting”).

The final questionnaire was piloted at three more units, one training unit, “Military camp-training 2”, and two factory units, “Military camp-factory 2” and “Military camp-factory 3”. The operations taking place at “Military camp-training 2” are classified, hence they will not be described herein. For the purposes of this paper, it suffices to mention that the potentially polluting activities taking place at “Military camp-training 2” are storage and handling of hazardous raw materials, wastes, fuels and ammunition, maintenance and parking. The environmental protection officer, who lacked specialized training, did not request any clarification on the questionnaire and completed it in one working day. The operations taking place at “Military camp-factory 2” are electronical and telecommunication system repair and maintenance. The potentially polluting activities taking place at “Military camp-factory 2” are storage and handling of hazardous raw materials and wastes, maintenance, parking, manufacturing and material quality control. The operations taking place at “Military camp-factory 3” are repair and maintenance of weapon systems and armored vehicles.The potentially polluting activities taking place at “Military camp-factory 3” are storage and handling of hazardous raw materials, wastes and fuels, and maintenance. The environmental protection officers at the two factory units have specialized training for hazardous waste management, did not request any clarification on the questionnaire and completed it in one working day.

Table 3. *Structure of final questionnaire to be completed for each military unit*

Part 1: Unit information
1. Branch of Armed Forces (MC[a])
2. Name of unit
3. Name of military camp
4. Unit type (MC[a])
5. Activity type (MC[a])
Part 2: Storage of raw materials and hazardous wastes
1. Storage facility (MC[a])
2. Storage medium (MC[a])
Part 3: Type and quantity of raw materials and hazardous wastes
1. Chemical substances & yearly quantities used
2. Estimate of quantities used (if exact are unknown)
3. Choice(s) from list of six-digit designations of relevant wastes and chemical groups (2014/955/EU) (MC[a]) & yearly quantities generated
4. Estimated order of magnitude of quantities generated (if exact are unknown): tens of kg or tones (MC[a])
Part 4: Potential pollution receptors
1. Proximity to surface water (MC[a])
2. Proximity to borehole well (non-drinking water) (MC[a])
3. Land use of neighboring areas (Presidential Decree 59/2018) (MC[a])
4. Proximity of drinking water source to the location of the activities in Part 1 – Question 5

[a] MC = Multiple Choice

Table 4 summarizes the scores of the five sites and includes for comparison the maximum possible score for each indicator. Four of the five sites received the maximum score in the contaminant group and three of the five sites (those hosting the three factories) received the maximum score in the receptor group as well. The sites hosting the two training units received scores of 59 and 75 and are categorized as potentially contaminated sites of medium priority (51 to 75), while the sites hosting the three factory units received scores of 80 and 90 and are categorized as potentially contaminated sites of high priority (76 to 100). Given that it is highly probable for a military camp-factory to receive the maximum score of 65 for the contaminant and receptor groups, its storage practices and location may determine its classification. For example, if "Military camp-factory 3" (i.e. Site 5 in Table 4) had safer storage facilities and was not as close to surface water, it would be classified as "medium priority".

Table 4. *Ranking results for five military sites and comparison with maximum possible scores*

Indicator	Maximum score	Site 1 Training 1	Site 2 Factory 1	Site 3 Training 2	Site 4 Factory 2	Site 5 Factory 3
CONTAMINANT	**33**	22	**33**	**33**	**33**	**33**
Type of wastes and raw materials	**17**	**17**	**17**	**17**	**17**	**17**
Quantity of hazardous wastes and raw materials	**16**	5	**16**	**16**	**16**	**16**
MIGRATION POTENTIAL	**35**	13	15	18	25	15
Storage facility – hazardous wastes & materials	**10**	**10**	1	6	5	4
Storage medium – hazardous wastes & materials	**4**	1	2	1	1	3
Proximity to surface water	**7**	1	1	**7**	**7**	**7**
Proximity to nearest borehole well (non-drinking water)	**6**	1	**6**	4	4	1
Proximity to nearest source of drinking water	**8**	0	5	0	**8**	0
RECEPTOR	**32**	24	**32**	24	**32**	**32**
Military unit type	**18**	10	**18**	10	**18**	**18**
Land use of neighboring areas	**14**	**14**	**14**	**14**	**14**	**14**
TOTAL SCORE	**100**	59	80	75	90	80
SITE PRIORITY	**High**	Medium	**High**	Medium	**High**	**High**

3.4 Discussion of ranking results

Three sites were categorized as potentially contaminated sites of high priority and two sites were categorized as potentially contaminated sites of medium priority. The two sites of medium priority, both training units, had scores differing by 16 points. These results suggest that the proposed methodology is able to reflect variation and differentiate sites at the higher end of pollution potential. However, it may not be able to differentiate sites at the lower end of pollution potential, considering that six of the nine unit types may readily accumulate 24 points for the receptor group and 22 points for the contaminant group, even with small quantities of hazardous wastes, and will thus be only 7 points away from the medium priority designation (which has a threshold of 51). Hence, it is recommended to revisit the score ranges of the site priority categories after applying the questionnaire to a larger number of sites. Two alternative classification schemes that relate in a non-linear fashion site scores and further characterization priorities would be as follows: 100–86 (or 100-81): potentially contaminated site of high priority, 85–61 (or 80-61): potentially contaminated site of medium priority, 60–25: potentially contaminated site of low priority, 25 > : site likely to pose no contamination threat.

3.5 Discussion of the methodology

The limitation of the approach proposed herein is that decommissioned sites will require a separate inventorying effort. However, the proposed methodology can be useful for those decommissioned camps slated for redevelopment, which are being managed by the MoD Directorate for the Armed Forces Real Estate Development. What is more, the rationale behind the choice and the grading of the indicators provides guidelines to active installations seeking to make improvements in order to reduce their potential environmental impact, for example, to improve storage facilities and media. In addition, the methodology helps the Ministry set priorities for decommissioning sites, for example, giving priorities to sites in close proximity to water bodies.

4 CONCLUSIONS

Sector-specific inventorying of potentially contaminated sites offers opportunities to tailor the procedure to ensure a comprehensive outcome. To this end, three components were deemed to be key for the Greek Armed Forces: delineating the administrative structure of the sector, identifying all types of active installations (without a priori excluding any) and developing a questionnaire involving answers based solely on data known to be available (not on judgement), in order to enable non-specialists as well to provide the required input. The questionnaire includes nine screening indicators, grouped in three categories, contaminant, migration potential and receptor, each contributing about one third to the total maximum site score of 100. Administering the final questionnaire showed that environmental protection officers were able to complete it without requiring additional clarifications. Final scores for five sites ranged from 59 to 90, i.e. the assigned grades appear to be capable of differentiating sites in terms of high or medium pollution potential. These two findings establish the applied promise of the proposed methodology. Should the Greek Armed Forces decide to adopt it, they will have the benefit of proceeding with a procedure custom-made for their administrative structure.

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APPENDIX

Table A1. *Matching the non-strictly military activities at military installations to the six-digit designations of waste types according to European harmonized list of wastes 2014/955/EU*

Activities	Waste type codes according to 2014/955/EU
Storage and handling of hazardous raw materials and wastes	06 01 04*, 06 02 03*, 06 02 04*, 06 02 05*, 06 03 13*,08 01 11*, 11 01 05*, 12 01 06*, 13 01 11*, 13 02 06*,13 05 07*, 13 08 02*, 15 02 02*, 16 01 07*, 16 07 08*, 17 06 05*
Storage and handling of fuels	05 01 11*, 13 07 03*, 13 08 02*, 13 08 99*,15 02 02*, 16 01 07*, 16 07 08*
Maintenance	06 01 04*, 06 01 06*, 06 02 03*, 06 02 04*, 06 02 05*, 06 03 13*, 07 02 01*, 12 01 06*, 13 01 11*, 13 07 01*, 13 07 02*, 13 07 03*
Parking	13 01 11*, 13 07 03*, 13 08 02*, 13 08 99*, 16 07 08*
Manufacturing	08 01 11*, 11 01 05*, 12 01 06*, 13 01 11*, 13 02 06*, 13 05 07*, 13 07 03*, 13 08 99*, 15 01 10*, 16 07 08*
Material quality control	06 02 03*, 07 01 04*, 13 01 11*, 13 07 03*, 13 08 02*

Legend
05 01 11* wastes from cleaning of fuels with bases
06 01 04* phosphoric and phosphorous acid, **06 01 06*** other acids, **06 02 03*** ammonium hydroxide
06 02 04* sodium and potassium hydroxide, **06 02 05*** other bases, **06 03 13*** solid salts and solutions containing heavy metals
07 01 04* other organic solvents, washing liquids and mother liquors, **07 02 01*** aqueous washing liquids and mother liquors
08 01 11* waste paint and varnish containing organic solvents or other hazardous substances
11 01 05* pickling acids
12 01 06* mineral-based machining oils containing halogens (except emulsions and solutions)
13 01 11* synthetic hydraulic oils, **13 07 01*** fuel oil and diesel, **13 07 02*** Petrol, **13 07 03*** other fuels (including mixtures), **13 02 06*** synthetic engine, gear and lubricating oils, **13 05 07*** oily water from oil/water separators, **13 08 02*** other emulsions, **13 08 99*** wastes not otherwise specified
15 01 10* packaging containing residues of or contaminated by hazardous substances, **15 02 02*** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by hazardous substances
16 01 07* oil filters, **16 07 08*** wastes containing other hazardous substances
17 06 05* construction materials containing asbestos

REFERENCES

2014/955/EU. Commission Decision amending Decision 2000/532/EC on the list of waste.

Canadian Council of Ministers of the Environment (CCME) (2008). National classification system for contaminated sites guidance document PN 1403 ISBN 978-1-896997-80-3.

COM(2006)232 final. Proposal for a Directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC (repealed).

COM(2021)669 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, EU Soil Strategy 2030.

European Environment Agency (EEA) (2022). Progress in the management of contaminated sites in Europe, https://www.eea.europa.eu/ims/progress-in-the-management-of

Gidarakos, E., Aivalioti, M., Yannis, A. & Kalderis, D. (2009). Study for the investigation, assessment and restoration of uncontrolled industrial and hazardous waste contaminated sites/facilities in Greece, Technical University of Crete (in Greek).

Pitsaki, K., Boura, F., Pantazidou, M. & Katsiri, A. (2014). Methodologies for compiling national inventories of contaminated sites and conducting preliminary site screening, Global NEST Journal, 16(1), 24-35.

Presidential Decree 59/2018. Categories and content of land uses, Greek Government Gazette (ΦΕΚ/Α/29-6-2018).

Tsompanidis, C., Lolos, G., Lolos, T., Pitsaki, K., Mavropoulos, A., Mentzis, A., Papagrigoriou, S. & Manitara, K. (2017). Contaminated sites from industrial-hazardous wastes in Attica Region and nine prefectures of Greece: Identification, characterization and preliminary risk assessment, Sardinia 2017, 16th International Waste Management and Landfill Symposium / 2-6 October.

Tzannes, G.D. (2021). Methodology for recording and ranking potentially contaminated sites at military installations. MSc Thesis (in Greek), MSc Program “Science and Technology of Water Resources”, National Technical University of Athens, http://dx.doi.org/10.26240/heal.ntua.22635